Inscribing Markets, Shaping Policy: A Sociological Investigation into the Yield Curve

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Declaration

I declare that this thesis has been composed solely by myself and that it has not been submitted, in whole or in part, in any previous application for a degree. Except where states otherwise by reference or acknowledgment, the work presented is entirely my own.

(Dylan Cassar)

To Johnny, Josette, and Erika.

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Lay summary

This thesis investigates the social role of a material device, known as the yield curve (i.e. a chart of interest rates), in markets and central banks. It draws on 51 interviews with financial market participants, such as investment fund traders, investment bank traders and economists, and central bank economists, supplemented by analysis of documents. The thesis is informed by a theoretical approach known as actor-network theory, which examines social life - including life in financial markets and central banks - as a network of humans and nonhumans (devices, materials, technologies, calculators etc.). The first part of the thesis looks into the historical process by which the yield curve came to be embedded in the practices of financial market participants and central bankers. It argues that, in this process, the yield curve shaped markets as it was employed as a core device in trading and investment decision processes. In turn, by being embedded in various contexts, the yield curve was shaped into different objects, from an object with which to extract value, to a risk management object, and to a policy device through which market expectations are calculated and governed. The second part turns to contemporary times, and argues that the yield curve acts as a coordinating device within and between markets and central banks. As a result, social order is made possible, in part by the mediating role of the yield curve, through a set of established practices. As crises, particularly the Great Financial Crisis of 2007/08, disrupted established practices, the yield curve took on new roles in central bank's monetary policy implementation as an attempt to restore order. The thesis calls for emphasis on the materiality of social life and practices of decision-making, interactions, and governance, while remaining cognizant of how social life is shaped by wider historical processes, such as escalating financialisation, and thus comes to be predicated on historically-contingent structures.

Abstract

This thesis investigates the central mediating role of a device, the yield curve, in the enactment of sociomaterial agencements in and around the secondary market for sovereign bonds. In part 1, it traces the historical developments by which the yield curve came to sit within the arrangements constituting government bond markets and later central banks, and the market and policy practices which it engendered. In part 2, it studies the contemporary organising of social order in the interaction between financial markets and central banks, and the perpetual reassembling of arrangements as a response to crises. The thesis relies primarily on a set of 51 elite and in-depth interviews with buy-side fund managers and traders, investment bankers, arbitrage traders in hedge funds, and central bankers, across Edinburgh, London, Frankfurt, and New York. Additionally, a set of primary and secondary documents from various sources, including the Bank of England and stockbroking firms, informs the historical analysis of the rise of government bond markets (UK and US) and the architecture of monetary governance in the UK.

The findings in Part 1's chapter 3 and chapter 4 follow a performativity argument to show how, as the yield curve became a core part of government bond markets, it shaped those very same markets which it was purported to represent. By assisting in the development of a novel set of evaluation practices in stockbroking firms in the City of London, it led to the consolidation of the gilt market. It was also a crucial component of the sociomaterial arrangements of investment banks in the US through which derivatives emerged and via which the risk-neutral world of 'no-arbitrage' was established. In turn, the yield curve was itself shaped as it came to sit within *multiple* sociomaterial arrangements and practices - from derivatives desks to arb desks and central banks – and thus took on multiple ontologies, from an object with which to extract value, to a risk management object, and from a mathematical universe to be solved via calculation, to a representation of market expectations. Chapter 5 elaborates on how the sociomaterial agencement of inflation-targeting central banking in the 1990s was the outcome of a long and complex process of reconfigurations of the alignments between central banks and bond markets, in the context of processes

of financialisation and liberalisation of markets, that ultimately put the yield curve at the centre of the central bank's sociomaterial arrangements and practices.

Part 2's chapter 6 switches gears and turns the focus on the ways in which, rather than leading to chaos or social disorder, the multiplicity of agencements explored in the previous chapters render order by way of a set of routinised and institutionalised practices. As a mutable mobile, the yield curve acts as a coordinating device around which fictional expectations and 'arbitrage' practices revolve, thus exhibiting a level of universality that transcends the locality of specific sociomaterial arrangements and, even more crucially, connects them. Nevertheless, chapter 7 shows how fragile this social order is as a set of crises threaten to disrupt it. As a response, the various sociomaterial arrangements reconfigured and reassembled 'the social' in order to weather the crises's threats and to re-establish social order.

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Chapter 1

Introduction

On 21 September 2016, in its Monetary Policy Meeting, the Bank of Japan's Policy Board agreed to introduce a monetary policy through which it would seek to control both short-term and long-term interest rates. Known as 'Yield Curve Control', the policy turned the yield curve into a direct operational target (Kuroda, 2017) and placed it "at the core of the new policy framework" (BoJ, 2016, p. 3). It was in many ways an extension of the previous policy of 'Quantitative and Qualitative Monetary Easing' which was, however, intended to *influence* - rather than *control* - the yield curve[1]. The new policy, on its part, involved a mix of old and new tools and operations, such as purchases of government bonds, with a view to fixing the yield curve towards the fulfilling of the central bank's mandate, that of price stability. Similarly, the Reserve Bank of Australia followed in the Bank of Japan's footsteps when in March 2020, at the start of the Covid-19 pandemic, it adopted the policy of yield curve control and decided to cap three-year yields at 0.25% and later in November 2020 at 0.1%.

The policy of yield curve control demonstrates an increasing preoccupation with *the yield curve* not just on the part of central bankers but also market participants. Even those central banks which resisted going down the route of yield curve control were and are still heavily involved in steering yield curves. Members of the Governing Council of the European Central Bank (ECB) have recently spoken of the need to resist shifts in the yield curve (Panetta, 2021), as the ECB is widely seen by market participants and economists commentators to have embarked upon a policy of informal yield curve control and of yield curves spread control across the euro area through its Pandemic Emergency Purchase Programme (IIC, 2020; Reuters, 2021; Randow and Neumann, 2021). Though not explicitly a policy, the yield curve has acted as a target of intervention within central banks' monetary policy since at least the turn towards inflation-targeting and expectations-management in the 1990s with ever-

[1] The notions of 'yield' and 'yield curve' will be explained in the next section.

increasing intensive focus on the curve particularly following the Great Financial Crisis of 2007/08 and the implementation of unconventional monetary policy as a response to the crisis.

On their part, market participants, particularly those in the government bond markets, watch and study the yield curve attentively. As Zaloom (2009) argues, the yield curve is treated by them as an object that represents the bond market and it therefore plays a principal role in the practices through which they assess the market's judgement. In the words of one hedge fund manager, the yield curve is today "*the sun around which everything else revolves*" (Zaloom, 2009, p.249).

The yield curve first piqued my sociological curiosity during my experience as part of a research team at the Central Bank of Malta, a member of the Eurosystem[2] and the European System of Central Banks[3]. On a daily basis, at around 10am, all staff members would receive a Market Report produced by the ECB which would involve a series of charts - yields curves and spreads – summarising visually the levels of interest rates across the main bond markets, from Bunds to Italian bonds and US Treasuries. The Report would include overnight *changes* in rates and curves together with a textual brief explaining the sources of those changes. On top of this, the Report would also present any ad-hoc important and relevant developments, such as Donald Trump's trade wars with China, or the massive antitrust lawsuits against Google and Apple, together with the reactions these developments engendered on the yield curve.

In the lead-up to the Governing Council meetings, which are held every two weeks, ad-hoc presentations are circulated with the national central banks. Often, these would be the result of economic analysis at the ECB staff level and would involve details and projections on macroeconomic growth, employment, inflation, and other relevant material. This would be accompanied by data and analysis of market pricing, primarily of government bond yields across the euro area, together with an interpretation of what these prices *mean* in terms of market expectations, often supported by regular surveys of market analysts. Potential courses of monetary policy prior to Governing

[2] The Eurosystem is the monetary authority of the eurozone. It is composed of the European Central Bank and the national central banks the jurisdictions of which have adopted the euro and are thus part of the euro area.

[3] The European System of Central Banks is composed of the European Central Bank and the national central banks the jurisdictions of which are European Union member states.

Council meetings, such as on asset purchases or forward guidance, would also be analysed and tested on their feasibility first and foremost in terms of what the market is pricing on the yield curve. 'First and foremost' quite literally, because practically all reports and analysis would spend the *first* few pages on market pricing and expectations as priced into the yield curve. In certain instances, national central banks would also circulate and put on the agenda research pieces analysing yield curves via yield curve models and the effects of monetary policy on them.

The yield curve thus sits at the heart of central banks' policy-making, as well as bond market[4] practices, and is therefore worthy of sociological scrutiny. But before I delineate what the thesis sets out to do, let us spend a few words on what the yield curve is on a technical level, its history, and the intellectual motivations behind this study.

1.1 A technical and historical primer on the yield curve

Technically, the yield curve for government bonds is a *graph* – i.e. an illustration of yield levels (and therefore a *yield* curve), or effective interest rate levels, of bonds, or debt contracts, with similar credit quality but different maturity dates. The *y*-axis represents the yields typically from zero upwards (expressed as percentages), while the *x*-axis represents the maturity dates (expressed in months and years), and typically going from one month (i.e. a bond with a maturity of one month) up to 30 years (i.e. a bond with a maturity of 30 years). On the left-hand side of the graph are what are usually called short-term rates, and moving towards the right-hand side are long(er)-term rates. The graph is therefore a comparative representation of yields on similar-quality bonds with different maturities. See Figure 1 for one such example.

[4] Any reference to the bond market or bonds in this research will be referring to government bond markets and government bonds respectively unless otherwise specified.

Figure 1: Yield Curve for UK Government Bonds (Gilts), November 19, 2021

Source: Financial Times, 2021

The *yield* is not, however, merely a technical object. The notion of 'yield' itself and its construction as a metric is primarily the outcome of a historical process firmly entangled with questions of power, politics, transparency and accountability, and nation-states. Deringer's (2018) broad but authoritative account of the rise of calculation and valuation in Britain is illuminative in this regard. Taking us back to the 1720 South Sea Bubble, Deringer lays out how calculation was employed as a means of holding political powers accountable. As South Sea Company's stock prices became increasingly inflated, Archebald Hutcheson constructed a new form of evaluation at the heart of which was a metric: 'intrinsick value' of a stock, involving discounting expected future profits, which bears strong similarities to techniques of modern finance, including the yield and its discounted present value.

Archebald's metric necessarily entailed the building of multiple scenarios because it largely depended on information that was kept (intentionally, in Archebald's view) secret by the Company. Upon deeming the scenarios as too good to be true, Achebald through this metric (discounted value of future expected profits) could claim that the cause of the bubble lay not with investors but with the Company. Although he could only make tentative claims about the dangers of the Company's practice of secrecy in the South Sea scheme, once the bubble burst and its stock fell below £200 – and after being appointed as a member on the 'Committee of Secrecy' tasked with investigating the Company's scheme – his calculative device allowed him to reveal the extent of corruption and fraud of political powers (p. 211). Calculative devices such as the yield model, "gained authority because of their value as instruments of dispute" not just as tools of rhetoric and persuasion, but also for a range of “argumentative tasks: to interrogate, measure, judge, flatter, needle, undermine, and insult.” (p. 9).

Beyond its political origins, the yield is also not entirely universal. As MacKenzie and Hardie (2009) show, the *standard* calculation of yield implies the “average annual rate of return offered by a bond over its entire remaining lifespan at its current market price, which is calculated by finding, by iteration, the discount rate at which the sum of the present values of the bond's coupons and principal equals its market price” (p. 47). However, the standard calculation of the yield is not applied universally and may be shaped by local knowledge. In their ethnographic case, Hardie and MacKenzie detail the work required to construct a specific agencement made up of, amongst other elements, the *Turkish* yield calculator involving not ‘compound yield’ but calculation of ‘simple yield’ – annual coupon payments as a percentage of price - which is the convention in Turkish markets.

The yield and the yield curve also have a long history as an important theoretical and empirical concern in economics, ever since the work of Irving Fisher in the early 20th century. According to Zaloom (2009) it was not until around the mid-20th century that they penetrated and proliferated in the world of modern finance, as yield curve analysis began to gain prominence with its policy and investment implications starting to be noticed. As the US racked up large volumes of debt to finance its war ventures, the Fed decided to peg short-term interest rates (T-bills) at 3/8 percent and long-term interest rates (>25-year bonds) at 2.5%. In effect, this amounted to an early form of yield curve control in which the Fed would purchase whatever amount of Treasuries needed to maintain interest rates at their target (Kliesen and Bokun, 2021, Rose, 2021). After the war, in 1946, Fed officials started to relax the strict control of the yield curve, “with the ultimate goal of a free market for all Treasury debt” (Garbade, 2020, p. 1).

According to Zaloom (2009), the yield curve became particularly central to investment management in the US during the 1970s as interest rate control was relinquished by the US government. As prices began to be set by the market, the market developed novel trading strategies, the pioneers of which were Martin L. Leibowitz and his team at Salomon Brothers (Leibowitz and Salomon Brothers will be the focus of Chapter 4). Leibowitz realised that he could develop a strategy by which bonds are not dealt in as distinct packages (1-year, 5-year, 10-year bonds[5]) but along a maturity continuum. Around the same time that Leibowitz was trading along the curve, the opening of the US Treasury Bond future pits by the Chicago Board of Trade presented traders with the opportunity to exploit spreads between bonds of different maturities, a strategy that largely depended on the yield curve. As a result, the yield curve started to be read as an object that represented the market (Zaloom, 2009). By the end of the twentieth century, actors in and around the bond market were reading the yield curve to assess the market's judgement about the future, to price and value bonds, as well as to manage the economy. As financial markets went global, the yield curve took central stage in bond markets and practices.

1.2 Motivation of study

Beyond the personal anecdote recounted earlier, this study is driven by a number of additional intellectual motivations. Firstly, studying the government bond market's yield curve is a pressing matter given the market's crucial importance to the economy and broader society. Bonds have historically been a crucial source of funding for governments and corporations alike, funding wars across the world and major infrastructural projects. With wider processes of financialisation, the bond market has been acquiring an increasingly important role due to banking disintermediation, where investors choose capital markets as a source of financing rather than the banking system, as well as due to increasing securitisation (Rethel and Hardie, 2017).

Government bond markets also have political implications. Processes of financialisation may reduce government's policy autonomy to international investors in the bond market, making it less able to disregard in its policy actions the policy preferences of international financial actors (Hardie, 2007, 2012), while government's fiscal decisions are also sensitive to the bond market and its ownership composition (see Rommerskirchen, 2019). Furthermore, bond markets may influence approval rates of US presidents (Hardie et al., 2020), lending support to Bill Clinton's political advisor James Carville's famous quote "I used to think that if there was reincarnation,

[5] I am using the generic term 'bond' to cover the whole spectrum of debt contracts instead of the more specific terminology in the market such as '1-year bill' and '10-year notes'.

I wanted to come back as the president or the pope or as a .400 baseball hitter. But now I would like to come back as the bond market. You can intimidate everybody" (Woodward, 2007). This makes the bond market even more powerful in the more developed world.

Bond markets have moved into the spotlight particularly during the Covid-19 pandemic, as governments and supranational bodies like the European Commission have raised finance via bond markets to support recovery programmes, stimulus packages, and lending programmes that were introduced to mitigate the effects of the pandemic-related lockdowns, job losses and business closures. Although the social studies of finance (SSF) literature has made some significant contributions to the study of financial markets, the bond market requires further scrutiny, especially in the sociology of it.

The bond market is increasingly relevant for *central banks* as they have placed it at the centre of their transmission mechanism by which they attempt to influence the rhythms of wider economic processes. But central banks themselves have grown in stature over the past few decades, and especially after the crisis[6], with some even venturing to claim that we are now living in a 'central bank-led capitalism' (Bowman et al., 2013). Their powers have grown and they have now increasingly expanded mandates and novel policy tools (Dyson and Marcussen, 2009, El-Erian, 2017, Goodhart et al., 2014, Tucker, 2018). Consequently, central bankers have become a favourite target of populists, being charged with furthering the neoliberal agenda, as the illegitimate leaders of our society, or as the enemy of the people. Central banking is therefore an increasingly topical and relevant problem in contemporary society that deserves further study.

1.3 Research focus and thesis

This thesis investigates the central mediating role of a device, the yield curve, in the enactment of sociomaterial agencements in and around the secondary market for sovereign bonds, and in the interaction between central banks and bond markets. By sociomaterial agencement, I am drawing on a concept developed by actor-network

[6] Any reference to crisis throughout the thesis will be referring to the Great Financial Crisis of 2007/08, unless otherwise stated.

theory (ANT) scholarship which refers to the human and nonhuman associations and relations that make up the social, as well as the practices that hold them together.

This thesis argues, firstly, that as the yield curve came to sit within various agencements in markets, it shaped those agencements in meaningful ways. It consolidated the gilt-edged market from its strict segmentation through the development of an evaluation practice known as ‘switching’. The latter also allowed market participants to identify mispricing in the gilt-edged market and to exploit it in classic performative fashion. Furthermore, the yield curve gave rise to derivatives in financial markets as it provided the raw material for their pricing and evaluation practices. In turn, as the yield curve became embedded in *different* agencements, it took on multiple and local ontologies and was thus itself shaped into multiple objects. It became an infrastructural object for derivatives quants, a mathematical universe for arb trading desks, a risk object with which to hedge, and a policy tool for central bankers.

The gradual and incremental process by which the yield curve came to occupy a core position in various agencement, in both markets and central banks, laid the ground for the future coordination between the latter two. However, a set of institutional and infrastructural conditions – including free, deep and liquid markets, and central bank independence, amongst others – were not yet in place which precluded the post-1990s coordination to take place. Once these conditions were established - a result of the increased mutual susceptibility between central banks and the gilt-edged market who found in each other a source of power over several decades - the post-1990s form of coordination, at the heart of which stood the yield curve, could take place.

My second part of the thesis’ argument claims that, despite the multiplicity of the yield curve, it holds a level of universality which allows social order to be (re)produced as multiple modes of ordering flow into each other via the yield curve. As a coordinating device, the yield curve is operative in the wider coordination between central banks and markets - part of what I call an ‘interactional alignment’ that represents the culmination of the mutual susceptibility between the two. The yield curve acts as a collective representation of ‘fictional expectations’ (Beckert, 2016) across the market. As market participants build ‘*a view*’, or a judgement, over future interest rates and inflation, they form ‘fictional expectations’ which they then express along or against the yield curve, as the latter shifts about along the ebbs and flows of market trading activities. As such, the yield curve becomes the collective view of *the market,* thus endowing the market with a sociomaterial existence that has no life outside of the yield curve.

In turn, for central banks the yield curve is a policy tool through which they can read market expectations and which they attempt to influence, as the primary channel of monetary policy to reach the real economy. Central banks thus anchor market's fictional expectations to the central bank's reaction function – what I call an *interpretive filter* – in which any market participants' view of future interest rates and inflation is necessarily also a view of the central bank's reaction to those macroeconomic outcomes.

This universality of the yield curve is in large part achieved by virtue of Bloomberg, as the authoritative external vendor system in fixed-income markets, which produces, disseminates, and popularises a *singular* yield curve through the sociomateriality of the Bloomberg Terminal which straddles the various agencements. This yield curve becomes the conventional yield curve – a *standardised* representation of yields – around which market actors and central bankers revolve. I argue that the universality of this standardised yield curve, itself an immutable mobile which travels across agencements but remains unchanged, allows it to act as a coordinating device within and between markets and central banks. For instance, market participants may come to judge the current policy rate as insufficient to bring inflation to target, thus pricing in compensation for inflation and pushing the yield curve upwards. In turn, central banks observe the yield curve to read the market's fictional expectations of future interest rates and inflation. They may respond by signalling their preferred policy path (which diverges from the market-implied policy path) or they may succumb to the market's demands by fulfilling those expectations. The market will then react once again to the central bank's communication and decision, thus establishing a feedback loop between the two through the yield curve. It is this process which I am calling coordination via the yield curve.

This explicit coordination is, however, supported by a less evident practice carried out by arbitrageurs. The latter's work ensures internal consistency in the yield curve. Arbitrage on the yield curve works against the influence of segmentation and idiosyncratic local pressures on the yield curve, while arbitrage *across* markets ensures consistency in expectations across different markets. Multiple related yield curves (e.g. money market curves, swap curves, bond curves) come to reflect a set of *consistent* expectations. This is then incorporated into the models and epistemic practices of central banks who read the yield curve purely in terms of expectations and through which monetary policy is seen to be more effective.

I close my core argument by claiming that the financial crisis of 2007/08 shook the very foundations on which this coordination relied. Sociomaterial agencements needed to be reconfigured in new arrangements, while the yield curve took on new forms of coordination following a period in which it was sidelined and briefly replaced by the money supply measure in the UK. However, the infrastructural and institutional foundations on which central banks and markets developed mutual susceptibility allowed the yield curve to take once again a coordinating role that went beyond the pre-crisis arrangements. Indeed, central banks attempted to control the temporality of the yield curve by engaging in forward guidance, as the yield curve became a tool of direct intervention for central banks who embarked on programmes of asset purchases that were meant to influence it *beyond* expectations, This, however, was once again only made possible by the (infra)structural entanglements developed by central banks and markets over their long histories of co-production.

1.4 Structure of thesis

Following this introduction in which I lay out the thesis and the contributions to knowledge, the thesis will take a tour of the social studies literature with a particular focus on the sociology of markets and central banking, and the political economy of sovereign debt (chapter 2). The analysis follows, split into two main parts: Part 1 presents a historical analysis of the yield curve's role within various agencements by putting focus on the UK's gilt-edged market (chapter 3), the US Treasury market (chapter 4), and the co-production between the Bank of England and the gilt-edged market (chapter 5). Part 2 builds onto the first by looking into how the historical re-assembling of multiple agencements led to a period of social order (chapter 6), which was nevertheless fundamentally fragile as it was disrupted by crises (chapter 7). Finally, in chapter 8 I will conclude by a recapitulation of the thesis, by a revisiting of the contributions to knowledge, and by laying out some potential threads for future research. What follows is a detailed outline of how the thesis's overarching argument will be built throughout the analysis.

Part 1 traces the historical re-assembling of arrangements constituting government bond markets and later central banks as the yield curve came to sit within them. The process of embeddedness of the yield curve as machinery in markets reconfigured those very same markets which it was seen to represent. In turn, as the yield curve became a core component of *multiple* arrangements, it was moulded into *local* and *multiple* ontologies (Star, 2010; Mol, 2002; Mol and Law 2002). In doing so, this thesis foregrounds the notion of *co-production* (Callon and Latour, 1992) between yield curve and markets.

Chapter 3 lays out the historical processes by which the yield curve became embedded in the UK gilt-edged market between the 1950s and 1970s. It explicates how the yield curve's embedding into sociomaterial agencements was due to a wider process of 'quantification'. New epistemic communities developed and coalesced within stockbroking firms in the City of London, in the most part led by actuaries, but including accountants and economists, who set up quantitative research departments. These communities faced resistance from older, established agencements, made up of communities whose work was based on subjective judgements and the leveraging of dense social networks in the City. Nevertheless, the new research-based communities succeeded in establishing a new set of quantitative practices in the gilt market that dislodged the older agencements. The result was a reconfiguration of the sociomaterial agencements in which the yield curve as material and cognitive equipment became a core part. The early practices to which these arrangements gave rise – known as 'switching' - were performative and shaped the market by consolidating it.

A similar process of quantification is analysed in chapter 4 in the context of the US Treasury market. The yield curve assisted market participants to develop new evaluation practices through which the could valuate bonds and express it by taking risk. In doing so, the yield curve also supported the rise of derivatives (at first linear[7])

[7] Derivatives are products the given value of which is a function of the underlying asset/s. Linear derivatives are products the future payoffs of which hold a linear relationship (often one-to-one) with the underlying rate.

and the rise of the risk-neutral world of ‘no-arbitrage’. Performative effects are, however, never one-way. In other words, as the yield curve performed markets, it itself was shaped (or performed) in practice. The chapter therefore follows Star (2010), Mol (2002), and Mol and Law (2002), and looks into the ways in which the yield curve was moulded into *multiple* objects. As the yield curve came to sit within multiple sociomaterial agencements, it itself was turned into multiple devices: an infrastructural object and raw material with which to price derivatives, a mathematical universe(s) from which to extract value, and a risk object at the portfolio level against which to hedge.

Chapter 5 then turns to the assembling of inflation-targeting central banking as a sociomaterial agencement and the process by which the yield curve came to sit within this agencement. Following Walter and Wansleben (2019), I identify two broad processes that largely shaped the agencement: firstly, the (infra)structural entanglements between central banks and bond markets, and secondly, the development of novel tools, devices and technique, in part informed by economics and particularly the increasingly influential strand of New Keynesianism on the inflation-targeting framework and institutional arrangements. I suggest that these two kinds of explanations are not necessarily rival ones, but rather lay focus on two important elements constitutive of the policy agencement and its practices. While chapter 3 explores the novel arrangements - practices, techniques and devices such as switching - developed by the gilt-edged market, chapter 5 shows how these were only possible by the Bank of England acting as counterparty and providing the necessary liquidity to a fragile, segmented, and thinly capitalised market. The latter, together with other institutional factors, precluded the market arrangements from being enrolled into a stable alignment between markets and central banks on the basis of which coordination could be established via the yield curve as coordinating device, as was the case post-1990s.

In *Part 2*, the thesis studies the contemporary organising of social order in the interaction between financial markets and central banks, and the perpetual reassembling of arrangements as a response to crises. Following Law (2009a) and Mol (1999), I argue that although the multiple realities expanded on in the first section led to different modes of ordering within the sociomaterial agencements, such modes of ordering can flow into one another to the extent that they produce social order on a wider level. The yield curve plays a crucial role in the ways such modes of ordering interact: in holding a level of universality that transcends the locality of specific sociomaterial agencements, the yield curve acts as an immutable mobile around which social coordination revolves, and through which social order is produced and reproduced between markets and central banks.

In Chapter 6, I elaborate on the *interactional alignments* between central banks and markets. In doing so, I give primary attention to *fictional expectations* (Beckert, 2016) by exploring their formation, how they assist market participants in making decisions and avoiding paralysis, and how central bankers repurpose them as tools of governance. But I also foreground the role which the yield curve plays in rendering such fictional expectations *graspable* and *calculable* for both market actors and central banks. On another level, the yield curve transforms a multitude of local fictional expectations into a collective set of fictional expectations commanded by '*the market*'. As a result, the market itself is transformed into a *singular* entity capable of action, and therefore an actor. This process is supported by arbitrageurs whose work renders assets, bonds and derivatives substitutable and equivalent. By connecting multiple yield curves and their codified expectations (i.e. discount rates), the market is reproduced as a singular entity and the expectations hypothesis of the yield curve is actualised (more precisely, approximated), thus rendering monetary policy more powerful. Furthermore, the yield curve is rendered universal by way of Bloomberg's authoritative agencement in the market, as the latter produces, disseminates, and popularises a single, conventional, standardised yield curve. This universality of the yield curve contributes to social order by establishing structures, shared temporalities, and communication. Such a process reproduces 'the social', not as a *single* actor-network (Law, 2009b) but as a set of agencements that are entangled in multiple and complex ways but which nevertheless exhibit order. This *interactional* alignment, I argue, is necessarily predicated on the infrastructural and institutional entanglements which central banks and markets have developed over the years, particularly those studied in the earlier chapters.

Finally, chapter 7 looks into the ways in which crises threaten to disrupt that social order, the attempts to restore it, and the reassembling of 'the social' as a necessary condition for social order. As crises fed into the ‘real economy’, central banks needed to provide accommodation via policy and thus reworked their policy arrangements. In doing so, the yield curve became even more prominent as a target of central bank intervention, firstly through forward guidance, and secondly, as an evaluation device with which central banks could implement monetary policy, specifically quantitative easing. While this provided market participants with opportunities to ‘game the system’, communication and cooperation between central banks and market participants established a set of expected and accepted practices that made quantitative easing socially possible. But this also required leveraging on the historical institutional entanglements between central banks and markets, especially during the dash-for-cash in March 2020. In conclusion, I show how the failures of arbitrage have made the model of ‘complete and efficient markets’ and the yield curve’s ‘expectations hypothesis’ no longer a reasonable approximation of reality. But rather than central banks abandoning the model, the very practice of quantitative easing has been an attempt to perform that model as a reasonable approximation of reality – as a state of the world - so that central banks can restore the yield curve’s expectations hypothesis and return to the pre-crisis social order.

1.5 Contributions

The first contribution which this thesis aims to make is primarily of an empirical nature as it aims to provide a deeper and more comprehensive analysis of the yield curve than the treatment it has received so far in the literature. Most of the scholarship on the yield curve is limited to economics’ and econometrics’ estimations or modelling that lack a sociological dimension. Additionally, the little social science literature that has looked into the yield curve (Christophers, 2017, Zaloom, 2009) has done so in a largely unsystematic manner. The latter exceptions, while important, only provide a preliminary exploration, using methods limited to public sources, of the yield curve’s role in and around financial markets. This points to the need for a systematic and in-depth study that provides a rich and detailed picture of the processes surrounding the yield curve.

On the conceptual and theoretical front, I aim to make four contributions. Given that this work’s starting point is the social studies of finance (SSF), the first contribution speaks directly to the SSF body of knowledge. I aim to add to recent work on evaluation practices (MacKenzie and Spears, 2014a, b, Spears, 2014, Van der Heide, 2019) by looking into the yield curve as a device that allowed and engendered specific evaluation practices, both historical (i.e. between the 1950s and 1980s in the UK and US) and contemporary, as well as in markets and central banks.

Additionally, my work also extends the notions of *market* devices and sociomaterial agencements to that of *policy* devices and agencements, following Hirschman and Berman (2014). Hirschman and Berman (2014) switch attention from the ways in which markets are constituted by 'market devices' as documented amongst other works by Callon et al. (2007), to the ways in which policy and policymaking is constituted by 'policy devices'. Similarly, I document a device that contributed to the construction of 'the social' in the market arena, which was nevertheless adopted and repurposed for matters of governance and policy by central banks. I contribute by taking this further and exploring how, as a hybrid of markets and policy devices, the yield curve acts simultaneously in markets and policymaking and in the *interaction* between them. As a coordinating device, the yield curve is therefore a core tool in the stable interaction between central banks and markets as these become increasingly susceptible to each other.

Secondly, I aim to bridge between SSF and the approach taken by Beckert (2016) on fictional expectations. These approaches have often been treated as incongruent due to their different ontological assumptions. While SSF tends to emphasise the role of science, technology, devices, calculation, and performative processes, Beckert's work stresses narratives, fictions, and imagination as actors deal with fundamental uncertainty. By adopting an actor-network theory sensibility, my work claims that the two can prove to be a productive combination in analysing behaviour and the construction of the social in markets and central banking. An agencement – i.e. a set of associations with the capacity for action – trading bonds would evaluate and calculate a bond's value by comparing it to a standardised metric of economics, but would also form fictional expectations by imagining the likely course of the economy and by listening to central bank narratives and stories. As we will see, the yield curve itself is operative in both former and latter practices, and it is for this reason that I seek to connect the two approaches.

A third contribution I seek to make is to the sociology of central banking. I follow the literature that has adopted a SSF perspective to central banking (Best, 2014, 2019, Braun, 2018a, 2015, 2016, 2014, Coombs, 2020, Ibrocevic and Thiemann, 2018, Nagel and Thiemann, 2019, Thiemann, 2018, Thiemann et al., 2020) and put my focus on an aspect of central banks that has been less studied, i.e. a policy device and the ways in which it shapes governance. I extend this work by looking at how the device can be operative in various agencements, not just central banks but also within markets, and how the interaction between these agencements leads to social order on a wider scale. In doing so, I attempt to rectify an implicit bias in this body of work whereby in studying the governance by central banks of markets, the latter are treated as passive actors and recipients of governability. From this viewpoint, the process of governability is a unilateral one from central banks to markets. In contrast, I therefore lay out the complex set of *relations* and *interactions* (what I call an interactional alignment) that constitute that same governability.

Nevertheless, I remain cognizant of the fact that science and technology is not all there is to central banking (and markets). I therefore aim to make a contribution by taking a cue from Wansleben's (2018) important critique of the literature in the sociology of central banks in which he argues that scholarship has often fallen victim to the same 'technocratic euphoria' which central banks themselves have promoted. Although my work's focus centers on a particular (perhaps obscure) device and the practices revolving around it, I situate it within larger processes of financialisation and state-market entanglements (Walter and Wansleben, 2019).

This is also highly relevant for the literature in the political economy of bond markets and economic policy, which is concerned with the influence of bond markets on states. I seek to contribute to the latter by providing more empirical depth than this literature is used to in its analysis. As such, I lay out the complex and long-winded process by which a central bank, the Bank of England, was reconstituted as an agencement and how this unfolded through entanglements with the gilt market and institutional developments in policy, markets and finance. I also show how the state (central banks) and markets become increasingly susceptible to each other and develop arrangements – devices, practices, and routines – that allow coordination via the yield curve as coordinating device. This, however, is necessarily contingent on the right (infra)structural entanglements and institutional conditions explored in this historical section of the thesis.

Indeed, central banks' attempts to restore order is not necessarily driven by a neoliberal agenda or capture, but rather because markets have now become the core channel through which they govern. Similar to some of the work in political economy (Dutta, 2018) and sociology (Walter and Wansleben, 2019) on central banking and sovereign debt, I explain this in terms of the processes of financialisation that have led central banks to embrace the infrastructure and plumbing of finance. But it also led central banks to adopt and incorporate the *models* of efficient markets and the expectations hypothesis in their governing techniques and practices. As such, post-crisis central banking required a 'temporary' reworking of its procedures and models to support financial markets (i.e. to restore order in finance and to re-approximate the model of efficient markets and expectation hypothesis[8]) in order to regain governability in the manner of pre-crisis monetary policy via the management of fictional expectations.

1.6 Methodology

This thesis presents a part-historical and part-contemporary account of the central mediating role of the yield curve in and around financial markets. I approached the design of the research as a *process*, rather than a one-off design that would serve as a fixed and strict protocol. The design thus involved continuous tweaking over a three to four year period. Indeed, the limitations encountered during the conducting of the research, in primis the Covid-19 pandemic right in the middle of it, were enough in themselves to enforce an element of flexibility to the research. Nevertheless, the in-built flexibility allowed me to steer the project as required and as deemed appropriate.

During the process, I made a conscious decision to restrict the analytical boundaries and focus of my project to a particular financial market, the secondary bond market, and the actors involved in it, including central banks. As a result, by construction, certain actors such as governments and their bond issuance practices were excluded. This is not to say that they are irrelevant to the story at hand, but rather that limiting the work to one specific market allowed me to generate a richer, more detailed account

[8] The theories of efficient markets and the expectations hypothesis will be explained in later chapters.

of the practices and arrangements making it up. Furthermore, while I did not exclude a priori other central banks such as the ECB and the Federal Reserve and the markets within which they operate, higher attention will be given to the Bank of England and the gilt market for practical reasons.

1.6.1 Interviews

The analysis relies primarily on data generated through in-depth interviews in investment banks, hedge funds and asset managers, as well as the Bank of England and the European Central Bank. In total, I conducted 51 interviews, two of which involving two interviewees jointly, and one of which being a repeat interview, for a total of 52 individuals interviewed. The longest interview lasted 180 minutes while the shortest 28 minutes, with the average length being 69 minutes. Because I wished to gain rich and detailed data, I used a loosely structured ‘interview key’ which, while giving some structure to the interview, provides space for a more free-flowing discussion with the interviewee. The more interviews I conducted, the less I made use of the interview key in order to see what kind of data I would be able to gather. This was useful to counter any potential intellectual bias or assumptions built into the interview key. Each interview key was adapted according to the interviewee, depending on the context in which they work. For instance, the key prepared for an interview with an investment bank trader differed from that with a central bank economist.

In terms of sampling, the first categorisation involved three ‘professions’: economists (research/strategy/policy), traders, and portfolio fund managers, while the second involved the context/organisation in which they were employed: fixed-income buy-side bond funds, hedge funds, macro funds, front-office investment banks, and central banks. Of the 51 interviews, about a third are current or former central bank economists, another third being traders or portfolio managers in buy-side funds, and a final third being traders or quants in sell-side investment banks. In the vast majority of cases, the career trajectory of interviewees involved a great degree of overlap across these loose categorisations. Because each interview was started with a simple ice-breaking question ‘How did you get in this business?’, practically all my interviewees laid out their career history from which it was clear to me that most interviewees had occupied various positions across their career trajectory. Some of the traders on the buy-side I spoke with had had some kind of experience at the Bank of England, while others had moved from investment banks to an investment management fund or hedge fund. Similarly, some of the economists at the Bank of England had worked in a hedge fund or as rates strategists[9] in investment banks. It was only the younger interviewees who had less of a varied career trajectory, some of whom being fresh out of university between two to four years ago.

While this was one of the strengths of the interviews, in that the interviewees could compare and make references to their previous experiences elsewhere, it also points to a potential weakness in the sampling process. Interview-based research in financial markets is notorious for a sampling bias with respect to the seniority of the interviewees in their organisations (Spears, 2014). Like Spears, I found that younger employees were often more reluctant to accept interview requests, and either directed me to more senior-level employees or failed to reply to my request. This was particularly so when contacted via their institutional email. In fact, I was successful in gaining access to some of the less senior employees via LinkedIn. I aimed for a mix of less senior employees and senior employees because the former were often those who worked directly with the yield curve, rather than in a managerial position, and therefore could provide me with the rich and detail data I was looking for. Nevertheless, I also aimed for some of the senior employees who, despite in many cases being in a managerial position, had more of a diversified career, as explained earlier.

To identify the interviewees, I employed a multi-pronged strategy. I started by going through online newspapers, such as Financial Times and Bloomberg, and looking for potentially relevant articles whose authors are currently working in a market organisation or which mention relevant participants, and who would potentially be helpful as interviewees. I also looked at other specialised newspapers or magazines, such as Risk and The Trade. The second strategy was snowballing. Once I gain access to an interviewee, I would ask them to recommend a few other individuals who would be able to help me with my research. This was a productive strategy that

[9] Rates strategists are strategists whose focus are fixed-income markets, but specialising on ‘rates’ rather than ‘credit’. Credit refers to markets that are no longer considered as risk-free but contain a risk of default. Often, desks in investment banks are organised along these distinctions. For instance, a ‘Rates desk’ will often trade risk-free bonds such as Bunds or Treasurys, which will be distinct from a desk that trades credit, such as Greek bonds.

provided me with a significant number of interviews. The downside to this strategy is a classic one identified by network sociologists (Burt, 2002, Granovetter, 1999, McPherson et al., 2001). Interviewees were more likely to refer me to someone within their own tightly-knit network, someone who they trusted and held regular interactions with. Because my research design was one which required more diversity, the homophily experienced within networks led me to interviews with similar individuals. While this was useful to give more depth to the data and analysis within *local* agencements, it also directed me to a less diverse set of networks. In other words, I needed to find bridges across networks and to move beyond singular ones.

The solution was not found in a human bridge or broker as in Burt (1992), but in a material technology - LinkedIn – which proved crucial towards this purpose. Although I could not find any sociological research suggesting that market participants are increasingly using LinkedIn, this is precisely the impression I had when looking for interviewees. Indeed, most of the interviewees I identified from the above sources are on LinkedIn (although this could very well be a sampling bias in that these were also some of the most visible people in the market, and thus possibly made more use of LinkedIn). Nevertheless, the fact that they are on LinkedIn allowed me to pore through their connections (which exist on the public domain) and identify potentially helpful interviewees. Indeed, a substantial number of my interviews were found through LinkedIn. The process led to higher diversity in terms of profession, organisations and seniority.

A limitation that comes with ‘studying up’ (Nader, 1972), i.e. studying people more powerful than yourself as the researcher, is access. After identifying the potential interviewee, another hurdle was the interviewee accepting to be interviewed. In many cases, potential interviewees are wary of being interviewed. The reasons for this vary: some may worry about an outsider, and a non-economist, interviewing them, while others do not see any benefit and only potential risk in being interviewed. Approaching the potential interviewee necessitated a degree of caution and care, promising them full anonymity and confidentiality, explaining to them in detail what the research is for and how it will be used, and that I would not be looking for any of the ‘secret sauce’ of their organisation. My experience suggests that central bankers may be even more wary of outside scrutiny than others. In many ways this limitation was mitigated by the fact that I worked at a central bank, and thus was perceived as an insider.

Some interviewees asked for the interview questions to be sent prior to the interview, and some of the more cautious ones made it a point to ask me specifically at the start of the interview to stick to the script, which I abided by. While my preference was to tape-record the interviews, a minority of interviewees preferred not being tape-recorded, in which cases I instead took handwritten notes.

One limitation that I struggled to overcome related to gender, which is a common limitation in this field (Spears, 2014). Throughout the process of identifying interviewees, I made a conscious effort to find female interviewees, especially knowing that financial markets tend to have a higher participation of men than women. However, the response rate of women was much lower than that of their male counterparts, and inevitably my interview sample is heavily skewed towards males, with only 2 women accepting to be interviewed[10].

1.6.2 Ethnography, documents, and the impact of the Covid-19 pandemic on methodology

The Covid-19 pandemic struck right in the middle of my data collection process. Inevitably, this necessitated making some important changes to my project. In many ways, the fact that the pandemic pushed people to switch to online and videoconference meetings meant that it gave my interviewees more flexibility and they were generally more available and willing to slot me an interview. I switched to remote video interviews immediately and the process of interviews went surprisingly smoothly.

Nevertheless, the pandemic posed some major limitations that could not be overcome. The first relates to the ethnographic element of my project. My intention was to try to incorporate some ethnographic material in my thesis. Indeed, prior to the pandemic I had come to an agreement with a portfolio manager in a buy-side fund for me to spend a day or two in their office observing their work. Admittedly, this is a short amount of time for a proper ethnography, but in the context of financial markets which are notorious for secrecy and known to not allow outsiders within their own physical space (see MacKenzie and Hardie, 2009), this would have been an important part of my research. The break-out of the pandemic meant that this was impossible to undertake,

[10] Because the vast majority of my interviewees are male, I will be using the gendered pronoun ‘he’ rather than ‘she’ or ‘they’.

not least because employees themselves were now working at home rather than their office.

In one instance prior to the pandemic, I did succeed in getting a flavour of ethnography. A sell-side strategist accompanied me to an investment bank trading floor and showed me how, following MIFID II regulations, sell-side strategists are now required to be physically placed in a secluded area on the trading floor – surrounded by glass walls and to which only sell-side strategists have access. Mifid requires investment bank's sell-side strategists division to be purely client-facing and to be self-sufficient in generating its own business. A side-effect, argued this strategist, was that sell-side strategist divisions are shrinking and might soon, in his view, cease to exist in investment banks. Clearly, then, the security and physical separation imposed by the regulator and self-imposed by the firm means that not even employees of the same organisation can have full access to all parts of the building. However, I did manage to get a glimpse of the ways in which the investment bank floor is organised.

A more crucial limitation relates to the historical section of the thesis. My intention was to rely on archival work in order to build a historical account of development in bond markets and central banks. The onset of the pandemic, however, meant that for a large part of my PhD the archives were closed and I had no access to those primary documents. As a substitute, I relied on primary sources that were digitalised and made public by the Bank of England, and other primary sources such as documents from stockbroking firms. Because stockbroking firms were to a large extent staffed by actuaries, as will be explained in chapter 4, I could make use of documents handed to me by a member of the Faculty of Actuaries in Edinburgh. Admittedly, this was only a microscopic sample of what I would have had access to in the absence of the pandemic. But, particularly when supported by secondary sources on the history of the bond market, this archival work sufficed in developing a rich historical account of gilt market practices and the role of the yield curve within it.

Chapter 2

Literature review

This chapter situates this thesis within the literature in economic sociology and the sociology of markets and outlines the substantive and theoretical gaps which it seeks to contribute to. It firstly provides a brief overview of developments in economic sociology, with particular attention to the various influential strands of literature ranging from classical economic sociology to the ‘new economic sociology’ (section 2.1). In sections 2.2 to 2.5 the chapter then focuses on the main bodies of literature in which this thesis is couched and to which it contributes, these being the social studies of finance (SSF), ‘Beckertian’ sociology, the social studies of central banking, and the political economy of sovereign debt.

To reiterate, the thesis assesses the yield curve’s role as a coordinating device in the enactment of sociomaterial agencements in and around the secondary market for sovereign bonds, and in the interaction between central banks and bond markets. In order to do so, the social studies of finance (section 2.2) and ‘Beckertian’ sociology (section 2.3) represent important starting points. Both bodies of literature approach the study of markets by looking in-depth at the construction of social life on markets, and on the ways in which actors make decisions and reach judgements. Given the larger aim of the thesis reiterated above, this chapter will delineate how the thesis attempts to bridge between the two bodies, and insodoing mitigating some of the respective limitations, which approach will allow for a rich and comprehensive picture of the role of the yield curve as a mediating device in and between markets and central banks.

By drawing strongly from both approaches (an approach not without challenges, as explicated in the theoretical discussion in section 2.7), the thesis seeks to make a substantive contribution to the sociology of central banks (section 2.4) and the political economy of bond markets and economic policy (section 2.5) in a number of important ways, primarily by contributing to important gaps in these literatures. For while the sociology of central banks has been concerned with developing an in-depth understanding of the practices and processes internal to central banks - in how the latter craft policy, make decisions, develop practices and so on - it has largely left markets unscrutinised. As such, by giving full attention to central banks, it has treated markets as passive recipients of central bank governability. In contrast, the political economy literature has put the interaction between states, often governments, and markets at the centre of their attention. However, it fails to provide the necessary depth to impart a rich picture of how that interaction unfolds. This latter literature often offers by means of models evidence for how, for instance, bond markets influence government policy decisions. But we know little *how* precisely that influence is enacted as a *process*. In other words, while the sociology of central banks provides depth and little breadth (because it is limited to central banks), the political economy of bond markets and economic policy provides breadth but little depth. Hence, by way of the literature of the SSF and Beckertian sociology, I will contribute to these two important gaps in sociology and political economy.

In this context, I aim to do two things: firstly, I aim to offer a rich and detailed reconstruction of the long-winded and convoluted historical process by which the Bank of England and the gilt-edged market became susceptible to each other, and how the yield curve came to sit within the various arrangements and interactions. With few exceptions (Walter and Wansleben, 2019, Wansleben, 2020, 2018) this would be a novel approach to both bodies of literature. Secondly, I aim to show how the yield curve became increasingly relevant as a central mediating device in the coordination between central banks and markets. It took on a coordinating role that allowed central banks and bond markets to function in concert on the back of an arrangement made up of tools, devices, repeated practices and routines, as well as infrastructural and institutional conditions built over decades prior. In doing so, I would be filling the gap in (a) sociology by laying out the *relations and interactions* between central banks and markets, and (b) political economy by looking at *how* precisely central banks and markets coordinate around each others' demands,

Section 2.6 then looks into how interest rates and the yield curve have been treated in the social studies literature (including sociology, anthropology, and political economy). Finally, the last section (2.7) lays out the theoretical and conceptual toolbox of actor-network theory (ANT) that will guide the empirical sections of the thesis. By drawing on concepts such as 'sociomaterial agencements' and 'ontological multiplicity', I hope to show how ANT itself can be a productive approach to consolidate the up-till-now largely separate (and in many ways conceived of as conflicting) strands of literature.

2.1 Economic sociology and the sociology of markets

Economic action and the structures within which this action is enacted have long been an object of investigation for the sociologist (Dobbin, 2004). Classical sociology examined economic phenomena ranging from the division of labour (Durkheim, 2014 [1893]) to money (Simmel, 2011 [1900]). Weber (2013 [1905]), in the influential *Protestant Ethic and the Spirit of Capitalism*, explored the way in which the disposition towards thrift and capital accumulation was driven by meaningful action founded in religious belief – the Protestant ethic - that nevertheless manifested itself in 'worldly' and material pursuits. Despite the sociological interest the founders of sociology showed in economic phenomena, sociology experienced a dearth of intellectual inquiry into 'the economy' during the middle part of the 20th century. What were the drivers behind this?

The intellectual context of this was a dispute between strands of economics that centred around the *scope* and *method* of economics: on the one hand, neoclassical economists who argued for a 'narrow' conception of economics revolving around the study of marginal utility and optimising behaviour, on the other hand institutional economists who favoured a scope of economics which studied the institutional, psychological and social elements making up economic behaviour (Camic, 1987, Ingham, 1996). The dispute's outcome in which neoclassical economics proved successful was that economics became increasingly focused on utility and rational choice at the expense of 'peripheral' social factors.

Amidst this dispute in the interwar period, Talcott Parsons attempted to rework the scope of sociology and to simultaneously provide legitimacy to a fledgling discipline in the US. In doing so, he refused to support the institutionalists for fear that sociology would be reduced to a subdiscipline of a broader and holistic field (Camic, 1987). He thus proposed sociology as a way out of the dispute, at the same time in which he sought to carve out a niche for sociology. While holding a post within the Economics Department at Harvard, he signalled to his Harvard fellow (neoclassical) economists that he would respect the institutional and intellectual boundaries between economics and sociology by not infringing on the economists' turf. In effect, he had made a pact with economists: sociologists would study society and values, while economists would study value and the economy (Stark, 2006). The politics involved between the disciplines pushed sociology into, in the words of the sociologist Albion Small, "the science of leftovers" (Granovetter, 1990) where sociology would study the 'extraneous' elements peripheral to strict economic behaviour, such as family and crime.

As a result, institutionally, the sociology profession and discipline in the first half of the 20th century was thus largely excluded from the economists' turf. In order for sociologists to be employable in universities, they needed to maintain a careful boundary between their profession's scope and the economists'. What came to be known as 'Parsons' Pact' (Stark, 2006), or what Ingham (1996) calls a 'gentleman's agreement' between Robbins and Parsons in the 1930s, would survive standing for decades to come.

In spite of the fact that some sociologists remained interested in explaining economic phenomena sociologically, Parsons' pact only started to be seriously challenged during the 1970s (McFall and Ossandón, 2014). From the economics' side, Becker and Williamson amongst others expanded their work onto what was traditionally 'sociological turf'. These however treated social factors such as trust and organisational scripts as frictions or lubricants that stand outside of the 'rational core' of economic exchange (Ingham, 1996). In a way, therefore, while such economists broke with tradition and started studying 'social matter', they retained the intellectual distinction between utility-driven economic action and social factors as peripheral to it.

Sociologists themselves also broke with Parsons' pact and began studying economic matters, in what came to be known as the 'new economic sociology'. It was Granovetter's 1985 seminal paper 'Economic Action and Social Structure: The Problem of Embeddedness', that largely spurred this new approach. It proposed the concept of embeddedness as economic activity mediated by networks of relations. This foundational concept is presented as a counterbalance against abstracted markets and the neo-classical *homo economicus*, that individual whose hyper-rationality and perfect information enables him to maximise utility. But it also counters an oversocialised conception of behaviour in which individuals have little choice as they follow scripts, norms, and customs. From this perspective, the network of relations do not merely provide a context or a framework within which individuals acts

(Callon, 1998a). Rather, the networks themselves constitute action, identities and interests, and as the networks change, so do the actors' identities and interests.

The new economic sociology grew rapidly, particularly in the US, and influential empirical studies proliferated (Baker, 1984a, Baker, 1984b, Berezin, 2010, Granovetter, 2000, Moran, 2005, Powell, 1990, Uzzi, 1996). While economic sociology of this type has made important contributions to the sociology of economic life in characterising markets as socially embedded, it has been criticised for taking the concept of the market as a given and failing to fundamentally examine it as a theoretical and sociological object. In doing so, the new economic sociology was criticised for falling prey to the same Parsonian trap that it was attempting to move out of, namely the atomistic conception of the economy as having a separate ontology from the social (Krippner, 2001).

2.2 The 'new new economic sociology' and the Social Studies of Finance

A development in the sociological literature that seeks to tackle the sociality of markets and economies has been what McFall (2009) termed the 'new new economic sociology', a body of literature in the spirit of Callon's (1998b) *The Laws of the Markets*. Unlike the new economic sociology which was presented as a counterpoint to the neoclassical economics' conception of the *homo economicus* and rational expectations, the new new economic sociology instead treats the *homo economicus* as an anthropological program. In this view, *homo economicus* is not natural, and the qualities it implies - of an actor that has and can synthesise perfect information, that can calculate and maximise welfare - are not innate (Callon and Muniesa, 2005a). Rather, markets imply an anthropology of calculative agents as they are *enacted* in a network of humans and nonhumans (Callon, 1998a). The latter is a result of a process of framing, modifying, and equipping with devices that constitute the actor as a calculative agent and it is this *making* that the new new economic sociology seeks to lay out.

The process of making calculative agents, and therefore the process of constructing markets, involves building a frame around the actors and what will be incorporated into the calculation. The frame defines actors, their relationships and associations, and the objects to be exchanged, as it disentangles the involved actors from those that are

- or more accurately, *become* – irrelevant to the economic exchange. As the economics' concept of externality implies, an actor may disregard in his calculation a potential relation, other interests or effects of the transaction (Callon, 1998b). For instance, a property developer who is keen on developing a large commercial complex in a residential area may overlook in his calculation the interests of the existing residents in the area, the increased vehicle traffic and the pollution that the complex may generate. The frame has disentangled particular actors and relations and framed it around the property developer, the potential buyers/renters, the complex itself and the materials required to build it, the costs of the material and so on. The frame assembles a calculative agent – of individuals, collective actors, and objects that go into or out of the calculation - through a process of framing and disentangling.

Calculative agents are not merely 'naked' humans but are also made up of equipment, tools, prostheses. Inspired by science and technology studies, a recurrent theme in the new new economic sociology is the place of devices in 'marketisation' (Callon et al., 2007, Callon and Muniesa, 2005b, McFall, 2009). Defining market device as "material and discursive assemblages that intervene in the construction of markets" (p. 2), Muniesa et al. (2007) argue that attention to market devices is more than warranted because they *do things*. Market devices *assist* in rendering objects calculable; they may singularise, collectivise, standardise, render comparable prices or objects; they give order, render visible or transform objects; and they may bring together disparate actors and objects. The constitution of a calculative agency is thus an ensemble of individuals and devices such as material calculators (MacKenzie, 2008) and screens (Knorr Cetina and Bruegger, 2002a, b); the layout and organisation of the room itself (Beunza and Stark, 2004), physical and emotional aids such as gestures (Knorr Cetina and Bruegger, 2002a). Information is an especially important point of consideration since it aids decision-making in a 'distributed cognition' manner (Hutchins, 1995), both in its on-site and multi-sited sense, often flowing through networks (Hardie and MacKenzie, 2007a, b).

But such devices *do things* not necessarily inside of humans' brains or as part of institutional and social frames, but as components of a network of associations between humans and nonhumans (Callon, 1998a). Devices act as prostheses to the human body without which a calculative agency – and the homo economicus - fails to be constructed. In this conception, the new new economic sociology offers the performativity thesis to explain how markets are enacted, or performed, and how economics itself provides the tools for such market construction. While the notions of performance and performativity have had a long history, and were used in multiple ways (Austin, 1962, Butler, 1990, Goffman, 1956, Searle, 1969), in the context of the sociology of markets performativity marks the ways by which economies are shaped or enacted by economics, understood in a broad sense[11]. In Callon's (1998) words, as the main proponent of this theory, "economics [...] performs, shapes and formats the economy, rather than observing how it functions" (p.2).

The latter has been especially influential in the social studies of finance (SSF), a strand of the literature in the new new economic sociology which has sought to examine the enacting of financial markets - "the application to financial markets not of economics but of wider social-science disciplines such as anthropology, politics, geography, sociology and science and technology studies (STS)" (MacKenzie, 2017, p. 173). A clear exposition of the performativity thesis in SSF can be found in the highly influential work by MacKenzie in 2006, An Engine Not a Camera, in which he makes the compelling case that economics – in the form of finance theory and models - is not a camera that studies financial markets, but an engine that fundamentally shapes them. Financial models as market devices are adopted by market practitioners from finance theory to study pricing. In doing so, however, financial models end up shaping prices themselves such that the prices come to reflect, and enact, the world which the model itself proposes and presupposes.

Although not necessarily adopting the strong performativity thesis as in MacKenzie (2006), several studies built on this approach in the study of financial markets (Callon et al., 2007). These focused, amongst others, on the sociomateriality of trading in the pits (MacKenzie, 2006, Zaloom, 2006), electronic trading (Beunza and Stark, 2004, Knorr Cetina and Bruegger, 2002a, Preda, 2009), financial analysis and evaluation (Beunza and Garud, 2007, Wansleben, 2013, 2012), models and market morality (Beunza, 2019), evaluation cultures, modelling cultures and epistemic practices (Lenglet, 2011, MacKenzie and Spears, 2014a, b, Spears, 2014, Svetlova, 2018), financial market infrastructures (Bernards and Campbell-Verduyn, 2019, Pardo-

[11] What Callon (2007) calls 'economics in the wild' is particularly relevant here. His argument rests on the idea that what produces the world is not simply 'pure economics' but one in the wild – including, for instance, engineering and management –as well as devices and tools such as models.

Guerra, 2019, Pinzur, 2021a, b, 2016), and more recently, algorithmic and high-frequency trading (Borch, 2017, Hansen, 2020, Lange, 2016, Lange et al., 2018, Lenglet, 2011, MacKenzie, 2017, 2018a, 2021).

Performativity has been considered as “the most challenging recent theoretical contribution to economic sociology” (MacKenzie and Millo, 2003, p. 107). This is because, contrary to new economic sociology, it does not attempt to provide an alternative conception of markets to the economists’, but rather to show how they are produced (MacKenzie et al., 2007). Nevertheless, according to Callon (1998) and MacKenzie and Millo (2003), the theory of performativity and new economic sociology’s approach can be perfectly complementary insofar as, rather than being atomistic, the homo economicus is necessarily embedded in social relations, culture, and morality.

While the starting point of the research process of this thesis has been the ‘new new economic sociology’, SSF and the performativity thesis, I depart from its principal focus on calculation and science in markets. Tracing its lineage to the sociology of scientific knowledge, this literature often treats markets as tantamount to scientific laboratories. Indeed, this is one major critique that is often made to the ‘new new economic sociology’. Riles (2010) claims that SSF makes “a deep assumption that markets are more or less analogous to scientific practice, that is, fields of knowledge” (p. 795), and argues for a broader view of financial markets that captures life beyond the confines of front-office traders. Similarly, Svetlova (2018) characterises decision-making in financial markets as involving “more than calculation” (p. 3) and in which models are practical instruments that help render markets ‘investable’, rather than acting as knowledge devices. Her approach is rooted in both SSF and Beckert’s economic sociology, an approach to which we now turn and which this thesis will follow so as to move beyond what is at times an excessive focus of SSF on science, knowledge and calculation in markets.

2.3 The sociology of expectations, imagined futures and uncertainty

A different strand of the literature in economic sociology, led by the work of Jens Beckert, has put economic actors’ capacity to imagine the future and form fictional expectations in the context of an uncertain future at the heart of its analysis. This literature pushes against Weber's argument that society is experiencing a process of disenchantment. The latter's argument posits that in an advanced capitalist society, actors would replace religious belief or magic with rational calculation in a process of 'disenchantment'. Intellectualisation and rationalisation, in Weber's terms, suggest that actors "are not ruled by mysterious, unpredictable forces" but that they "can in principle *control everything by means of calculation*. That in turn means the disenchantment of the world." (Weber et al., 2004, p. 13; emphasis in original).

In contrast, Beckert (2016) emphasises the idea that the future is fundamentally uncertain, thus not *calculable*, and individuals making a decision that is necessarily future-oriented would be paralysed in the face of uncertainty. The uncertainty of the future is driven by the multiplicity of possible 'futures' that technological change and innovation, and creative amalgams in local and global markets can bring about. This uncertainty, in line with what has become known as Knightian uncertainty, differs from Knightian *risk* (Knight, 1921) in that an economic actor cannot calculate the probabilities of each outcome, precisely due to the fact that the actor cannot know the range of potential outcomes. Beckert's work thus criticises neoclassical economics on the grounds that it has blurred the boundaries between Knightian uncertainty and risk (Beckert, 1996). For him, it is only risk that can become subject to calculation; uncertainty, on the other hand, requires more than just calculation.

In Beckert's view, actors operate in a world of fundamental uncertainty and deal with it by forming imagined futures and fictional expectations. These are interpretive frames that help economic actors structure their own decision-making. As actors create stories, narratives, fictions about the future that function as mental representations, and as they assign symbolic meaning to material objects, they acquire the conviction to act, thus countering complete paralysis and are thus able to circumvent the fundamental (or radical) uncertainty. Against the thread proposed by Weber, Beckert suggests that rather than calculation and instrumental rationality taking over, economic actors rely on fictions as "a kind of *secular enchantment* of the world" (Beckert, 2016, p. 283; emphasis in original).

Similar to the new economic sociology, Beckert's work and the strand of literature which it fostered attempts to counter the rational expectations model that is central to neoclassical economics, in which actors make decisions on the basis of their instrumental rationality and (full) information, and in which actors know the model (i.e. take the model's predictions as true on aggregate). Unlike this model, Beckert's proposition of fictional expectations suggests that actors' fictional expectations are not restricted to observable facts, that they help actors imagine several future scenarios and make plausible links between them and the present, and help ascribe meaning.

Beckert and Bronk (2018), building on Beckert (2016), compares fictional expectations to literary fictions but argues that they differ from literary fictions to the extent that "disbelief in them is normally suspended only if the expectations have practical credibility as potentially feasible in the real world" (p. 10). The way in which actors build fictional expectations and structure their action upon them is then reflected in prices. Evaluation practices, in Beckert's and Bronk's conceptualisation of economic action, are primarily driven by contingent fictional expectations that are themselves formed within social structures, interpretive frames and institutions. Market prices, therefore, are reflective not only of fictional expectations, but of the way in which fictional expectations are constituted by social factors such as social structure, sense-making processes, networks, and social norms.

Evaluation practices are also subject to the politics of expectations as different actors attempt to influence others' expectations. Prices, therefore, also reflect a market struggle (Weber, 1968) in which actors lever their power and resources to shape expectations or to exclude others in pursuit of their material interest (Beckert, 2016, Beckert and Bronk, 2018). This focus on politics in markets is more than warranted, especially given its frequent neglect in the social studies of finance. As such, this thesis will also observe the politics of expectations that play out and that revolve around the yield curve in the coordination of social order between markets and central banks.

The way in which Beckert and Bronk conceptualise evaluation practices, constituted primarily by fictional expectations, can therefore be seen as somewhat antithetical to the way SSF understands such practices in which calculation and knowledge prevail. Recently, an important development spurred by Beckert and Bronk's work seeks to draw some workable links between the earlier work by Beckert (2016) and Bronk (2009), and the 'new new economic sociology' literature with its emphasis on calculation and calculative devices. The theoretical schema they present is thus one in which imaginaries and narratives interact with calculative devices in the formation of fictional expectations in markets. Devices, in this view, are no longer purely a function of social construction wherein humans assign symbolic meaning to materiality in the fashion of Durkheim's study of totemism. Rather, calculative devices allow actors to engage in rational analysis alongside and in interaction with imagination and beliefs.

Expectations are thus an outcome of both rationality (disenchmantment) and imagination (enchmantment), which in their turn interact in multiple ways. In such a view, calculative devices – economic theories, models, marketing instruments, forecasts – act as *instruments* of imagination. They allow actors to systematically imagine several potential futures and to analyse rationally the feasibility and plausibility of these futures. Beckert and Bronk concede that there can be "a number of stable and well-understood causal mechanisms or tendencies" (p. 14) which make some aspects of the future amenable to calculation. Similarly, calculative devices are (at times) also useful in extrapolating from past data into the future, thus helping individuals diagnose emerging trends.

By way of an empirical case explored by Besedovsky (2018) in Beckert and Bronk's edited volume, different epistemic cultures of risk management in financial markets give rise to different forms of doing risk management. A traditional approach, mostly found in credit rating agencies, treats risk as partially calculable and attempts to minimise risk. In doing so, analysts assign ratings to countries' credit on a relative and ordinal basis. A credit rating is thus a calculative device that does not imply probabilities of risk or of default but rather implies a measure of health and stability, and thus embodies an implicit understanding on the part of the analyst that risk cannot be fully calculable. In contrast, structured finance as an epistemic culture treats risk as fully calculable and controllable. Structured finance analysts employ mathematical models as devices through which they assign cardinal probabilistic measures of risk, thus eschewing the notion of ontological uncertainty in their evaluation practices. Besedovsky's work, then, elucidates how calculative devices interact with "belief in precise calculability of risk [as] one of the most powerful and influential imaginaries of financial markets." (p. 253).

Despite this recent attempt towards bringing Beckertian sociology closer to SSF, an epistemological divide between the bodies of literature remains in the way calculative devices are characterised. For despite the possibility of causal mechanisms of market devices enabling calculation of the future, for the most part devices in Beckertian sociology are still treated as instruments, or props, of imagination which justify action in the context of an uncertain future. In this thesis, I will rely on both bodies of knowledge and seek to make an intervention on the theoretical front by attempting to resolve this theoretical 'divide' via actor-network theory, as explained in section 2.7.

2.4 Social studies of central banks

Economic sociology is not strictly limited to the study of *markets*. Various scholars in economic sociology have produced important work in 'adjacent' areas such as economic policy-making and regulatory bodies. Amongst these is a thriving and growing body of knowledge that has put central banks under the microscope. While the literature in this area is diverse, I parse it into three approaches: the socio-cultural and organisational approach, the science studies (and performativity) approach, and the financialisation approach. The approaches are by no means mutually exclusive or clear-cut, but reviewing the literature in terms of these categorisations helps to get a strong sense of how this literature has been evolving.

The first approach, rooted in organisational and cultural sociology has provided us with key insights into policy-making within central bank committees like the US Federal Reserve's Federal Open Market Committee (FOMC) (Abolafia, 2010, 2020, Fligstein et al., 2017, Golub et al., 2015, Nelson and Katzenstein, 2014, Rosenhek, 2013). Abolafia's (2020, 2012) work explores how central bank committees are spaces in which each *individual* member's mental model gives way for a 'shared narrative'. In this process of narrative construction, the Committee as a group makes sense of the policy world and events surrounding it that serves as a guiding (sensemaking) frame towards collective action.

Similarly, Fligstein et al. (2017) explain the failure of the Fed in identifying the crisis and responding to it in terms of cultural interpretations and sociocultural frames present on the FOMC. The Fed's primary sensemaking frame of macroeconomics and macroeconomic theory, in their view, precluded the Fed from eventually taking the necessary action on time at the start of the crisis. Golub et al. (2015) argue that while the FOMC members were aware of a developing housing bubble, the dominant paradigm (or interpretive frame) precluded the FOMC from taking action. Additionally, borrowing from the organisational sociology literature (Vaughan, 1999), Golub et al (2015) suggest that organisational routines strengthened the dominant paradigm.

The second approach is one closer to a science studies perspective. A first set of studies examines the ways in which science, knowledge and expertise are leveraged by central banks towards shoring up their legitimacy and to depoliticising their actions (Abolafia, 2012, Claveau and Dion, 2018, Fontan, 2018, Marcussen, 2009, Mudge and Vauchez, 2016). Marcussen (2009) identifies a trend in central banking via which central banks have undergone a Weberian process of rationalisation and scientisation. In his view, central banks are both producers *and* consumers of scientific knowledge – though this is not necessarily an open form of science that others can test, debate and counter. By presenting central banking as scientised, central bankers attempt to disentangle central banking from its politics, and thus to apoliticise their actions. On these lines, Abolafia (2012) claims that while central banks employ a *discourse* of technical rationality for purposes of legitimacy, in practice central banking relies much on interpretive techniques and expert judgements in their decision-making.

Both of these approaches have made important contributions to our knowledge of central banks from an organisational and/or Bourdieusian sociology. However, these strands of the literature fail to put sufficient light on material tools, calculative devices, and expertise in decision-making and practices of governance. While the first strand largely neglects the materiality of policy (e.g. devices), the second treats devices as props and tools of legitimacy on the back of a process of scientisation and de/apoliticisation. The way in which materiality shapes the doing of economics in central banks remains, therefore, a gap in these bodies of work.

This gap has been filled by another strand in the literature taking a science studies approach. In line with a science and technology studies (STS) perspective and the performativity literature in economic sociology, this strand looks instead to the role of science and technology in the practice of central bank governance (Best, 2014, Braun, 2018a, 2015, 2014, Braun et al., 2018, Coombs, 2020, Holmes, 2013, Ibrocevic and Thiemann, 2018, Nagel and Thiemann, 2019, Thiemann, 2018, Thiemann et al., 2020). Braun does precisely this as he bridges work in political economy with the social studies of finance. His work examines how central banks can be performative as they reshape the economy in the image of their macroeconomic model (2014, 2018) via a communicative apparatus (that goes beyond discourse) that renders expectations governable (2015). Another study that does look into the sociomaterial make-up of central banks is Coombs (2020) whose work deals with central bank's stress tests as sociomaterial and calculative procedures that are managed as a Goffmanian performance thus making the stress test predictable.

Given the literature's theoretical and methodological proximity to SSF, my thesis speaks directly to this body of work. However, I will depart from the limited focus (empirical and methodological) of the literature on central banks themselves. Indeed, most of these studies, with a few exceptions (e.g. Braun, 2015) have laid their emphasis on practices of policymaking and struggles *internal* to central banks or primarily *revolving* around central banks. Methodologically, these studies rely only on interviews with central bankers or documents by central banks. When studying practices of governability, they have limited their attention to how central banks construct that governability, thus reducing the markets to passive recipients of governability, and therefore largely assuming that governability is an automatic success. I suggest instead that, rather than stopping short, we need to follow that process of governability to the end, by identifying *who* is potentially being governed, and *how* that process of governability flows, how it works and how it may fail. In doing so, I follow Braun by relying on interviews with *both* central banks and market participants, exploring how they relate with each other, and thus studying how that attempt at governability is 'received' by market participants and whether/how/when it is successful. In turn, following the political economy literature, I also explore the power of markets in making judgements on central bank decisions and pushing through their own demands, thus also exerting a form of governance on central banks.

On a similar note, this limited purview on central banks themselves, and the practices and devices of governance internal to central banks, has meant that we have come to know little on how central banks are embedded in wider processes and institutional features of society. This thesis will therefore also make a contribution to a third set of studies which investigates the entanglements between central banks and financial markets in the context of a process now known as financialisation (Braun, 2018b, Krippner, 2011, 2007, Walter and Wansleben, 2019, Wansleben, 2020, 2018) and the ever-changing boundaries between states and economies (Coombs and Thiemann, 2021). Krippner's (2011) work on central bank's monetary policy was groundbreaking in this regard. She makes the intriguing point that central banks' policy innovations led them to ‘enlist’ market mechanisms in such a way as to ‘let markets to do the [central bank’s] work for it” (p. 478). Consequently, central banks became insulated from public scrutiny on the grounds that their (political) decisions were subject to market (expectations) mechanisms, and in effect, depoliticising their actions.

Walter and Wansleben (2019) claim that central bank’s programmes of governing (Rose and Miller, 1992) become aligned with financial markets’ architecture which in turn provide the space within which the programmes are enacted. Although still influenced by STS and SSF, particularly in the attention they give to material technologies in the making of governing programmes, Walter and Wansleben (2019) take a cue from Krippner’s work who traces such practices and alignments in wider structural processes of financialisation that were embraced by central banks in order to deflect political questions around their policies. However, Walter and Wansleben argue that these developments go beyond *motivations*; rather, they can be located in the technical conduct of monetary policy that shaped markets and led to infrastructural and institutional entanglements between central banks and finance. A striking concluding argument from their work is that, while central banks’ action through financial markets has allowed them to govern, the very fact that central banks govern through financial markets has meant that the former needs to safeguard the latter’s architecture to the extent that central banks now have an interest in honing the very process of financialisation.

Similarly, Wansleben (2018) amalgamates Beckert’s emphasis on expectations with that of financialisation. His work shows how expectational governance techniques, as part of a performative arrangement by central banks, rely on felicity conditions in wider, structural, and institutional settings. This was only an outcome (at least in the UK) driven by a failed attempt by monetarists to devise the institutional foundations in which monetarism could succeed as a programme. He concludes that the diffusion of and convergence over inflation-targeting as an expectational governance technique across the central banking world is due to processes of institutional convergence in which central banks have appropriated and cultivated a form of financialisation at the centre of which is a set of interconnected and liquid financial markets.

2.5 Political Economy of bond markets and economic policy

The set of studies just outlined bears some overlap with what is traditionally seen as political economy. Such studies have been captivated by how processes of financialisation shape the power of financial markets in the wider economy and of state capacity. From analyses of shadow banking (Gabor, 2016, Thiemann, 2018) to market-based banking (Braun, 2018b, Hardie and Howarth, 2013), PE scholarship has raised questions on what this means for what is increasingly seen as a financialised society (Van der Zwan, 2014). In this section, I will review the body of knowledge in political economy that has investigated sovereign bond markets and their interaction with economic policy broadly. I will outline the limitations of some of these studies and introduce my substantive contribution to this literature.

While the social studies of finance has been relatively less concerned with bond markets, poitical economy has long recognised the core role played by bond markets, especially sovereign bond markets, in contemporary society. An important body of literature in political economy contends that bond markets hold, to various extents, some influence on economic policy and politics generally (Ballard-Rosa et al., 2021, Brooks et al., 2015, Hardie, 2012, Hardie et al., 2020, Maxfield, 1998, 2001, Mosley, 2001, 2004, Rommerskirchen, 2020). This influence is particularly pronounced in the borrowing capacity of governments as the success or failure of governments in pushing through their economic policies is contingent on its ability to borrow.

Within this literature, Mosley (2001) provides an authoritative account of the ways in which different types of governments are constrained by financial markets, specifically the sovereign bond market "because it provides a most likely location for the operation of financial market pressures" (p. 17). She defines market pressure in terms of its strength (i.e. the extent to which markets react to a given policy outcome or indicator) and scope (the set of indicators considered by market participants). She argues that, in the case of developed countries, bond market pressure is strong in degree (i.e strong reactions by markets) but narrow in scope (markets consider a limited set of indicators). In contrast, for developing countries, influence of bond markets is strong and broad. Because investors in developed countries have ex-ante beliefs in the creditworthiness of a government, they are therefore more likely to focus on a relatively narrow set of indicators than those in developing countries.

Asking similar questions, Maxfield (1998) attempts to overturn the widespread idea that private capital flows, because they are impatient, pose a *direct* constraint on governments, especially in emerging market countries). Her work proposes a framework that differentiaties asset holders by product and investment obejctive. The influence over economic policy by capital flows is therefore variegated, and dependent on types and motivations of asset holders. The more volatile (impatient) the investment, the higher the likelihood of constraints on government policy. But this will vary according to whether the investment was pushed (e.g. by low yields in *other* countries) or pulled (e.g. due to factors internal to the country) into the host country.

In a three-case study of Brazil, Lebanon and Turkey, Hardie (2012) extends Maxfield's framework and argues how greater financialisation puts constraints on governments in their ability to borrow and borrow cheaply (see also Hardie, 2011). The power of bond markets is examined by Rommerskirchen (2020) who finds that governments' decisions in the fiscal space are sensitive to the composition of ownership in bond markets (see Rommerskirchen, 2019). Interestingly, Hardie et al. (2020) find evidence that US Treasury yields have historically influenced (via the mortgage market) the approval rates of US presidents.

While this literature has thrown light over an urgent problem in modern society, i.e. the influence of markets on economic policy, it has largely treated the problem as an outcome. In other words, we still know little about the processes by which markets exert their power, voice, and influence over governments and states. One exception is Mosley's work which looks at the problem from the perspective of markets and asks not how governments react to market pressure, but how market evaluates policy and how that pressure is enacted. She finds, for instance, that market participants in developed countries base their decisions on indicators such as the deficit/GDP ratio or the inflation rate, and that these indicators provide the necessary information to make judgements on investment risk and pricing. Her work, therefore, makes a contribution by developing "a causal model of government– financial market relations" (p. 24). In other words, market influence on economic policy is the result of a *process*: financial market participants evaluate government policy, markets react (or not) to policy, governments observe this reaction (or lack thereof), governments maintain or change their policy depending on that reaction, thus adding a new loop in the process.

This thesis will therefore make a contribution to the literature by following Mosley (2001) in focusing on the process by which market participants influence economic policy. Interestingly, this literature has shown how this pressure is imparted by markets through interest rates (or yields) as channel of power . My work will precisely put this channel under the microscope to show how markets and central banks are attentive to this device and coordinate around this device. I will therefore extend this work by throwing light onto a novel aspect: ‘central bank – financial market relations’ as a new locus of power. *How precisely* do states (in this case, central banks) and markets coordinate? And *how* is that power translated and channeled *in practice*? This is precisely where a sociological study of this sort is best-placed to make such a contribution.

This approach also allows us to speak to a different, but related, strand of the literature which has thrown light over the ways in which states themselves have been influenced by ‘marketisation’ practices – in what is known as ‘the financialisation of the state’. Primarily focused on government debt management, these studies show how governments have implemented methods and practices of debt management that resemble financial market practices. Fastenrath et al. (2017) claim that debt management has been financialised due to “the increasing reliance on financial markets as governance mechanisms” (p. 247) but also due to the incorporation of an epistemic framework rooted in financial economics as debt managers start treating their debt as a portfolio in the manner of Markowitz’s portfolio theory. Likewise, Preunkert (2017) looks into changes in debt instruments and techniques of debt management since the 1980s across Europe as governments adapted to the structures and practices of financial markets. Providing an institutionalist account of government debt management, Trampusch (2015) shows how states not only supported capital markets via deregulation but also implemented accounting procedures drawn from accounting practices in finance.

There is, therefore, a sense in which these processes have thus made states more susceptible to finance. Indeed, a number of scholars have thus investigated the ways in which such processes of financialisation and the changing structures of financial markets have been supported, enhanced and cultivated by states and state agencies.

Braun (2018b) lays out how the European Central Bank, with an interest in having a European repo market, sought to and succeeded in supporting a repo market by putting a stop to efforts for a tax on repos and by developing a general collateral basket of repos that would be used as collateral. It also assisted in the development and reviving of the asset-backed securities market following the GFC. The ECB therefore was a key supporter of market-based banking given that both repo markets and securitisation markets play a crucial role in this form of banking. On the same lines, Gabor (2016) traces the construction of what she calls 'the repo trinity' – liquid government bond markets, financial stability, and free repo markets – as policy objectives of central banks.

A crucial point of contention within this literature has revolved around *why* states seem to have been catalysts of financialization processes. While some have pointed to revolving doors, ideational influences, capture by financial interests, or the lobbying power of market participants (Helgadóttir, 2016, Jacobs and King, 2016, Strange, 2015, Streeck, 2014), others have argued that it is the 'infrastructural entanglements' that provide the means by which 'finance wins' (Braun, 2018b). In other words, it is because central banks and governments have to go through financial markets, in their implementation of monetary policy and debt management respectively, that financial markets enjoy and leverage infrastructural power.

And yet, the vast majority of the studies outlined in this section have treated states as victims of financialisation, even if some acknowledge the capacity for state manouevre (Mosley, 2001). I will claim that, as central banks become susceptible to and reliant on markets for their methods and practices of governance, infrastructural power is also granted to central banks and governments as it enhances state capacity (Dutta, 2018, Knafo, 2013, Konings, 2011, Lagna, 2016). This follows works by Dutta (2018) who reclaims the Big Bang in London as a win for the state as the debt market grew in size and liquidity, thus allowing the British government easier financing and monetary policy implementation. Similarly, Lagna (2016) shows how states can act strategically in repurposing financialisation processes to reach political-strategic goals, as the Italian government used derivatives-based strategies to participate in the Economic and Monetary Union (see also, Dunbar, 2000).

My thesis will therefore show how central banks and financial markets have become increasingly susceptible to each other, and how they engage in coordination to reach their respective goals. I will show how this susceptibility grew over decades of interaction, how they developed practices – from the symbolic to the technical - that revolve around each other, in what I will call infrastructural and interactional alignments. Amongst other elements, this includes an exploration of the sociomaterial nature of financial markets and states, and their interactions, which political economy has often disregarded. Recent work in PE seeks to rectify this by focusing, amongst others, on the sociomateriality of financial trading and how this may explain the divide between human-based and high-frequency trading in shares and bonds across the US and Europe (MacKenzie et al., 2020), or on infrastructures (Bernards and Campbell-Verduyn, 2019). But this work also lays emphasis on the role of states, in the form of governments and their regulators, in shaping those very same markets. Indeed, it calls for more synergies between PE work that focuses on the state-market nexus and ANT-inflected sociology focusing on the materiality of everyday life. This thesis will thus contribute to the literature precisely in this vein.

2.6 Interest rates and the yield curve in the social studies of finance

While all of the above studies have made valuable contributions to the area of central banking and sovereign bond markets, interest rates and the yield curve have largely been of peripheral interest to them. One important work which does focus on interest rates is Spears (2014). His study looks into the evaluation cultures of quantitative analysts working on interest rates derivatives modelling in Libor markets, and provides a historical account of the social shaping of modelling practices by evaluation cultures. His main thesis holds that term structure modelling as practised by financial economists represented an analytical form of modelling that only sought to understand the behaviour of interest rates. As this modelling was adopted by quants, and therefore came to inhabit quite a distinct world, it turned into a calculative tool for pricing and hedging of derivatives. The argument that 'culture' shapes modelling practices, while perfectly compatible with Callon's conception of performativity (2007) where the relationship between model and its world is neither unidirectional nor completely causal, diverges from earlier studies of performativity where the model itself shapes the world it inhabits (MacKenzie and Millo, 2003).

Spears' (2014) study also contributes in other ways to our knowledge on the organisation of modelling practices and the use of models in financial markets. Trading desks in dealer banks, he argues, practise a similar kind of modelling technique that connects the various trading desks. Especially relevant to this study is his incursion into the world of a specific desk, the linear products desk (a desk that makes markets in government bonds). On this desk, model objects like forward curves (which ultimately amount to alternative forms of the yield curve) are used in an algorithmic manner to construct and quote prices to the bank's clients, as well as for valuation and hedging purposes as "a mundane piece of informational infrastructure" (p.110).

The yield curve occupies a more central position in Zaloom's (2009) and Christophers' (2017) work, albeit in slightly distinct ways. Zaloom (2009) conceptualises the yield curve as a site of relations, where "financial participants are knitted in a loosely entangled economic public through recursive loops of feeling, reading, interpreting, and acting around this tool." *(*p. 247*).* It also brings together geographically-dispersed actors ranging from traders to economists who "become impassioned about the future as the curve bends and twists" (p. 247). As Christophers (2017) argues, the yield curve is employed by investors to compare asset values, and as a guiding tool for future interest rates, while central banks use the yield curve as a predictor of economic activity, interest rates, and inflation. As a result, central bank "monetary policy is deeply informed by an indicator that is itself a projection of monetary policy" (Christophers, 2017, p. 67). In other words, the expectations about future interest rates underlying the yield curve are both projections of future central bank policy rates as well as inputs to the conduct of central banks' policy, in what he call a feedback loop.

The curve is also itself capable of action. It is a *producer* of uncertainty and affect, in the form of anxiety, fear and suspicion about who is moving the market (Zaloom, 2009, 2012). For Christophers, the yield curve is also a producer, but in a slightly distinct way. It is performative of future interest rates, inflation and wider economy activity. This process is especially evident in the central bank's monetary policy, where the latter "fashions the economy through the yield curve; the economy reacts back on monetary policy through the yield curve" (p. 68). In his view, it is not just that central banks employ communication to influence markets that provides them with an ability to perform the economy, but it is also the fact that central banks *produce* the yield curve *materially* that endows them with power, privilege and stronger performativity capacity, a matter that brings to light the political economy of markets.

Finally, Braun (2014, 2018) argues that the performative capacity of central banking is also being diminished by the central bank's own actions. While historically central banks used to target the short-end of the yield curve, they have now moved to target the whole yield curve via unconventional monetary policy[12]. The very fact that the central bank is now active in the whole market means that yields are no longer a measure of *market* expectations about future conditions, and neither central bankers nor market participants can now read the yield curve in terms of market expectations in devising policy and trading respectively. How central banks intervene on the market to the extent that they shake the informational value (and the expectations hypothesis) of the yield curve is, in this case, an intriguing matter.

In this short literature on the yield curve, the latter has been conceptualised as an epistemic and affective object that provides a window onto financial knowledge and in the way this is organised around reason and affect (Zaloom, 2009). Its various uses, both in investment and policy spheres, and the way it unifies thought and action of the various actors involved, enables reflection on others' action and beliefs as well as gives a degree of predictive capacity to the curve itself. It has been argued that this prediction, coupled with the way the curve is produced and employed, is an effect of the performativity capacity possessed by the curve, especially due to the way in which central banks act as architect of the yield curve itself on a material level (Christophers, 2017).

2.7 Actor network theory: a toolbox

By way of conclusion to this literature review, I will set forth an analytical toolbox that will guide this study. I will follow an actor-network theory (ANT) approach that attempts to study the ontology of 'the social'. In doing so, I will borrow from ANT the concepts

[12] This unconventional monetary policy amounts to two forms: Forward guidance and quantitative easing. Forward guidance is a discursive and communicative tool employed by central banks to signal to markets its future monetary policy, the intention of which is to influence market expectations. Quantitative easing is a tool of monetary policy where central banks purchase large amounts of assets (typically in government bonds but also corporate bonds and other instruments) in order to push down long-term yields, and to stimulate the economy. These tools have been adopted and implemented in various forms by several major central banks following the Great Financial Crisis of 2007/08.

of ‘sociomaterial agencements’ and ‘ontological multiplicity’ that have been so influential in science and technology studies literature as well as in the social studies of finance. These concepts have proved a powerful explanatory set of tools in laying out the sociality of life in markets. Nevertheless, I remain cognizant of some of the legitimate reservations raised by some scholars towards the ANT-inflected social studies of finance, particularly with respect to the, at times, excessive focus on science in markets (Riles, 2018, Svetlova, 2018, Wansleben, 2018).

Actor-network theory emerged from a body of scholarship in the sociology of science and scientific knowledge that can be traced back to Robert Merton and Thomas Kuhn. The core concern of the sociology of science was in social epistemology, namely in understanding how scientists employ methods of knowing as a collective endeavour. Early on, Merton had questioned the widely held assumption that science and scientific knowledge existed outside ‘the social’, and instead started to treat science as a social institution like any other (Woolgar, 1992). Yet Merton limited himself to explaining the institutional frameworks of science and was hence less interested in explaining sociologically the *content* and *nature* of scientific knowledge (Bloor, 1991).

This approach was countered by the Edinburgh school of the sociology of scientific knowledge, led by David Bloor, who proposed what he called *‘the strong programme’*. This programme departed not just from a Mertonian approach, but also from a weaker programme which treated only false theories as legitimate sociological material thus leaving true scientific theories for scientists themselves. Instead, the Edinburgh school proposed a symmetrical form of explanation where “the same types of cause would explain, say, true and false beliefs” (Bloor, 1991, p. 7). Additionally, Bloor suggested that the strong programme would be impartial in dealing with truth and falsity, would seek to attribute causality to how beliefs come about, and would also be reflexive such that its explanations would be applicable to sociology too.

It is within this intellectual context that actor-network theory was born in France as the brainchild of Bruno Latour and Michel Callon. ANT takes the sociology of scientific knowledge a couple of steps further. It firstly moves away from studying *practices of representation*, i.e. the practices of knowing and the generation of knowledge as representation of an *external* world. In turn, ANT aims for an examination of ontology proper (Woolgar and Lezaun, 2013). The ‘ontological turn’ signifies a shift from knowledge and representation as a central concern, to how “objects are enacted in practice” (Mol, 2002, p. vii).

ANT thus eschews taking a predetermined ontological position at the outset of the empirical study. Instead, ANT scholars suspend an ontological commitment in order to present a study of ontology, i.e. by looking into the ways in which the social comes into being. This is a point of contention on which a heated debate between ANT scholars, principally Latour and Callon, and the Bath school of the sociology of scientific knowledge, represented by Collins and Yearley, hinged in Pickering’s (1992) edited volume ‘Science as Practice and Culture’. Collins and Yearley (2010) attacked ANT arguing that such an approach would end up reproducing the world of the scientist (or technologist) and thus to reduce the object of investigation to nothing more than a second-hand account of the scientist, a sort of prosaic world in which sociology has no place.

In contrast, Callon and Latour (1992) argued that the Bath school predetermined a priori the world into two categorisations, nature and society, or at least a spectrum on which nature and society sit at the extremities. “We have never”, argued Callon and Latour, “been interested in giving a social explanation of anything, but we want to explain society, of which the things, facts and artifacts, are major components.” (p. 348). In other words, ANT refuses to impose a priori the sociality of anything that is to be studied, but rather seeks to allow and follow the social as it is enacted as a form of “coproduction of society and nature” (p. 349). The ‘social’ does not exist outside of the specific associations, relations and configurations at any one point in time. In their view, the social and society is not a ‘thing’ but a particular formation or configuration between things that could be either - as in common knowledge or traditional sociology - nature or society (Latour, 2005). The proviso ‘in common knowledge or traditional sociology’ refers to the fact that, unlike common terminology or traditional sociology, ANT has no fixed repertoire that defines what is society and what is nature. Hence ANT does not make any a priori distinction between nature and society.

Callon and Latour also criticise the Bath school on its social constructivist perspective. By taking social constructivism as an ontological starting point, Collins and Yearley treat any nonhuman object as either ‘natural’, out there in the natural world, or else as socially constructed (i.e. reduced to how humans, particularly scientists, conceptualise and talk about the same object). Rather than alternating between natural realism and social realism, ANT scholarship present nature and society as an *outcome*, or a result, of an activity which it calls network building. In doing so, it treats nonhumans on par with humans, in the sense that together they may form networks, associations, relations, that build society. It is therefore the arrangements of particular networks between humans and nonhumans that constitute society. As a result, ANT takes the idea of symmetry even further than the Edinburgh school, by applying it to humans and nonhumans.

Allowing for nonhumans the potential to engage in action, and therefore seeing nonhumans as actors on the same dimension as humans, has proved a controversial suggestion. Sociologists like Collins and Yearley have rejected this suggestion on several grounds, the most forceful of which being the claim that nonhumans possess no intentionality and therefore there can never exist any symmetry between humans and nonhumans. Yet Callon and Latour counter this point by presenting a less restrictive account of action. For them, an actor is not necessarily one driven by intentions but as "*any thing* that does modify a state of affairs by making a difference" (Latour, 2005, p. 71). This is not equivalent to claiming that nonhumans *determine* a course of action, but rather that there is a spectrum of potential acts and actions in between full causality and inexistence. A nonhuman may "authorize, allow, afford, encourage, permit, suggest, influence, block, render possible, forbid, and so on" (p. 72). Excluding the possibility that nonhumans may be actors, or that they may constitute the social, is tantamount to reducing society to a community of baboons (Strum and Latour, 1987), or naked humans (MacKenzie and Wajcman, 1999).

We are now, therefore, in the sociomaterial. It is a society made up not of naked humans, but humans alongside technologies, machines, mundane objects of the everyday. Following this stream of thought, therefore, I will adopt the notion of *sociomaterial agencements* to mean precisely this: a society formed out of sets of networks or associations, particular formulations, configurations and arrangements between humans and nonhumans.

This notion of sociomaterial arrangements as advanced by ANT scholars is broader than the performativity studies that it itself engendered in economic sociology and the social studies of finance. As they take the sensibilities of ANT in their investigation of social life in markets, performativity scholars raise a crucial point on the ways in which economics, understood in the broader sense of the term, enacts calculative agencies. “Calculation is neither a universally homogeneous attribute of humankind, nor an anthropological fiction. It is the concrete result of social and technical arrangements.” as Callon et al. (2007, p. 5) argue. And yet, Callon (2007) himself conceded that the anthropological program of economics cannot ever produce a “monolithic agency that is entirely calculative” (p. 346), inasmuch as there will always be overflows from the framing process. The sociomaterial agencements that are shaped by economics as an anthropological programme can never exist as *pure* centres of calculation, but also involve extra-calculative forces amongst which one may include networks, trust, belief, fictions and narratives.

It is on this point that I will claim that scholarship on performativity and the literature propelled by other economic sociologists, in this case Beckert’s, are not necessarily incompatible. Although economics has proved incredibly influential in the shaping of markets, and this is evidenced by the literature already reviewed in this chapter, there is more to market sociality than pure calculation. The ‘overflows’ or competing programs, in Callon’s terminology, are as important in the study of the various configurations as practices of calculation. As I will show, while the yield curve is an object of economics that often allows calculation, it is also a powerful device which constructs the market as a singular entity from a set of dispersed configurations on a *symbolic* level. While this is not necessarily a function of the calculative practices that engenders the yield curve, it is nevertheless entirely within the framework of an ANT approach.

A second element to this is related to the problem of materiality. As already mentioned, the controversial approach in ANT of giving materiality the potential for action has also extended to the study of markets. One possible reason why other literature in economic sociology has been so critical of the ANT-inflected economic sociology is due to the extensive focus given to materiality by the latter. In trying to ‘correct’ the bias of traditional sociology and the new economic sociology which neglected the role of the material in society, ANT-inflected economic sociology gave primacy to the material. The unfortunate outcome is that the focus on materiality obscures the fact that ANT would not a priori be partial to the material elements of society. In other words, because ANT refuses to impose an ontological position onto what it is studying, it leaves space for (and follows) a construction that is *both* material and 'human'. There may be agencements in which materiality takes a second role to human intentions, to the symbolic element of social life, perhaps to power relations within a sexual act of *naked* humans (MacKenzie and Wajcman, 1999).

ANT is thus neutral with respect to what constitutes ontology, and, as such is not antithetical to a Beckertian examination of social life in markets. The recent attempts in Beckert and Bronk's edited work (2018) to incorporate the role of materiality – of material devices, of calculation – in its intellectual purview would find strong sympathy from ANT scholarship. It is from this viewpoint, therefore, that this study will also rely on Beckert's work on expectations, fictions, imagination, and calculation, as part of a larger approach that takes ANT as its starting point.

Within this theoretical schema, material devices matter irrespective of whether they render agencements purely calculative or not. As the second conceptual tool, I will lay emphasis on how a *material device* such as the yield curve may act as a mediator, in Latourian terms. Unlike an intermediary that simply transports meaning without transformation, a mediator is an object that may "transform, translate, distort, and modify the meaning or the elements they are supposed to carry" (Latour, 2005, p. 39). The sociology of markets has taken this notion and applied it to markets, by which they have investigated the role of *market* devices in the social life of markets.

One such market device that holds some affinity to the yield curve is the stock ticker. The argument by financial economics that observation of prices reduces uncertainty, argues Preda (2006) should be complemented by a focus on price-recording technologies. The construction, recording and observation of prices is a central part of the social constitution of prices. Preda's proposition is that these tools should be studied for three primary reasons: 1) transactions are central to markets, and they depend on data, 2) the interpretation of market events is grounded in data, and 3) formal models of price behaviour depend on data. In the fashion of performativity, studying price technologies requires studying what they do and what they bring about - how they enact calculative spaces via singularisation and standardisation (Çalışkan and Callon, 2010, Callon and Muniesa, 2005b); the framing processes around price data; the transversability they impart on prices (Preda, 2006). These processes allow comparing between alternative goods and investment decisions, a method that underlies any investment (Hardie, 2004, Hardie and MacKenzie, 2007b). The good being traded becomes calculable in this process, a notion that sits comfortably with (2007) view of market transactions.

Material objects like price technologies also play a role in aggregating, though not in their entirety, dispersed transactions that would be inconceivable to grasp in the absence of such objects. They do so by virtue of their ability to transcend time and space limitations, and through which they shape or make ‘global microstructures’ (Knorr Cetina and Bruegger, 2002a). In effect, the spatial and temporal dynamic of markets become localised onto a tool or chart, an entity that represents the market. It “made the market in its turn visible as an abstract, faceless, yet very lively whole”, argued Preda with reference to the stock ticker (2009, p.765). As it represents the market, the stock ticker enacts it by way of specific temporal, spatial, visualisation and linguistic structures that it produces and reproduces. We are now beyond baboon society or naked humans. The social is as much constituted by humans as it is by technology and ‘devices’.

Such material devices are not necessarily accepted uncritically by humans. Indeed, humans often take a critical stance to how true or accurate their devices are. Human beings are not ‘model dopes’ (MacKenzie and Spears, 2014a), meaning that they adopt and work with devices in a reflexive and creative manner (Beunza and Stark, 2004, Svetlova, 2018). In this regard, it is important to note that such devices do not reduce calculation to pure quantitative measurement. Actors, partly because they are reflexive, support quantitative calculation with qualitative judgement and intuition (Callon and Law, 2005, Callon and Muniesa, 2005b) in a process that Cochoy (2008) terms ‘qualculation’.

While economic sociology, and specifically the social studies of finance, has focused on devices as *market* devices, the conceptual tool as suggested by Callon (2007) has wider potential. It is in this sense that I will follow Hirschman and Berman (2014) in extending the idea of devices to ‘policy devices’ in policy circles. Hirschman and Berman (2014) have characterised policy devices as either ‘devices for seeing’ or ‘devices for choosing’. The former are devices - including the inflation rate and GDP - which assist policymakers by making the world they are supposed to intervene in more manageable, while the latter are devices – including cost-benefit analysis - that assist complex decision-making by establishing clear procedures. The yield curve as a policy device helps central bankers to observe what the market is thinking as a collective, and as such is closer to a 'device for seeing'. However, like Hirschman and Berman (2014)'s point, the yield curve may give rise to a consequence of a more political nature, inasmuch as "our attention is drawn towards certain facets of the world and away from others. (p. 800)". In this case, the fact that the yield curve acts as a policy device may divert our attention away from the fact that it is effectively a representation of the market. In other words, policymakers are employing a device so as to observe how the *market* is judging policy. This is a matter on which this thesis puts attention by tracing the historical relationships between markets and states in the context of financialisation, which is ultimately a political matter.

In this context, this thesis will go further than Hirschman and Berman (2014) by looking into the process by which the yield curve is transformed from a market device into a policy device and, more importantly, into the actual coordination the yield curve itself allows between markets and central banks. For the yield curve is not limited to the boundaries of either markets or central banks (see Coombs and Thiemann, 2021), but is a core part of the interaction and coordination between them. As such, it is a manifestation of the increasing susceptibility between central banks and markets, and is a device that makes this susceptibility durable and material. The yield curve, therefore, is a device that sits within *multiple* sociomaterial agencements that are persistently *interacting*. Hence I will adopt the concept of *ontological multiplicity* (Mol, 2002), an idea so influential in actor-network scholarship.

By ontological multiplicity, I refer to the notion that there exist a multiplicity of realities enacted in practice (Mol, 1999). As Mol (2002) shows in her seminal work on the '*body multiple',* a disease is enacted in different ways as sets of arrangements between humans, apparatus, language are brought to bear on the diagnosis of the disease(s). A 'simple' textbook plaque build-up in the artery walls, atherosclerosis, *is* something different in the outpatient clinic as the patient visits the doctor's clinic who diagnoses the disease by asking questions about side-effects and measures blood pulsations, and *is* something else entirely in the pathology lab as an amputated leg is dissected under the microscope. These are not aspects or sides of a disease, but *versions* and *sites* of disease. A disease is multiple.

This is also not about social construction, the way in which scientists think about or talk about the disease. Nor is it about practices of representation that leave the object under investigation intact and untouched. Rather, it is about ontology, as the object itself - in this case, disease - is intervened on, *enacted* and *done* in practice. Similarly, the Zimbabwean bush pump investigated by De Laet and Mol (2000) is multiple in the sense that it achieves fluidity as it moves from one set of sociomaterial networks to another. From this viewpoint, as the yield curve is employed locally in multiple sociomaterial agencements, it is shaped, moulded, and worked differently. As such, there is no fixed or prefabricated thing-ness to a material object (Star, 2010). Indeed, the ontology of these objects is therefore not pre-given, but produced in practices (Mol, 2002). Actor-network theory is a way out of Euclideanism, in the sense that objects do not possess a given form or exist by way of a fixed geometrical space constituted of a set of dimensions and coordinates. Rather, their ontology is enacted “by virtue of their position in a set of links or relations” (Law, 1999, p. 6; emphasis in original).

By enacting multiple realities, the multiplicity of sociomaterial arrangements allows for multiple and different modes of ordering. As Law (2009a) argues, these modes of ordering that multiple realities bring about are often irreducible to one another. Yet, at times, they flow into one another. Anaemia as a disease can be performed both clinically (as a doctor sees his/her patient with symptoms and diagnoses anaemia) and statistically (a laboratory test compared against a statistical standard). The performances of the anaemia, and therefore the different *versions* of the disease, are not in conflict with each other. Instead, they are sequential versions the outcome of which sequence is the treatment of anaemia (Mol, 1999). The interactions between multiple sociomaterial agencements and the enactment of multiple ontologies can therefore succeed in maintaining social order, though this is invariably necessarily an *attempt* at ordering that is also fragile (Law, 2009a).

As we will see, there is a sense in which the multiplicity of realities enacted around and on the yield curve give way to a sense of social order as the yield curve mediates local and multiple realities. Although ANT sensibilities of these sort have developed out of the sociology of knowledge, they also hold potential to explore elements that go beyond *science*. In this thesis I will draw on the social theory of ANT while remaining actively aware that central bank policy-making and financial market practice is not simply a matter of applying linearly principles and ideas of technical rationality and academic science into practice (Wansleben, 2018). Therefore, adopting the notion of sociomaterial agencements and ontological multiplicity in the way just explained will also assist in capturing *alignments* between central banks and markets (Walter and Wansleben, 2019) that are not necessarily limited to the technical practices of governance and the influence of science (i.e. economics) on these practices. Rather, the interactions between central banks and markets, and the sociomaterial arrangements in and through which they are enacted, go beyond the doing of economics, and are also necessarily constituted by infrastructures and institutions (Braun, 2018b, Walter and Wansleben, 2019, Wansleben, 2020) such as the role and place of government bond markets in a financialised society.

Part I: Assembling multiple agencements and new evaluation practices

Chapter 3

Evaluation practices and the shaping of the UK gilt-edged market (1950s-1970s)

This chapter takes a historical look into the ways in which the yield curve became embedded in the UK gilt-edged market between the 1950s and 1970s. It argues that its embeddedness in sociomaterial agencements was part of, and in many ways a consequence of, a larger process which I will call the 'rise of quantification'. This involved new epistemic communities coalescing: led by actuaries, but including accountants and economists, who set up quantitative research departments within the larger stockbroking firms in the City of London. Despite resistance from the established communities relying on subjective judgements in their decision-making, and on social networks in their client-driven business, the new epistemic communities succeeded in establishing a new set of quantitative practices in the gilt market. The result was a reconfiguration of the sociomaterial arrangements in which the yield curve as material and cognitive equipment became a core part. The early practices to which these arrangements gave rise, known as 'switching', shaped the market in consequential and performative ways. The chapter concludes by exploring the attempts and failure by actuaries to hold onto their prominent position of authority at the heart of the gilt-edged market as they were replaced by financial economists.

3.1 Constructing a sociomaterial agencement

The context of the first half of the 20th century was a favourable one for the gilt-edged market. While the two World Wars impaired the equity market, they had the inverse effect on the gilt market (Reader and Kynaston, 1998). Wars and bond markets have historically held a symbiotic relationship. Indeed, the first sovereign bond is known to have been issued to finance King William III's war against France in 1693/4, the latter also giving rise to the Bank of England as a private bank acting as banker to the Government to fund the same war. In a similar fashion, the funding needs of the British government during the two World Wars led to the National Debt-to-GDP to balloon from 28.3% in 1913 to a peak of 259% in 1946 (FRED, 2021). Some of the newly-issued debt did bypass the Stock Exchange, but enough went through it to ensure a healthy and active secondary bond market, supported by the nationalisation of key industries, from steel to railways, by the Labour Government following the War. As a result, the turnover of the Stock Exchange consisted in the large part of British Government bonds, which Reader and Kynaston (1998) estimate at somewhere about 85%. Despite institutional challenges for the Stock Exchange (Michie, 2001, p. 330), it became an increasingly important feature of British finance.

Members of the Stock Exchange whose role was one of intermediation between buyers and sellers[13], had an incentive to capture client business. Known as stockbroking firms[14] had several practices through which they attempted to acquire client business. Historically, the most common one had been personal relationships. According to Michie, "[p]ossibly the majority of the Stock Exchange's brokers were of this kind, each serving a client list built up over many years of business, and doing so through a great deal of personal contact and trust" (p. 107) and "reinforced through family, educational, or other ties" (p. 203). While this is closer to what Uzzi (1996) calls 'embedded ties', stockbroking firms tended to develop relationships through what Granovetter (1985) calls 'weak ties'. In some cases, such as Sebags, brokers recruited individuals within the firm precisely because they had extensive connections (Michie, 2001, p. 380). Beyond relationships, brokers sometimes sought recruits with a certain habitus (Bourdieu, 1979), for example from a public-school background (which also enabled connections), because their target and actual clientele was of a similar habitus.

But during the mid-20th century, a number of stockbroking firms were developing significant quantitative-driven expertise in the gilt market, which would soon prove to be a successful strategy for acquiring new business. Coupled with the increased debt

[13] Interestingly, Michie (pp. 111-112) notes that stockbroking had only been granted legitimacy around the end of the 19th century when the Stock Exchange began to investigate and sanction 'dishonourable conduct' such as defrauding clients.

[14] Stockbroking firms acted as brokers between their own clients (investors) and the jobbers (the market-makers) within the London Stock Exchange. Under the single capacity system, stockbrokers could not act as market-makers and thus did not trade on their own books. See Michie (2001) and Attard (1994) for more detail on the history of the Stock Exchange.

issuance and market depth, the gilt-edged market had great untapped potential to be subjected to quantitative and mathematical treatment. Some stockbrokers therefore established a sociomaterial agencement: research departments staffed by technical and quantitative-driven individuals aided by material equipment, which would quickly give rise to a new set of evaluation practices.

One of the earliest to do so, on the initiative of Sidney Perry, was the then-relatively unknown, small stockbroking firm, Phillips & Drew. Perry, an actuary, joined P&D in in 1936 as a partner, determined to build his own research team. Between 1936 and the mid-50s, he recruited a significant number of actuaries, together with some accountants and mathematicians. The team would specialise in the business of switching, a new investment technique which was only practised by a few other brokers. Switching involves swapping between a similar bond and another when the two are out of line with each other[15]. The role of P&D, as brokers, was to recommend such opportunities to their institutional clients rather than exploiting them on their own books. To this end, therefore, Perry's team would do the research and analysis, and develop new techniques to be able to recommend to clients.

Such a practice differed from the then-all-too-common buy-and-hold strategy in which an investor invests in a bond on the basis of his subjective judgement of the intrinsic or fundamental value of the bond. In effect, switching was an early form of what nowadays we have come to know as 'relative value', i.e. a value of a bond is principally a function of its comparability to other similar bonds. Relative valuation, therefore, involves comparisons between similar bonds which in turn require *metrics* through which bonds are compared (Hardie and MacKenzie, 2007a, MacKenzie, 2008). Weaver, one of the earliest members on Perry's team recalls two such metrics developed at P&D (Reader and Kynaston, 1998, p. 24):

> I began to familiarise myself with Perry's method of monitoring Government stocks. It was his practice to adjust the price of each stock to what it would have been if it had a 4% coupon. These adjusted prices were graphed weekly and the lines inspected for divergencies.

[15] The term for bonds during that period was 'stock'. I will, however, be using the term bonds to make a clear distinction with shares and equities, given that the term stock in contemporary times tends to be used for the equity market. I will keep quotes intact so that I remain as faithful as possible to the original texts, but any mention of stock there should be taken to refer to bonds, unless otherwise stated.

> […] [T]he prices were plotted on translucent paper, ruled logarithmically, and then compared by putting two together and holding them up to the light. I found this not to my liking and got rid of all the graphs by taking logs of all the prices and calculating the difference between all possible pairs which gave a measure of the changing ratio of the prices. There are clearly limitations to this method but it remained the main method for monitoring gilt-edged prices up to the mid-1950s.

Switching, or RV, therefore required not just metrics but a sociomaterial arrangement. Perry's technique involved a hypothetical bond, weekly graphs, lines, translucent paper, paper positioning, light itself and the observer's eye. Weaver's involved logging prices, pairing bonds together, calculating their prices' differences, and finally a price ratio.

This was an unusual agencement for those in conventional brokerage who relied on competitive commission rates or social networks. Perry himself claims that the rest of the firm looked on his team "rather as magicians conjuring business out of thin air (especially the switching business which was at the time a very large section), and were perhaps a little suspicious of the permanency of it" (p. 27). Later, they grew more than suspicious when observing how successful Perry's team was. Reader and Kynaston (1998) report that between 1939/40 and 1945/46, gross brokerage of the whole firm grew by 370% whilst that of Perry's team within the firm grew by 609%. Clearly, then, the team's contribution to the firm's revenue and profits was growing at a much faster pace than the rest of the firm. A senior partner would allegedly refer to Perry's team as 'the circus' and there was animosity between Perry's team and those in conventional brokerage. Yet, the team was consistently profitable, brought in ever-rising client business, and built a reputation of technical expertise in the gilt-edged market across the City of London.

3.2 Material devices: The 'yield' and 'spread' as metrics of relative valuation

Developments in analytical techniques were only starting, led by P&D and a number of other stockbroking firms who also developed their own in-house research effort. One of the major developments in the sociomaterial agencement was the use of a device, known as the yield, that largely took over from price differentials or ratios. Technically, the yield is the expected rate of return on a fixed-income investment over a period of time. But why does it matter? A trader with a long experience in the industry told me:

> The yield of a bond is a model. You know, it's a lot easier to think about the yield of different bonds than it is to think about the price and the coupon and the maturity. So yield is the kind of model which helps people to understand relationships between different things. (Interview GH)

Each bond is unique. Let us discount the fact that there are different issuers of bonds. The UK government can issue bonds with different coupons and different maturities. Once issued, bonds will vary in price at any given moment and they will vary qualitatively, some being on-the-run and others off-the-run. How can a trader or investor compare two bonds with such different characteristics on the same plane? Price ratios and price differentials, for instance, do not account for maturity so an investor would have to make a quick subjective judgement (or an extra calculation) on how maturity influences the price ratio or differential.

An alternative metric is 'the yield', or yield-to-maturity. The yield is the internal rate of return of a bond for the holder on the assumption that the investor holds the bond to maturity. More technically, the yield is the singular discount rate at which the (present) value of the bond's cashflows equals the bond's price. The yield "serves the enormously important role of being a convenient, common yardstick for relating cash flows of all bonds to their market prices" (Homer and Leibowitz, 2013, p. 151). The strength of the concept/model of yield is that it serves as a 'common yardstick', i.e. it 'eliminates' the variety in characteristics of the various bonds, though as we will see it also excludes some underlying factors. The yield, therefore, transforms two very different bonds into two easily comparable singular numbers expressed in percentages. Assets are rendered equivalent.

Comparing between two yields also gives rise to a singular device, known as the 'spread'. Beunza and Muniesa (2005) have analysed the critical role played by the 'spread plot', a *graphical* representation that plots the difference between prices of two firms in the context of merger arbitrage. The world of fixed income, in contrast and as I have just argued, moved away from prices and practices in these markets generally revolve around yields. The spread in fixed income, therefore, refers to the difference in yield between two bonds. Phillips (1996, p. 106) reports that the spread was "the most widely used analytical device for making relative value assessments in fixed-income markets around the world”. An investor would compare two bonds, find the current spread between the two and perform a historical analysis of the spread in order to find out which bond is undervalued and which is overvalued. Buying the undervalued and selling the overvalued, an institutional investor could then increase the portfolio’s yield and eventually switch back, though not necessarily, when (and if) the two are once again in line. These new evaluation techniques in the gilt-edged market became known as ‘switching’, and they rest upon a concept of *relative* value, rather than fundamental value, operationalised through the metrics of yields and spreads.

Up until the end of the 1940s, buy-and-hold and switching techniques prevailed, together with devices of price ratios, yields and spreads, which involved “more than 1000 recorded calculations each week” and “about an hour spent each day studying these data to try to detect cheap and dear stock” as Cottrell (2008, p. 43) and Pepper (2008, p. 9) recall respectively. At this point, there were several types of yields developed by different stockbrokers. Bryce Cottrell, joining P&D just out of Oxford, developed the concepts of ‘break-even yield’ and ‘average yields’. Bernard Fison, an actuary, developed ‘zig-zag charts’ which enabled the price and yield history of two bonds to be depicted on the same chart.

During the 1950s, however, governments began to rely more actively on monetary policy and the ‘Bank Rate weapon’ in controlling short-term interest rates primarily to control inflation. And unlike the US, direct interest rates and credit controls were at first ruled out, instead using debt issuance to influence long-term rates. Using this two-pronged approach of monetary policy and debt management, the Chancellor at different points in time influenced different interest rates according to the government’s exigencies. The result was higher volatility in interest rates across the board. For instance, between 1952 and 1957, Bank Rate was raised from 2.5% to 7%, and then back down to 4% the following year and to 6% in the mid-1960s. While long-term rates never reached 5% during the 1950s, the early 1960s experienced rates which never fell below 5%, in what came to be known as ‘dear money policy’ by the Conservative Government (Wormell, 1985).

This interest rate volatility led to a realisation that the concepts of price ratios, yields and spreads were not adequate to understand the underlying risk involved in switching. As a result of the need to better understand the gilt-edged market and bond mathematics, new techniques and analytics proliferated in the market. Institutional investors, such as pension funds and insurance funds became concerned with the gilt market as a source of investment, and not just for liability-management. What were largely passive investors employing buy-and-hold strategies turned into active investors. The 'Golden Age' of government bond analysis had begun, claims Gordon Pepper, the so-called 'guru of the gilt-edged market', in 'The Golden Age of Government Bond Analysis in the UK (1961-1986)'. In effect, this period coincided with an intensification of recruitment of professional actuaries, mathematicians and economists in both stockbroking firms and investment managers.

3.3 Knowledge diffusion and new epistemic communities

In part, the rise of quantification spread outwards from the practices and research of early quantitative practitioners in stockbroking firms. This was aided by the institutionalised rules of the Stock Exchange which stifled some of the competition among strockbrokers. The Stock Exchange's fixed minimum commission system established a floor (*minimum* commission) below which commission rates could not move. This, however, also meant that as stockbrokers competed for clientele, they forced their commission rates downwards towards that floor. As such, "research was an alternative form of competition", argues Gordon Pepper (2008, P. 6), a Cambridge graduate and later actuary who started his career on the London Stock Exchange's floor and then became senior partner at Greenwell, a large stockbroking firm and competitor of P&D. Pepper claims that, unlike in the US, the microstructure of the UK gilt market in which brokers were purely intermediaries provided no incentive for brokers to withhold knowledge from their clients. While Pepper's claim is probably an underestimation of the extent of knowledge diffusion in the US market, as we will see in the next chapter, there is certainly a sense in which brokers in the UK actively sought out this knowledge diffusion as a *strategy*. They therefore *competed* on cutting-edge research which they disseminated to their clients. "The more rapid exchange of ideas in London produced an intellectual forum that stimulated research". One example is

P&D's brochure in August 1962, entitled "Some Switching Methods", which sought to parse out different switching techniques.

Pepper himself later established the Greenwell Monetary Bulletin, a regular publication that was disseminated to institutional investors. The Bulletin "had a degree of influence in the City and with the government which no comparable publication had previously attained and which has certainly not been matched since." (Robinson, 1998, p. xix). In being disseminated to institutional clients, such brochures allowed new devices, techniques, and practices to *travel* across organisations. The sociomaterial agencement constructed within the stockbroking firms spread outwards.

But this was also supported by institutional developments which allowed these objects and practices to gain hold in the investment firms. As Pepper (2008) notes, investment was part of the Institute of Actuaries's examinations since the 19th century. In the 1960s, however, seeing the increasing demand and attempting to capitalise on it, the Institute of Actuaries was on a drive to institutionalise the proliferation of actuarial work in financial markets. Hence an advanced investment exam in 1961 and a Certificate in Finance and Investment in 1963 were added. The Institute was the first to have an examination in investment, because neither the Stock Exchange itself nor the Society of Investment Analysts required formal training and qualification in investment for membership.

The institutionalisation of the actuarial profession was one development which created the conditions for more professional actuaries to enter the market through vocational training and examinations. A second development was that the actuarial practitioners in the market, particularly those within the stockbroking firms' research arms, became much more involved with the academic community of actuarial science. Knowledge that was being developed within the market by these actuaries was routinely published in journals such as the Journal of the Institute of Actuaries, the Transactions of the Faculty of Actuaries, and the Investment Analyst. The new techniques and metrics being developed were also emphatically debated in conferences and meetings organised by the Faculty or Institute of Actuaries.

While actuaries were prominent in the market, the research arms also included mathematicians and some accountants, and some work was also published in non-actuarial journals, such as the Institute of Mathematics and its Applications. Nevertheless, there is a sense in which the new market practitioners had developed an epistemic community which was largely quantitatively and analytically driven. Practitioners from competing organisations frequently met at academic conferences, communicated privately or referred to each others' work in their own. The long discussions between the practitioners at the end of the conference – documented at length in the publications of the journal papers – is one strong indication of this. The effect was an epistemic community in which devices and practices coalesced into a diffused and broadly-speaking stable sociomaterial configuration. This is what a certain L. G. Hall (see discussion in Pepper, 1964) had to say at the end of one of the conferences:

> It had been fashionable a few years earlier to inquire whether investment was an art or a science. In the more distant past it had doubtless been an art; recently it had become steadily more scientific. The author, dealing with the one group of United Kingdom securities in which there was a wide variety of terms and conditions yet no risk of default, had travelled far from the art, beyond the science, and sometimes even gave the impression of having reduced the management of a gilt-edged portfolio to an esoteric branch of mathematics.
> (p. 100)

The practitioners themselves, therefore, perceived the increasingly technical methods of valuation as more scientific than art, and felt a sense of belonging to an 'epistemic community' revolving around actuarial and mathematical expertise. The community provided spaces in which practitioners could discuss, debate, disagree and produce knowledge. Their publications, both in the various stockbroking firms' Bulletins as well in the academic journals, allowed them to share knowledge with the rest of the community and to standardise practices across organisations, even the smaller and less resourceful ones. Finally, would-be actuaries willing to join the community across the stockbroking research departments would need to undertake three years of actuarial training in which courses related to advanced investment featured heavily. Those who were not interested in becoming professional actuaries could still join the community via the Certificate in Finance and Investment offered by the same Institute of Actuaries. At least up until the early 1970s, "the actuarial profession was the only profession in the UK to have formal examinations in investment" (Pepper, 2008, p. 7) and examinations for membership at the Stock Exchange only started in 1970. This makes it likely, though quantitative evidence for it is unavailable, that at least a good number of the members of the community in stockbroking research departments went through the route of the professional actuarial training or the non-actuarial Certificate in Finance and Investment. In effect, this solidified practices and rendered them durable.

3.4 The yield curve's performativity in a new sociomaterial agencement

It is within this institutional and sociomaterial configuration that the yield curve became first enrolled, first and foremost as an object with which to understand risk, and secondly to trade on. As the previously mentioned 1962 brochure by P&D (Reader and Kynaston, 1998, pp. 87-88) claimed:

> In so far as there is anything original in our approach, it perhaps lies in our emphasis on the assessment as far as possible of the risks that are taken in the course of making gilt-edged switches; we believe that in the past many switches have been made which have been unsuccessful because of a lack of appreciation of the risks involved, and these switches have sometimes been between the most innocent and apparently similar pairs.
> …
> The chart is drawn so that all stocks on the same vertical line have the same term index and its use as a switching tool comes from the fact that it is broadly (but not precisely) true to say that stocks on the same vertical line will react in the same way to a change in interest rates. Thus if we believe that there is an anomaly between two stocks on the same vertical - let us say a 2s 6d per cent difference in yields between a pair which usually stand on the same yield - then any changes in overall market levels before the two stocks again offer a common yield should not wipe out the switching profit. Put another way, switching between pairs on the same vertical line minimises the risk of error... It should not be inferred that we are in any way opposed to the taking of risks when carrying out switches: all we are intending to do is to ensure that they are 'calculated' risks as far as possible.

The 'chart' referred to in the quote, known then as 'Term and Coupon', is an iteration of what later became known as the yield curve, which depicts yields and maturity (term). And while the brochure is advocating the use of the chart for switching purposes, it served an underlying function for investors to understand the risk of each bond and the risks involved in switching trades – "[t]he crucial long-lasting benefit of the technique was increased understanding of the market" (Pepper, 2008, p. 11).

Phillips (2008, p. 47) argues that "[i]t is generally recognised that Gordon Pepper's paper to the Institute of Actuaries 'The Selection and Maintenance of a Gilt-Edged Portfolio' in 1963 marked the beginning of the Yield Curve era." The paper dissects prices of bonds in terms of three factors: general level of interest rates, term structure of interest rates (i.e. yield curve), and deviation of the bond from the curve. The yield curve can be an opportunity for a switching operation, but the paper defines it also as a tool for the understanding of *risk*. The first factor, the level of the yield curve, affects any two bonds *differently* due to their different maturities and coupons. Suppose the yield curve moves up by a few basis points across the board. A 1-year bond's price will be affected differently to a 2-year bond's price because the general increase in the level of interest rates will increase the return of the 2-year bond for a longer period than the 1-year. In other words, bonds with different maturities have different sensitivities to a change in general interest rates. The same is also true for bonds with different coupons (but same maturity). Together, this risk is known as (modified) duration.

Practitioners therefore understood that switching between bonds of similar duration (or Term Index, or Effective Term) will minimise the risk of a change in the general level of interest rates. The method presented above, in which bonds of similar duration are presented on the same vertical lines was one way through which a practitioner could easily compare between bonds while simultaneously dealing with duration risk. But this implied that any change in interest rates will only affect the *level* of interest rates. It did not account for a change in the *shape* of the yield curve. Because yield curves are precisely that, *curves*, they rarely move up and down in parallel fashion. The curve's shape can change. As it changes, it has uneven effects on different bonds such that a switch might be exposed to 'curve risk'. Any practitioner involved in switches, therefore, needed to account for curve risk in the switching operation.

While from my research there is little evidence that practitioners actively dealt with curve risk, Pepper provides an anecdote of how he attempted to do so at Greenwell. He used the expectations theory of the term structure to model forecast the shape of the yield curve. The expectations hypothesis goes back to Irving Fisher (1930) whose main idea amounted to an early theory of expectations, further developed by Lutz (1940), where long-term rates are essentially an average (and therefore a prediction) of future short-term rates. The basic premise is that the return on holding a long-term bond to maturity is equal to the expected return on holding multiple short-term bonds to maturity (their aggregate maturity being equivalent to the long-term bond)[16]. However, Pepper claims (2008, pp. 12-13)) that the "exercise was nearly a disaster" as "the forecasts were badly wrong" due to the fact that expectations of the short-term rate mattered less than expectations of the Bank of England's 'tap stock' at the longer end of the curve.

Despite forecasting issues with yield curve models, practitioners started taking directional views using the yield curve but without attempting to forecast it mathematically. Rather, they would take a heuristic approach by building a view on where they thought rates would move and how the yield curve would behave. One of these techniques was known as 'policy switching', which involves purchasing and selling bonds with different duration and capitalising on an opportunity of future interest rate changes which affects the bonds differently over a long period of time. A market participant who held a view that long-term interest rates would fall would switch out of short-term bonds and into long-term bonds. Known today as 'yield curve flattening', a fall in long-term interest rates induces a rise in long-term bond prices (yields and prices move inversely). Therefore, if a market participant expects *today* that long-term interest rates will fall *in the future,* switching today into long-term bonds would make the switch profitable, if the view proves true, because his newly-acquired bond will become more valuable in the future once rates fall. Building a view of future rates required an understanding of policy-making and economic data. Because of this, the practice of policy switches had less immediate appeal because the quantitative-driven research arms of stockbrokers were less interested in interpreting economic data and predicting policy. Therefore, they largely opted to rely on predictable mathematical relationships.

Indeed, even more importantly, while the yield curve was a conceptual device to analyse risk, "it is as a central measure of value that the yield curve is probably most

[16] Other scholars working on similar areas also espoused the same idea (Hawtrey, 1938, Macaulay, 1938).

valuable to the gilt-edged analyst" (Phillips, 1996, p. 120). According to Pepper (1964), a simple yield comparison between two bonds misses the ways in which the bonds' performances depend on general market movements. It is only by modelling the gilt-edged market as a yield curve, and then examining changes in the yield curve that one can make a proper assessment of two bonds and their (changing) relative valuation. Pepper provides four factors that need to be considered when comparing two bonds: changes in the general *level* of interest rates, changes in the *shape* of the yield curve (e.g. whether it will steepen, flatten, invert), how the two bonds fluctuate about the yield curve (e.g. whether singular bonds are expensive or cheap to the curve), and the effect of the passage of time.

The yield curve had performative power even in those early days. Cottrell (2008) implies that traditional evaluation practices which revolved around large numbers of separate 'pairs of bonds', shifted to analysing bonds and implementing switching operations in terms of the yield curve. For instance, practitioners would employ 'weighted switches', i.e. switches that involve buying and selling two bonds the value of which is weighted inversely to their duration, so as to protect the switch from a parallel shift in the curve. However, the employment of the yield curve is especially evident in the case where practitioners would look at bond's deviations from the curve rather than from each other – a practice known as 'anomaly switching' which "was a major, if not the major constituent of overall fixed-income market turnover" (Phillips, 1996, p. 227) during the mid-1960s.

This involved a practitioner drawing the yield curve by hand, comparing the yield of a bond with the corresponding point on the curve, and making a judgement on its deviation. Crucially, the curve reconfigured sociomaterial arrangements by replacing large sets of calculations of price ratios, yields, and spreads with a singular metric. The yield curve came to represent a large number of bonds – it became a benchmark, a material embodiment of the market onto a 2-dimensional space. With the chart in hand, a practitioner could put a bond, metaphorically or materially, onto the chart and observe whether and how much it deviated. But just because a bond deviated from the curve did not necessarily mean that it held 'anomalous' value to be profited from. Indeed, some bonds lie permanently above or below the curve because of some idiosyncratic quality. A market practitioner therefore had to make a judgement on whether the bond at hand is deviating because of some idiosyncratic characteristic or due to an ‘anomaly’.

To make a proper judgement, a practitioner could produce historical yield curves and do the same process with the same bond in order to observe whether the bond today deviated ‘excessively’ from its historical deviation. That is to say, he – and it was almost always a ‘he’ - would make a judgement on whether the deviation today is higher than historical trends, in which case the bond would be judged as overvalued or undervalued relative to its historical average deviation. With the use of such charts, “[a] ‘feel’ is obtained similar to that resulting from market experience” (Pepper, 1964, p. 73). However, in practice, comparing it with a large number of historical yield curve charts was a tedious job. Instead, practitioners would still rely on their tacit knowledge to the extent that they would not need to refer to the historical charts, except for a second check. Spending many years observing and intervening in the market, practitioners often built an ‘instinct’ or ‘feel’ that would help them make such qualitative judgements. Nevertheless, relying on memory and tacit knowledge was a less precise practice, according to Pepper. The sociomaterial agencement had to be reconfigured. Enter technology.

The 1960s were years of significant technological development in stockbroking firms and their clients’ offices. New electric typewriters, telephone answering machines, monitor screens showing official market prices in real-time, were among some of these developments. Pepper (2008) recalls that until the 1960s computers were not yet available. Instead, only calculators were - mechanical calculators, desk-top and manual calculators turned by a hand-wheel, and some sophisticated Monroe calculators that were nevertheless not highly programmable. Phillips & Drew installed their first computer, an IBM 1440, in summer of 1965 (see Pardo-Guerra, 2019, for a similar discussion on the historical use of technology by stockbroking firms).

At Greenwell, Pepper intended to programme them to calculate yields and to use them for data assimilation. Cambridge had by then invested in two computers – the 1st and 2nd generation EDSAC 2. Attending a Cambridge Summer School in 1957, he later started using Greenwell’s 2nd generation LEO 2 to produce the gilt-edged yield curve. His 1963 paper’s introduction asserts that “[t]he advent of the electronic computer has opened up an entirely new field of statistical data thus making some of the old methods obsolete", and later that "with the use of a computer, a curve can be fitted accurately and regularly" (p. 73). The computer would therefore allow the practitioner to carry out the analysis in a *consistent* manner and to do so for larger sets of (historical) data. Pepper (2008, p. 10) recalls that when he first used the computer to produce such historical graphs, experienced managers "grabbed the graphs with enthusiasm and reminisced, with remarks like 'I remember that' or 'that is what happened'. The graphs had immediate appeal. Further, they tightened people's thinking". Computers, therefore, allowed for the systematisation and the precision of quantification within the practices of the research analysts and investors.

What was the performative effect of the yield curve on the gilt-edged market? On the one hand, the yield curve allowed for the elimination of excessive deviations. On the other, it congealed the various segments of the market. It is of course difficult to make a claim of performativity, especially in a historical study of this sort. Nevertheless, we can rely to a large extent on the claims of experienced practitioners who were directly involved in the market at the time. Let us take these performativity claims in turn.

Firstly, as already argued, one of the suggestions in Pepper's paper is that a practitioner could use the yield curve to exploit deviations from the curve (see also Cottrell, 2008). But this practice was not without problems or resistance. As mentioned earlier, reliance on mechanical calculators involved huge numbers of calculations and hours put in for minor profits, "making this an infrequently performed task" (Phillips, 1996, p. 120). Once computers were on the scene, this problem was largely mitigated for those with access to computer power. While it was less than straightforward for practitioners without access to a computer to be systematic and consistent in their approach, those that did have computer access still had other obstacles to overcome. For instance, Phillips reports that competing gilt-edged brokers employed different techniques in yield curve construction and fitting, thus producing different assessment of bond cheapness and dearness. Furthermore, "[f]und managers who had grown up with, and cut their teeth on, price ratios and yield differences were loath to give up using those tools of their trade, which they themselves could calculate, for the new statistics which, of necessity, they had to take on trust from an outside source." (p. 120).

As a result, while some did use the ready-made yield curves provided by the stockbrokers, many did not *replace* their own techniques and practices. In a way, they did not act as ‘model dopes’ (MacKenzie and Spears, 2014a) because they did not accept blindly the models provided by the stockbrokers, if for no other reason than the fact that they were sceptical about the new quantitative-driven analysis. Instead, they would double-check the yield curve’s implications and ‘recommendations’ by using older techniques for sense-making purposes (Phillips, 1996). Interestingly, Reader and Kynaston (1998) note that in the early 1960s a form of ‘automatic’ or ‘systematic switching’ was being marketed. This would involve “a scheme, comprising a complete set of rules, which we have developed so that an investment manager, local authority treasurer or trustee can be relieved of the need to identify and scrutinise each possible gilt-edged anomaly switching opportunity as it arises, while being satisfied that his fund will take advantage of all appropriate market movements” (p. 89). But it had limited appeal because market participants refused to entrust their decisions to ‘systematic switching’, an early form of algorithmic trading. This was also the case with some of those analysts who developed the techniques on which the algorithm was based. Indeed, Pepper (1964) himself argues that ‘statistical methods’ cannot replace human judgement. Despite the lack of uptake of such a system, it is striking that algorithms were already on the scene back in the 1960s.

Despite this level of scepticism, enough investors took up the stockbroker’s recommendations on anomaly switching to allow Pepper (2008, p. 10) to conclude that:

> When the technique was first developed inefficiencies in the price mechanism were exposed. There was an early lesson that things do not always happen in accordance with economic theory. According to theory a jobber[17] should raise his price when confronted by more buyers than sellers. This was correct providing the jobber continued to have a bull position; that is, if he still owned stock that he had not yet sold. It might not be correct if the jobber had a bear position, that is, if he had sold stock that he did not own. In the latter case raising the price would result in a capital loss when the stock was bought back. If the jobber thought that he could get away with it he would lower the price and try to attract sellers by making attractive bids for the stock relative to the new price. Offering a bargain is one of the oldest tricks in the game. Many people fall for it. In this way the jobber could often ‘job’ his way out of an unwanted position without loss.

[17] Recall that jobbers were market-makers within the London Stock Exchange.

> The new technique disclosed when the jobbers were moving a stock's price in the 'wrong' direction. For a short while making profits was embarrassingly easy. The jobbers soon learnt that the tactic no longer worked. The price mechanism then became more efficient in accordance with the efficient-market-hypothesis.

This practice, therefore, not only *exposed* price inefficiencies leading to market practitioners to exploit these discrepancies and eliminating those opportunities – similar to MacKenzie (2006)'s argument. But, the very fact that these practices now existed, and that jobbers knew about them, made them behave in such a way to 'perform' economic theory. In other words, they were disposed to do away with practices which would create those large deviations in the first place. In doing so, such deviations became less common. When they did occur, they were exploited by yield curve modelling and switching techniques.

Through this bifurcated process, we can say that the 'yield curve' was not only performat*ive* by exposing price inefficiencies, but was itself perform*ed*. A yield curve can be conceptualised as a best-fit line across a scattered plot of selected bonds. Inevitably, techniques of best-fit and bond selection involve qualitative judgements, but let us discount that for the argument at hand. The curve is only a best fit, meaning that bonds are scattered around the line and do not sit precisely on the line. A market participant identifies an anomaly by gauging how far a bond strays away from the curve in excess to its historical deviation. If a bond deviates from the curve towards the top-end of the chart, then the bond is undervalued (and vice-versa). To exploit the anomaly, a market participant purchases the bond in the hope that the bond moves closer to the line/curve and its price rises. Once the bond moves towards the line, and therefore the anomaly has disappeared, the investor can sell once again the bond and realise a profit from the anomaly because the price of the bond is now higher than when first purchased. The resulting effect of switching is that bonds move closer to the curve. The curve, therefore, becomes smoother and the fit of the curve improves. We can say that the yield curve has been performative (in allowing the identification of the anomaly) *and* performed (as bonds move closer to the curve).

Pepper (2008, p. 10) claims that while "the price mechanism became more efficient accidental anomalies disappeared but the ones for which there was a genuine reason remained". One of the clearest examples given by Pepper himself is the case of 'tap stocks', where the Bank of England as the then-debt manager would have a figurative 'open tap' to sell bonds whenever demand materialised. Because the Bank did not wish to make the market fall whenever a new issue was announced, it often made the bond's price expensive when it offered it for sale. When demand increased, the Bank would raise the bond's price more slowly than prices of similar bonds, thus making the bond cheap relative to the rest. In doing so, the Bank was creating (intended) anomalies on the curve.

But these anomalies were also later exploited. Phillips (1996) reports that the effects of 'tap stocks' would be visible on the curve. If, for instance, the Bank has an open tap on the 10-year bond, a hump or dip would be exhibited on the curve. Technical practitioners could, and sometimes did, employ 'balanced switches'. Known today as butterflies, a practitioner could structure switches by three or more bonds, selling two and buying the bond at the centre of the curve or vice versa. In doing so, a practitioner could exploit humps and dips in the curve. If enough market participants engage in this practice, humps and dips would disappear and instead a smoother curve would be performed, again. While Phillips does refer to this practice, there is less evidence that this was either widespread or even practised by the more quantitative-driven practitioners. However, writing in 1985, Wormell (p. 164) claimed that historical data of such anomalies are kept on computers and thus "[t]he speed and ease with which anomalies can now be identified makes such switching opportunities rarer than previously" precisely because they are more systematically exploited.

However, the yield curve was also performative in a different sense. Market participants often spoke of the gilt-edged market in terms of 3 segments – shorts (bonds with shorter maturities, generally shorter than 5 years), mediums (bonds with medium maturity, generally somewhere around 5-10 years), and longs (bonds with longer maturities, generally more than 10 years). There is a sense in which the market was segmented in practice, with different investors occupying different segments of the market. Early on, switches were also restricted to singular segments. The market was therefore clearly segmented. Looking at the early days in which the yield curve became a central part of sociomaterial configurations in markets, it is clear that segmentation loomed large in the way practitioners conceptualised and intervened on the market. Indeed, yield curve construction involved modelling the three segments separately and then splicing them together to achieve the curve. This is also the way the Bank of England would model the curve. However, the onset of the yield curve brought about new possibilities. It allowed practitioners to conceptualise the market as a singular one and allowed them to perform switches *across* segments. The resulting performativity was a more closely-connected market, a congealing of the market segments into a singular one (Interview PX). Indeed, Wormell (1985, p. 161) argues that "[s]witching enables the authorities to influence a range of stocks by dealing in only one." Therefore, if the authorities pushed Bank Rate up or down, or if they opened a 'tap stock' at a particular price, switching ensures that this effect of the authorities' decision would be transmitted across the curve. This is not to say that segmentation disappeared altogether, but rather that the market was more unified than before the yield curve was part of the sociomaterial arrangements in the market.

This is not, however, to say that these practices rendered gilt-edged market an approximation of the idealised 'perfect market' of neoclassical economics. Indeed, the market remained fundamentally fragile insofar as it was thinly capitalised and suffered from bouts of illiquidity in which jobbers were not able to deal with price volatility. As such, as we will see in more detail in chapter 5, it was up to the Bank of England to support this fragile market via operations of market-making and liquidity provision. The Bank acted as counterparty to the market, buying bonds in its market-making role, and selling them in its debt management function. In fact, the switching techniques and performative effects outlined above would not have been possible without the frequent and substantial intervention of the Bank of England, which was involved in the vast majority of trading activity in the gilt-edged market. As we will see in chapter 5, this is a far different market to the one that would develop - in part with the support of the Bank of England itself - during the 1980s and 1990s.

3.5 Model misfire, model entrenchment and a failed reconstruction of sociomaterial agencements

The yield curve models popular in the 1960s were statistical in nature. They were never intended to be perfectly accurate but rather an approximation, a best-fit-line across the relevant bonds. During the 1960s, the model fit of the curve with the bond data was considered as adequate, which is what allowed practitioners to employ such models in their evaluation practices. A poor fit would have exposed practitioners to regular losses which would render yield curves infeasible to employ. But this is precisely what happened in the 1970s.

As inflation and interest rates rose, the prices of older bonds fell while new bonds were issued with higher coupons, and a greater variation between bond prices and coupons was exhibited. The problem market participants faced was that, as coupons rose to highs of 18%, bonds would result in higher-coupon bonds yielding much higher than lower-coupon bonds of similar maturity. One major reason for this was due to the taxation system in place (Chalmers, 1967, Phillips, 1996), which led to two types of investors: gross investors and net investors. The former consisted of two entities: non-profit-making organisations which were exempt from both income (dividends) and capital gains, and jobbers/banks/discount houses which paid the same tax rate on both income and capital gains. The latter were other investors for whom income and capital gains were treated differently because dividends were taxed while capital gains (for gilts held for more than a year, following a 1969 decision on CGT on gilts[18]) was untaxed (BoE, 1972b, Hamilton, 1973, Wormell, 1985).

As coupons rose for new issues, such tax considerations took effect as yields for higher-coupons and yields for lower-coupons diverged. Within the same maturity band, bonds which normally would have returned similar yield irrespective of the coupon at which they were issued, began to yield differently and to increasingly diverge. The tax system, therefore, led to yields becoming much more dependent on coupons. In the absence of the tax distinctions between net and gross investors, redemption yields for all bonds with similar maturity would have returned equal yields, and the issuance of bonds with higher coupons would not have broken the relationship between gross redemption and term to maturity.

Many bonds thus started to break free from the curve and to exhibit large deviations from the model, which was understood as a phenomenon of model inaccuracy rather than anomalous pricing. In other words, the yield curve became a poor representation

[18] The battle around Capital Gains Tax on gilts between the Treasury and the Bank of England will be explored in Chapter 5.

of the world. The concept of yield-to-maturity became a less accurate measure of value while the model itself became highly dependent on the mathematical equations used and the fitting method. As a result, “the conventional type of yield curve has become less satisfactory as a descriptive device.” (Clarkson, 1977, p. 111). There were several attempts between the closing of the 1960s and the first half of the 1970s to get around this problem[19]. Some decided to exclude certain bonds lying at the extremities of the distribution of coupons such that the model’s goodness-of-fit is improved, with little success. The model values displayed by the yield curve consistently failed to capture the actual yield values and their change over time. The yield curve had misfired.

There was subsequently a rush to regain hold of and ‘tame’ the market through a new model. The most popular solution was to shift away from a 2-dimensional model such as the yield curve (charting yields and maturities) towards a 3-dimensional one. Pepper (2008, p. 14) “very nearly took a sabbatical to try to develop a three-dimensional model” but opted to assign the problem to Imperial College’s G. R. Salkin and his M.Phil and Master’s students. The students came up with several iterations of a 3-D model, but all iterations were not stable enough to permit profitable switching. Nevertheless, when Pepper and Salkin read a paper at the ‘Symposium on Mathematics in The Stock Exchange’ at the ‘Institute of Mathematics and its Application’ in 1972, it led to a meeting between R., S. Clarkson, Peter Burman (Chief Statistician at the Bank of England), and Salkin himself. The meeting gave birth to Clarkson’s (1977) ‘A Mathematical Model for the Gilt-Edged Market, submitted to the Transactions of the Faculty of Actuaries, which “ushered in the ‘three-dimensional’ era” (Phillips, 2008, p. 47).

The paper presented a model based on three dimensions: annual income, capital amount on maturity, and maturity. Rather than a curve, the model fitted a surface. While traditional yield curve models assumed linearity between prices and coupons, the 3-D model presented mathematically and pictorially their non-linearity. Pepper (2008, p. 14) explains that “[Clarkson] proved that the structure of the gilt-edged market was like a rope ladder twisted through 90°. The bottom rung, for zero term,

[19] By this time, the concepts and metrics of duration and convexity – which help practitioners evaluate and deal with price volatility, especially in the context of rising interest rates - had not yet been developed.

was straight. The top rung, for a term of infinity (that is, for an irredeemable bond), was also straight. In between, the rungs were progressively more curved, until the curvature reached a maximum, when they became progressively less curved”.

There were high hopes for the 3-D model. In the discussion following the presentation of the paper to the Faculty of Actuaries, T. Grimes felt comfortable to open his intervention by claiming that “[t]he yield curve is dead” (Clarkson, 1977, p. 149) and that other models are now superseding it. Pepper argued that, just like in the early 1960s new devices such as the yield curve were highly effective in exploiting and ridding the market of anomalies, so was the current situation highly amenable to anomaly switching through the 3-D models. Replacing the broken yield-to-maturity concept and the yield curve with another device such as the 3-D model would make anomaly switching highly profitable consistently once again. But it was not just in the practical application of the 3-D model to anomaly switching techniques that it was expected to contribute.

The new model will also be useful, argued Pepper (p. 147) in “monitoring the changing structure of interest rates by observing [Clarkson’s] parameters”. A practitioner could therefore also read the model not just as an object of valuation but as a device through which to understand the market and the behaviour of interest rates. This would depend heavily on the interpretation of the practitioners – for instance, whether to take the curve as a representation of market expectations on future rates or whether an element of segmentation exists in the market such that different actors influence different segments of the surface because of idiosyncratic needs. From an object with which to intervene in markets, the 3-D model would also become a device through which to study and understand the market. Interestingly, this would be a ‘counter’ process to what performativity scholars have explored in the social studies of finance literature, in which models are transformed from ‘cameras’ with which to study the world, to engines with which to intervene in the same world (see MacKenzie, 2006). But despite the acclaim Clarkson’s model received, its adoption in the market’s sociomaterial configurations and practice was far from straightforward. Indeed, the yield curve was by then entrenched in market practices and configurations such that it resisted being supplanted by a new model.

The 3-D model was successful in terms of accuracy and rigour. But it was a ‘failure’ in the sociomaterial sense of the term – it failed to become part of market arrangements and practices, and therefore it was also a misfire of performativity (Callon, 2010). Two reasons explaining its failure can be identified. The first reason is that the model was too mathematical and, despite how technical and in some cases mathematically trained practitioners were, its mathematical depth acted as a barrier when it encountered practitioners in the market. Pepper (2008, p. 15) claims that “Clarkson’s paper was brilliant but only comprehensible to genuine mathematicians”, referring to the “paper’s incomprehensibility”, and that its “mathematics of fitting such a surface to the gilt-edged market were horrific”. When the paper (1977) was first presented at the Faculty, this is how the first discussant, W. G. Knox, opened the discussion:

> Mr. President, Mr. Clarkson, Ladies and Gentlemen - My first introduction to this paper was hardly reassuring. In a telephone conversation with the author I think I understood him to say that only one person in the country would truly understand his paper. We were quick to agree that that person was not I. However, we do have before us tonight a paper which has been described by one eminent actuary in the stockbroking community as " an instrument to replace forever gross redemption yields " - but I wonder.
> (p. 139)

The second reason is a related but different one. The model failed to be adopted not just because of how heavily mathematical it was, but also because of its impracticality. Practitioners value parsimony. Similar to Hansen (2020), many of the current market participants I spoke to told me that they hold an aversion to highly complex and parameterised models which involve large amounts of resources, time and effort. Instead of using parameterised term structure models, participants tend to use reduced-form models such as Principal Component Analysis. A similar process was at play in the case of Clarkson’s model. While the end of the 1970s was a time in which computers were available, the 3-D model could not become a market device because it relied on judgements along the construction, testing and running processes, every step of which involved heavy mathematics. As a result, market participants were not ready to adopt the model in their day-to-day practices, with a few sporadic exceptions (e.g. Greenwell itself). In any case, being adopted by one or two stockbrokers was not enough for its *diffusion* to other market organisations.

But what was the alternative? Market participants decided to stick with the yield curve in spite of its misfires. Writing in 1996, Phillips (p. 121) argues that “[d]espite the difficulties, the yield curve continues to be popular mainly due to its ease of comprehension and the fact that its general methodology can be applied to many different bond markets around the world.” Therefore, the yield curve has an inherent parsimony which markets value. But equally, the yield curve was not replaced with the 3-D model because it was the idiosyncrasy of the gilt-edged market which rendered the yield curve inaccurate. As a model, it could still be applied to other markets especially in a context where ‘Global Macro’ trading – where traders put on positions of relative value across national markets – was just budding. Additionally, having a standard device through which to evaluate multiple markets, and which enables communication with other practitioners in *different* markets was a socially and materially relevant reason for not abandoning the yield curve. The yield curve was far from dead.

3.6 The missing piece in stockbroking? From actuaries to financial economists

The paper submitted by Clarkson to the Faculty included some terminology and concepts that would seem suspiciously familiar to someone who has even the most basic of training in financial economics. The opener of the paper went like this:

> 1.1. The market in British Government stocks in many ways resembles what might be called a perfect market. In particular, very large amounts can be dealt in, dealing expenses are low, powerful statistical techniques are used to identify price anomalies, and frequent switching operations take place to exploit these anomalies.
>
> (p. 85)

The paper goes on to present a general argument of “price equilibrium under switching action” which is defined as true “if and only if no switch exists from any one stock into any combination of stocks of the same term as that stock which results in” higher income or capital (p. 91). The paper hinges on the propositions that if two bonds have the same maturity and running yields but different capital profit at redemption, investors holding the lower capital profit will move into the higher capital one. Similarly, if two bonds with the same maturity have the same term and capital at redemption but different running yields, investors will move out of the one with lower running yields and into the higher one. If such switching opportunities exist, the gilt-edged market is out of equilibrium, and vice-versa. It is interesting that these arguments in effect amount to an argument of *arbitrage* (which is the term Clarkson himself used in a later paper published in 1989) and *efficient markets*, popular in financial economics. The paper, however, diverged from this conceptualisation to adopt non-linearity and market disequilibrium.

Nevertheless, given these similarities in concepts and terminologies between the work that was being done in the UK's fixed income markets and the work of financial economics, it is striking that at least until the early 1990s there was little interaction between financial economics and actuarial work in the UK to the extent that published work by actuaries does not even *refer* to financial economics. Van der Heide (2019) provides great detail on how UK life insurers came to value risk by moving away from actuarial prudence and adopting some of the epistemic machinery (Knorr Cetina, 1999) of modern financial economics, e.g. by modelling markets. But in the case of our actuaries sitting at the very heart of the gilt-edged market, they had been modelling the market at least since the early 1960s, and the relative valuation practices they developed (especially anomaly switching), were in many ways similar to the practice of arbitrage which developed concurrently from financial economics (see the next chapter). The *field* - in Van der Heide's terminology - of investment banking and management in the UK was more conducive to the epistemic machinery of financial economics. And yet it seems like actuaries had failed to develop practical and much-needed devices for themselves and other market practitioners around the end of 1970s and 1980s. Was the actuarial profession, or more precisely, the actuarial presence and influence in the UK's fixed income market in danger?

During this period, a simultaneous large-scale development in the microstructure of the UK gilt-edged market was underway. Reaching its peak with the Big Bang in 1986, it opened the way for national and foreign banks (especially from the US) to enter the gilt-edged market and absorb the stockbroking firms. Phillips & Drew was taken over by UBS, Greenwell by Samuel Montagu, de Zoete's and Wedd Durlacher by Barclays, amongst many others. Surely, therefore, there was space for financial economics to infiltrate the quantitative-driven and actuarial research arms of the former stockbrokers?

By the early 1990s, just after prominent financial economists – Markowitz, Miller, Sharpe – won the Nobel Prize for Economics, this issue became a hot topic for those actuaries involved in investments. In April 1990, the 1st AFIR (Actuarial Approach for Financial Risk) Colloquium was held in Paris with over 560 participants attending from 34 countries. One of the aims of the Colloquium was "to introduce the ideas of financial economists to actuaries and to make financial economists aware of the distinctive approach of actuaries" (Wilkie, 1990, p. 119). Among the papers presented were James Tilley's yield curve model based on a stochastic process, and Neave and Morgan's yield curve model based on Ho and Lee (1986), a no-arbitrage model in the risk-neutral world. The second Colloquium, held in Brighton in April 1991, aimed to "provide a forum within which a distinctive actuarial approach to financial economics can evolve" (Tomlinson, 1991, p. 509) and included two afternoon sessions on interest rate and term structure models.

Just a year later, in 1993, David Wilkie seconded by Tilley, moved a motion to the UK's Institute of Actuaries debated on March 22 proposing: 'This House Believes that the Contribution of Actuaries to Investment could be Enhanced by the Work of Financial Economists'. The motion proposed some background reading of financial economists, such as Ingersoll, Merton, Markowitz, Sharpe, Fama, and Jarrow amongst many others. The motion also introduced some of the terminology popular in financial economics, such as Capital Asset Pricing Model, Arbitrage Pricing Theory, Wiener processes, and Black-Scholes option pricing. However, it is the subsequent debate which is especially of relevance.

During the discussion, Wilkie argued that the field of financial economics is vast and influential, particularly in the investment banking and management world outside of the UK. His aim was to align actuaries with financial economists: "They are on the same side as we are; and I deeply regret that we have, for too long, treated them as opposition" (p. 398). He suggested that actuaries would do well to acknowledge and become familiar with the work of financial economics, and referred specifically to work on yield curve models:

> I am quite willing to criticise some of the assumptions of financial economists and some of the ways in which their work has been misinterpreted. My own stochastic investment model attempts to remedy some of the deficiencies of the random walk hypothesis, as does Mr Tilley's work on yield curves and interest rates. Yet there is no point in rushing into yield curve models without understanding what has been proposed by Cox, Ingersoll & Ross(5), or by Heath, Jarrow & Morton(6), or by Ho & Lee(7), amongst others.
> (superscripts in original, p. 400)

In contrast, Arthur and Clarkson among others, argued vehemently against financial economics and financial economists as a science and profession respectively. But where did the debate stem from?

In part, it had political undertones. The underlying concern for Wilkie and the supporters of the motion was that actuarial work in the investment world was on the brink of being replaced by financial economists and suffering a quiet death. Wilkie (pp. 398-400) pleaded to the House:

> Why have we allowed others to steal our clothes? … In the same year, 1952, a young student, Harry Markowitz, published his paper on portfolio selection(2). It is surprising that an actuary had not written that paper sooner … Our education system makes a great mistake in taking in good mathematicians and spending 4 or 5 years knocking the mathematics out of them. It is all too easy in this hall to get a sympathetic laugh by ridiculing those who introduce an integral sign or a correlation coefficient into the discussion. Those people will be pleased that I have used no formulae here, but, if we do not preserve our mathematical skills, then we shall end up being taken over by MBAs, management consultants or accountants. We are already in danger of losing the influence we once had in the investment field. Nowadays investment managers and market makers employ real rocket scientists, those with PhDs or good degrees in mathematics, rather than qualified actuaries. Unless we retain our mathematical heritage, we shall lose out; and unless we learn, master and improve the work of financial economists, we shall lose out again. I urge you to put aside your conceit, to resist the blandishments of the opposition, to remember your scientific background, to lay aside your prejudices, and to vote in favour of this motion.

Evidently, therefore, this was an attempt to safeguard the profession's influence in investment banks and investment management. In contrast, those opposing the motion criticised financial economics as a body of knowledge because, in their view, it relied on unrealistic assumptions. In particular, they put their finger on financial economics' behavioural assumption of rationality, simplistic linear models, and the general approach to risk. Clarkson was scathing in his criticism:

> Capital market theory is an immature and misguided science, with no relevance to the financial society in which we actually live, but how can the methods of financial economists be misguided when they have the support of the proposer, one of the most eminent actuaries of our time? Most of the methods which he applies to investment problems, from his essentially academic viewpoint, assume that the financial world is linear and in equilibrium. From my quite different practical and mathematical viewpoint, it is obvious that the financial world is far from linear and rarely in equilibrium.
> …
> I shall concentrate on the opposite of the motion, which I would express very starkly as follows: "Financial economists are guilty of promoting a narrow-minded Stone Age methodology, which has no relevance to the financial world in which we actually live".
> (p. 404)

He criticised financial economics as "rotten to the core", its general methodology as "unscientific in the extreme", and sought to warn the House "about this 'Trojan Horse of statistical trickery'" (pp. 405-406), even liking it to Marxism and Flat Earth Society. In turn, Pepper claimed that he thought that "[t]he efficient market hypothesis is correct. The deduction from it, that all price movements are the result of unexpected news announcements, is incorrect." (p. 410).

As fierce as the debate was, it was only just the beginning and, as van der Heide shows (2019), it would eventually extend to insurance risk and other areas of actuarial science. Indeed, in the following years, there were other instances when the supporters and critics of financial economics from the actuarial camp argued passionately (e.g. Clarkson, 1977). Nevertheless, the motion of 1993 was carried and financial economics made inroads into actuarial work. Similarly, Van der Heide (2019) shows that the practice of insurance risk adopted the epistemic machinery of financial economics, though not without amendments. I suggest, however, that this was not enough to save the actuarial presence in the UK's government bond market.

In the case of stockbroking firms, actuaries lost their influence and position of authority in the gilt-edged market particularly with the onset of the Big Bang, the growth of derivatives, and the rise of quants (see Chapter 4). Spears (2014) shows how yield curve models were adopted by derivative quants and turned into no-arbitrage pricing models. Similarly, I show in Chapter 4 how practitioners, especially derivative quants and arbitrageurs, also did away with the real-world valuation models which depended on historical analyses. And yet, while actuaries have failed to maintain their presence in markets, some of the valuation practices and devices which they gave rise to along the years, which we encountered in this chapter, are still very much part of the constellation of market practices and sociomaterial arrangements. In effect, while the actuarial presence on investment bank floors waned, the sociomaterial arrangements which they had built over the years remained, if in an altered state. The new quants did not conjure their configurations out of thin air, nor did they build them from scratch. Rather, in classic ANT fashion, they worked with, repurposed, and reconfigured the entrenched devices and practices which were already in place in markets.

In this chapter I have argued that the yield curve's process of embeddedness in the market was part of a larger process of quantification in the UK's gilt-edged market. I have shown how research departments were set up by stockbroking firms, which were largely led by actuaries who established new cognitive and material equipment. The interests of stockbrokers – of competition and profitability – led them to share their practices and devices with the market. As a result, the yield curve quickly became a core part of sociomaterial agencements across the City of London, assisted by technological developments. I further argued that in becoming a core 'market device', it shaped markets by 1) giving rise to new evaluation practices such as relative value and different forms of 'switching' which eliminated excessive deviations, and 2) congealing markets and eliminating anomalies. But I also showed how the yield curve misfired, and how it resisted other models from supplanting it due to its practicality and ability to standardise practices within and across markets. Finally, I explored how the larger process of quantification was itself shaped by epistemic and (micro)structural changes in the gilt-edged market, and emphasised how the rise of financial economists in markets and the 'new' sociomaterial assemblages which they constructed are in part a result of the durability of pre-existing devices, practices and arrangements. It is to the latter process of market (re)construction by financial economics that we now turn.

Chapter 4

Evaluation practices and ontological multiplicity in the US Treasury market (1970s-1990s)

In this chapter, I shift attention to the US context and lay out a parallel and related process of quantification through which the yield curve became embedded in the Treasury market. While the previous chapter has explored the ways in which the yield curve has shaped the markets within which it became embedded in sociomaterial agencements, in this chapter I follow Star (2010), Mol (2002), and Mol and Law (2002), and emphasise the 'inverse' process by which the yield curve was moulded into *multiple* objects. I argue that with the adoption of the epistemic machinery of financial economics, quants turned the yield curve into a) an infrastructural object and raw material with which to price derivatives, b) a mathematical universe(s) from which to extract value, and c) a risk object at the portfolio level against which to hedge.

Many of these developments in the US were in part the result of spill over from the technical, epistemic, material, and social developments in the UK we explored in the previous chapter. But these were enacted within a new type of agencement and by a different breed of actors – financial economists rather than actuaries. These financial economists came equipped with (and introduced to markets) a new set of epistemic practices that revolutionised finance (Dunbar, 2000, MacKenzie, 2006). Such developments led to the rise of derivatives, evaluation devices such as yield curve models, arbitrage practices and risk management tools and practices that would eventually loop back to the UK. These would later be a crucial piece of the puzzle in supporting the UK's turn towards free, liquid, and deep financial markets. As we will see in chapter 5, this was one institutional condition – a *felicity condition* – that was essential for the yield curve to move into its core role as coordinating device. Furthermore, the arbitrage practices developed in the US would be embraced by central banks, including the Bank of England, and incorporated into its models (as we will see in Chapter 6 and 7), thus rendering monetary policy more effective.

4.1 Market devices and quantification in the US Treasury market

New York, 1973. Gordon Pepper travels from the UK to deliver a keynote speech at the First Institutional Investor Bond Conference. Following two days of conference proceedings which proved "an excellent opportunity to reconnoitre analysis of bonds in the US" (2008, p. 7), he concluded that while analysis in the US equity market was more advanced than the UK, on the other hand the "UK was far ahead of the US in terms of analysis of bonds with no risk of default". Indeed, representatives from the World Bank such as Hugo Shielke visited London following the conference to "pick the brains" of the leading analysts in stockbroking firms, including John Brew from Grievson Grant, John Lewis and Bryce Cottrell from Phillips & Drew, and Gordon Pepper himself amongst others from Greenwell & Co.

Following the World Bank, another visitor was received in London by the stockbroking firms: Salomon Brother's Martin L. Leibowitz. Leibowitz himself acknowledges the London stockbroking firms in the preface of his highly influential co-authored book 'Inside the Yield Book' (Homer and Leibowitz, 2013, p. 119):

> First of all, it turned out that the London gilt firms were far ahead of the U.S. market in terms of their sophistication and even in their use of computer tools. Unlike U.S. firms, those in the United Kingdom had many senior staff members who were broadly trained actuaries with powerful mathematical backgrounds. Through his network in the United Kingdom, Sidney Homer was able to send me to London with introductions to key bond people at firms such as Greenwell and Co., Phillips and Drew, and Grieveson Grant. Our British friends were not used to such visits, but they received me with great warmth. (The three-hour luncheon meetings were unlike any I ever experienced—before or since. I think they may now be ancient history in London.) Everyone in these firms was extraordinarily forthcoming about their analytic approaches to the market. Although most of their techniques would not have worked in the United States without considerable reworking, we went to great lengths to incorporate what we could of their thinking into our analytical tools, and some of their ideas surely improved our later memoranda.

There was therefore a degree of influence transmitted from the London stockbroking firms to the investment banks in the US. For instance, chapter 6 of Inside the Yield Book, which appeared as a separate memorandum in the earlier days of Liebowitz, includes a classification of ‘bond swaps’ which resemble very closely switching techniques developed in London. Nevertheless, even if we cannot observe direct influence, there is a sense in which Liebowitz could realise that bond markets can be amenable to quantitative techniques and *successfully* at that. And while the stockbrokers in London lost some of their sophistication due to a variety of reasons, including the Big Bang in 1986, “and the ‘Golden Age of Gilt-Edged Analysis’ (1961-1986) came quietly to an end” (Phillips, 2008, p. 48), it was only starting in the US. Before we delve into the new evaluation practices developed and the role of the yield curve within them, it would be useful to provide some context on the US bond market up to the 1970s.

Practitioners who experienced the US bond market before and during the 1970s tell me that the market was neither mathematically sophisticated nor exciting. Interviewee RQ, who would later head the hedge (and options) group at Salomon, put it to me this way:

> When I was teaching, I thought equities were the market. And I can remember teaching in the graduate class and say bonds are boring, but we'll spend one night on them… And, you know, I subsequently devoted 35 years of my career on Wall Street to bonds. And that only happened because I was in the CFA programme after I finished my PhD, and in the CFA programme we had to read Marty Leibowitz's book ‘Inside the Yield Book’. And I thought that was just fascinating compared to anything I'd seen on bonds before.

Marty Leibowitz (2013, p. 115) himself claims that “bond trading was an arcane backwater”. But what kind of evaluation practices and sociomaterial agencements constituted the market?

A bond trader or investor at his desk would be equipped with a device known as the ‘yield book’, or ‘bond basis book’. The yield book was a collection of numerical tables showing prices and yields for bonds with various coupons and maturities. A core equipment in the bond market, the yield book was a component of trading and investment desks across the US market. Despite it being a collection of numbers, it involved little calculation. A portfolio manager in an investment firm might call a salesperson at Salomon Brothers who would quote him a bond price, say 76.71[20], for a bond carrying a coupon of 2.5% and which matures in 24 years and 6 months. The investor, upon hearing the price, would need to turn that into yield in order to allow him to compare the bond to other bonds, as explained in the previous section. He would find the yield book section which shows the yields and prices for a 2.5% coupon bond, turn a couple of pages in order to find the page which includes the range of maturities within which the bond in question can be found, run his finger horizontally until finding 24-6, and then run his finger down in a vertical manner until he finds the price. Upon finding the price, he would run his finger leftwards finding the yield, i.e. 4%. Often, the price quoted would not match perfectly the prices on the yield book, and so the investor would need to identify the two prices between which the quoted price is found, and perform a quick calculation (known as interpolation) in order to find the right yield. In some cases, the dealer and investor would agree on the yield basis of a bond, rather than price, and therefore the final few steps would follow the reverse order.

Just like the concept of the 'yield' in the previous section, the yield book as a material device allowed market participants to compare between bonds of different qualities on a uniform plane. However, while the yield book served this purpose in the evaluation practices of market participants, it would soon become obsolete for two different but related reasons, the first practical/technological and the second epistemic. Firstly, rising interest rates in the 1960s and 1970s meant that the yield book had to keep up with them, which made yield books thicker and thus more cumbersome for the dealer and investor to convert prices into yields or vice versa in a short span of time. Concurrently, it was also a time when computers began to appear on trading floors, and Marty Leibowitz was the first person to man a computer at Salomon. This is how he remembers it:

> The traders and salesmen were generally kind to me. They became even kinder when I was able to develop a package of computer programs that facilitated a number of trades. Also, with my little time-sharing terminal, I could determine the yield for any given price with great speed and accuracy. However, the traders were themselves

[20] Prices were generally quoted as a percentage of par (the amount of money to be repaid at maturity). In most cases 'par' was 100, i.e 100%, and therefore 76.71 is a percentage. A bond priced at 76.71 is a discount bond because it is trading at a discount to its par value. Furthermore, for trade execution, bond prices are quoted in increments of 1/32, meaning that traders would need to convert this first.

> very adept at using the look-up tables—their so-called "yield books"—to find the yield values required to complete their trades. So, at first, my "high-tech" yield calculator was just a curiosity. But in 1970, when interest rates moved higher than the levels available in any of the traders' yield book tables, I became the only game in town. Senior partners lined up in front of my terminal, desperate for the number that could confirm their latest trade. Needless to say, this boosted my standing on the floor, although it put me in a harrowing position in which any mistake could prove fatal. In a curious sense, one might say that I benefited from interest rates moving "outside" the yield book.
> (p. 116)

Interestingly, it is here that we can observe the materiality of devices. In this case, interest rates moved 'outside' the yield book – the terminology of which is itself telling on how central the yield book was to evaluation practices. The yield book, therefore, had some real material limitations, because it did not capture higher interest rates[21]. The central computer manned by Leibowitz proved to be only a temporary solution, and it soon came to be replaced by multiple desk-based or handheld calculators, firstly by the Monroe 1272 and later by the popular Monroe 360/65 Bond Trader, which could do the job previously done by the yield book.

The second reason was epistemic, and it is through this development that the yield curve became an important tool in sociomaterial agencements. With the encouragement of Sidney Homer, a bond manager known as the 'bard of the bond market', Marty Leibowitz started applying mathematical techniques to bonds, primarily for analytical purposes. In a parallel development to the London stockbroking firms in the 1950s and 1960s, Salomon Brothers established a research department, led by Leibowitz, which was soon to propel Salomon to the forefront of the market's fixed income expertise. As Salomon began publishing memoranda and disseminating them to the rest of the market, many market participants attempted to resist Salomon's analytical techniques and results. For instance, Henry Kaufman recalls that market participants "had come to rely upon these yield books as gospel, with all too little understanding of the underlying mathematical and financial concepts."[22] As a result, when the first Memorandum explaining how bond return depends crucially on

[21] One is immediately reminded of a similar issue in 1986, at Chernobyl, when the Geiger counter measuring the radiation levels following the nuclear disaster failed to capture the higher radiation levels due to the material limitations of the device, with dire consequences.

[22] It is useful to remember that Salomon's yield books were not the first on the market.

compound interest (and not simple yield-to-maturity) was published, "it was viewed by many readers as an attack on the sanctity of the standard yield measure [and] [t]here was considerable outrage among many of the crustier members of the bond community" (p. 118).

This was just one of the changes in fixed income markets that Leibowitz himself contributed to. During the 1970s, for instance, he published several papers that dealt with bond portfolio optimisation, ranging from the effects of taxation of bond portfolio return, to how to use Macaulay duration for portfolio immunization[23]. In doing so, he brought to the mainstream several concepts that are now common in the investment scene. The papers were, however, targeted primarily at institutional investors such as insurance and pension funds who viewed bonds as safe assets and took a long-term view towards investing. It was only the rise in interest rates at the end of the 1970s and early 1980s, exposing the inherent riskiness of bonds, which led Leibowitz's research effort to grow in size and scope, and to be directed towards other areas of finance, from derivatives pricing to proprietary trading.

The so-called Volcker shock of 6 October 1979 was a major turning point for the bond market. As the Federal Reserve switched from targeting interest rates to targeting the money supply, it allowed the markets to determine the price of reserves and wider interest rates. Price volatility in the Treasury market ensued. It was not just investors who realised that volatility could be fatal for them. Investment banks' trading desks, such as Salomon's, held large inventories of bonds that would decline in value at any moment (Derman, 2004). They had to somehow deal with this 'new' form of risk. They found their answers in derivatives and risk management, and this required an understanding of derivatives and new practices of risk management which was fertile ground for 'the quant' (see Spears, 2014).

[23] Macaulay duration, termed after Frederick Macaulay, is the bond's cash flow weighted average maturity. The weighted average is a function of the cash flow's present value and the bond's price. Macaulay duration is a favourite technique of portfolio managers in their portfolio immunisation strategies.

4.2 The rise of quants, derivatives, and the risk-neutral world of no-arbitrage

Quants, or quantitative analysts, were PhDs in engineering, physics, mathematics, who would soon revolutionise financial markets. Leibowitz envisioned a highly quantitative research team, and they started to recruit ‘quants’ as part of what came to be known as Salomon’s Bond Portfolio Analysis (BPA) group. Amongst them was John Meriwether, a young MBA from the University of Chicago, who would later rise to stardom within Salomon itself and as one of the founders of Long-Term Capital Management. Dunbar (2000) reports that it was Meriwether who, just a few days before the Volcker shock, came up with the idea to hedge a $1b bond underwritten for IBM using futures. This required an understanding of the yield curve as raw material in practices of derivative valuation and risk management. In what way?

By 1980, despite the fact that digital technologies had supplanted yield books, market participants still conceived of bonds as an asset that gives off a set of coupons over a period of time. In the early 1980s, however, bonds came to be seen as a series of cashflows, or ‘zero-coupon bonds’. Zero-coupon bonds are bonds which do not pay coupons but provide their holder the face value of the bond when it reaches maturity. In effect, therefore, a regular bond which pays annual (or semi-annual) coupons can be conceptualised as a *series* of bonds. The dealers at the investment banks soon realised that they could ‘strip’ a regular bond into a number of zero-coupon bonds. Logically, the price of the bond should equal the sum of the zeros’ prices. If the prices are not equal, then a trader could realise a profit by selling the bond and buying the zeros, or vice-versa. Although the Treasury and the Fed resisted the development of the zero-coupon market, the investment banks engaged in some early financial engineering to sell zeros – Merrill’s TIGRs, Salomon’s CATs, Lehman’s LIONs (Stigum and Crescenzi, 2007). The US Treasury soon saw the potential in such a market and developed its own STRIPs programme with the help of Salomon’s BPA (Interview ZP). The zero-coupon market was born.

But the lasting influence of this was less in the construction of a market for zero-coupons and more in the epistemic space. In line with arbitrage thinking, the arbitrage-free valuation approach differs from traditional pricing in which bonds are valued by discounting it using a singular discount rate. In contrast, the concept of zero-coupon bonds gave rise to the idea that any fixed income product is fundamentally a series of future cashflows that can be replicated with other instruments if properly calibrated, and in which the law of one price holds. The arbitrage-free valuation approach hinges on an iteration of the yield curve, the theoretical zero-coupon curve (spot curve or 'the term structure of interest rates'). Rather than discounting a bond or fixed-income product using a singular discount rate, this approach takes the spot curve as a series of discount rates which should be applied and matched to each cash flow (remember that a bond is now a *series* of cashflows).

While the yield is still, to this day, a useful metric by which a market participant can quickly compare a bond against another, the theoretical yield curve is a fundamental building block and device in the practice of derivatives pricing. It is a mathematically 'cleaner' object that is able to standardise across fixed income markets – bonds, bonds with embedded options, swaps, interest rate options amongst others. No-arbitrage thinking took hold on the pricing of derivatives early on at Salomon's BPA. Spears (2014) points out that early pricing techniques for linear derivatives such as swaps[24] and FRAs[25] most likely involved the use of a single discount function rather than a discount *curve*. Pricing techniques of that sort therefore resembled traditional bond pricing. Interviewee RQ confirms to me that the use of discount curves was a 'big sea change' at Salomon:

> I was really in the forefront of a lot of things. I'd say that we did a lot on valuation of swaps. I was one of the authors with somebody from corporate finance and three people from the desk on the first paper on how to value swaps. Janet Showers, who is the woman from corporate finance, she and I independently came up with five different ways to value swaps. And they all were the same, so we felt pretty comfortable that she and I were right... Initially, we thought of them as 'I'm giving you a short-term bond, and you're giving me a long-term bond'... The trading desk told us, we were absolutely wrong, because swaps didn't involve a transfer of principal at the end. So we couldn't possibly be right. Ultimately, we were right for par swaps. At one point, there was a zeros trader at Salomon Brothers, a fellow named Mark Wilkerson… he went from the zeros

[24] Swaps here refer to an over-the-counter derivative contract where two parties exchange sequences of cash flows over a period of time. These are not to be confused with the *practice* of swapping, where traditional investors would exchange one bond with another.

[25] Forward rate agreements (FRAs) are over-the-counter derivative contracts which set the future interest rate to be exchanged on a notional amount and on an agreed-upon date. FRAs differ from swaps because the contract stipulates the interest rate for a one-time exchange between the parties, rather than a *series* of cash flows. In effect, FRAs are equivalent to a single-period interest rate swap.

> desk to the swaps desk. And he came back to me one day, and he said, “You know, I'm trading swaps now. And when I think of it as just a collection of cash flows, why would I price those flows any differently than I priced zeros?” “Yeah, you're absolutely right.” And that became the big sea change at Solomon Brothers, when everything began to be priced off the spot curve.

Clearly, therefore, it was not simply a question of knowledge production by the BPA group which led to the spread of arbitrage thinking across markets. In this case, as the trader moved from one desk to another, he transferred knowledge and practices tied to a particular desk, the zeros desk, to another desk. In doing so, this opened the way for other fixed income derivatives and desks to be amenable and to be moulded into a particular sociomaterial agencement.

In turn, this also pushed the BPA itself to produce knowledge in the area. For instance, the first papers published by Thomas E. Klaffky, who would later head the BPA under Marty Leibowitz, were precisely about zero-coupons. The first, in August 1982, was entitled “The New World of Coupon Stripping”, while the second in October 1982, “Coupon Stripping: The Theoretical Spot Rate Curve”. According to Emmanuel Derman (2004), one of the earlier quants on Wall Street, Klaffky’s “claim to fame at Salomon was his participation in the creation of the zero-coupon Treasury Strips out of Treasury bonds.” (p. 187).

During the rest of the 1980s, the BPA developed significant expertise on derivatives such that internally they became central to the operations of financial engineering. Salomon’s subgroup on corporate finance were, in the words of Interviewee RQ, “creating things that our software was not designed to handle. So we were always faking the software into doing things it wasn’t designed to handle”. The BPA members were therefore not purely producers of knowledge. They were also engineers, or software developers, who tweaked and reconfigured the material infrastructure of the firm. And it was not just the firm who turned to them. According to Derman, the BPA were writing “high quality, well-written pieces that straddled and almost dissolved the border between academia and practice” and “[i]t was their publications you turned to if you wanted to understand how to value swaps and swaptions before the necessary methodology appeared in textbooks” (Derman, 2004, p. 176)

At times, the material infrastructure itself failed. When the Kingdom of Denmark issued a bond that included in it a warrant to buy, the early quants at Salomon realised that what they were looking at was effectively an option. As we have seen, option pricing had by then become popular on the equity side. But this was the first option on the fixed income side, and it involved tweaking the material infrastructure in a way that rendered it workable in the fixed income space. A calculator with an embedded option pricing function – the Black-Scholes model – had just been introduced at Salomon. The quants adjusted the model to account for the dividend rate (which earlier versions of Black-Scholes did not account for) and adjusted the semi-annual coupon payments of the bond into quarterly dividends. Once they priced the model, they took it to Lou Margolis, a salesperson on the equities floor, for a check:

> And I said, 'so here's what it gives you. And here's what it's worth'. And Lou Margolis said, 'That number's way off, it's not worth that at all'. I said, 'no, watch!' And I started to key in the numbers. And he says, 'Don't give me that! If that option's worth that I can buy that bond, short two options and I'm protected up and down 300 basis points. And so that price is wrong'. So there's some guy who sees option prices all day long and thinks about them. We went back and checked. It turns out that the model put the hooks in to put in the dividend rate but ignored it. But I thought that was pretty amazing that this equity trader can immediately intuit that that price was wrong. And we had no insight like that.
> (Interview RQ)

Interestingly, the earlier quants at Salomon lacked the tacit knowledge that a person on the trading floor who is in constant touch with flows and prices develops. By the mid to late-80s, however, the BPA (and later arb desk) had developed such expertise that they would tell other desks when they were mispricing some derivative or other. However, this was only possible once a sociomaterial arrangement was in place, one in which yields curves, iterations of them, and their modelling were turned into embedded infrastructure.

The problem of option pricing in fixed income was an urgent one in the mid-1980s. A decline in interest rates meant that holders of bonds, such as institutional investors, were getting lower returns. In consequence, they began selling bespoke over-the-counter call options[26] against the bonds they held. The investment bank would tailor the option for the fund and buy it from them at an extra fee (the compensation for the risk taken by the bank). But a call option required a model that determined its price and risk. As we have seen with the case of the bond warrant, the early practice of pricing bond options was 'simply' one of adopting and tweaking Black-Scholes. As Derman (2004) recalls, the most *apparent* problems with the model were in its materiality. A trader or salesperson would need to type in a significant amount of data, sometimes repetitively to achieve different scenarios, which made the process time-consuming and impractical. The earliest model at Goldman, for instance, was so cumbersome that the bank and its client could take two days to strike a deal. Constructing a workable agencement was a daunting task:

> And one thing that's really kind of interesting and important is because the world was moving so quickly, and these opportunities in different markets were developing so quickly, you kind of were like, you know, building the engine while the bus was going down the road. The systems weren't there, the models weren't there, but people saw the opportunities. And a lot of the work was just being done on Excel spreadsheets. And when trades were done, they were written on tickets on pieces of paper, sometimes with options with, you know, specialised terms, and just sort of thrown into a closet. (Interview CL)

Beyond the material infrastructure, the more urgent task was in the theoretical inconsistencies these early models embodied. Black-Scholes was written for the stock market – stocks guarantee no future returns and they do not expire (maturity). In contrast, bonds make regular payments, have specific maturity dates, and require a model to restrict the maturity price to the principal. The early quants were able to persuade their models to respect these constraints. But the models suffered from a serious theoretical limitation that breached no-arbitrage principles. Unlike stocks, bonds are intimately related to each other because they 'sit' on a yield curve.

Let us take the yield curve as a representation of the future - after all, bonds are claims, not just in numerical value terms, but as *assertions* about the future. If we stand at the

[26] Call options on bonds are contracts that give the buyer the right, but not the obligation, to buy a bond at a prespecified price within a prespecified period. In effect, they are a bet between the two contracting parties that the bond's price will be in excess (for the buyer) of a prespecified price in the future. While the seller of the option receives an initial premium, the buyer has the right to exercise the option if the bond price does exceed the prespecified price. In the event that it does, the seller of the option has to deliver the bond at the prespecified price even if it is worth more today.

zero-point of the yield curve looking along the x-axis (maturity) towards the, say, 30-year horizon, and collapse the bonds into cashflows each spread over some time period, the cashflows will overlap because they are claims of the 'same' future. A bond issued by the UK Treasury today and which expires in 10 years embodies within it another bond issued today by the UK Treasury expiring in 5 years' time. Put differently, in five years' time, the 10-year bond will be a 5-year bond. In practice, therefore, one cannot treat bonds as independent objects because they are claims of the same future. As Derman (2004, p. 155) argues, "the yield curve is a continuum, a string or rubber band whose every point, at any instant, represents the yield of a bond with corresponding maturity".

The concept of zero-coupon bonds (i.e. treating bonds as cashflows) is one which renders bonds mathematically *substitutable, interchangeable, equivalent*. A 10-year bond is a collection of ten 1-year bonds just like a 5-year bond is a collection of five 1-year bonds. Bonds, from an arbitrage perspective, are therefore interchangeable. We will return to this issue in chapter 6, but suffice it to say at this point that treating them as independently of each other would breach arbitrage principles. And yet this is precisely what the early models migrating from equities to bonds did. Derman (2004, p. 154) notes that these models "had no way of enforcing this equivalence" and that the only solution would be to "build a model of the future evolution of all bonds, that is, of the yield curve itself. This was our aim."

The resulting models were arbitrage-free interest rate models such as Ho and Lee (1986), Heath et al. (1992), and Black et al. (1990). The models are theoretically and practically attractive due to the fact that the concept of the replicating portfolio eliminates the need to take real-world probabilities into the equation. In other words, while in the 'real-world' the price of a derivative would depend on market expectations, the replicating portfolio turns market actors into risk-neutral ones and therefore their expectations become irrelevant. The model would, therefore, take every price path of the derivative, construct a risk-neutral probability, and determine the price on the basis of this probability. Such a model was in the spirit of the equilibrium models by Vasicek (1977) and Cox-Ingersoll-Ross (1985), which applied a stochastic process to a single rate, the short-rate.

Spears (2014) documents in great detail the migration of term structure models (or yield curve models) into arbitrage-free approaches and risk-neutral pricing. Models which inhabited a particular form of epistemic culture – general/partial equilibrium economics and monetary policy – migrated into a new epistemic culture, the arbitrage-free financial theory. As they migrated, these models were transformed into a different object. Rather than an epistemic tool through which one could understand interest rate behaviour, they turned into a pricing/hedging tool in the context of derivatives markets. Within this modelling practice, yield curves were no longer an output, but an input. As an input, the yield curve is the primary 'model object' to which the model is calibrated. Calibration to observed prices implies that the model *precisely* matches the prices of the underlying instruments, because it is those underlying instruments that a market actor would replicate and use as hedge.

Furthermore, these models needed to become infrastructure before they could be functional. One of the earlier quants on Wall Street, for instance, tells me that when these models first developed they were not used immediately because "to calibrate them was very difficult, to put them into operation was difficult" (Interview CL). However, once they did become part of the material infrastructure, they became an essential component of the agencement (Spears, 2014). Therefore, the yield curve, or more accurately the discount curve (e.g. of cash securities such as bonds), has become a core object in the sociomaterial infrastructure in and through which a vast and growing architecture of derivatives markets are constituted.

4.3 A trip from Salomon to Salomon North and beyond: Practices of fixed-income 'arbitrage'

In the previous section we have explored the process by which the rise of derivatives was entwined with a parallel sociomaterial, if messy, one in which quants came to build interest rate and yield curve models to price these derivatives. We have seen how Salomon's BPA was central to this process, not just within Salomon itself but also across Wall Street, and how it was underpinned by the adoption of no-arbitrage principles in a risk-neutral world. In this section we will explore another process in which a set of financial economists within the BPA led by John Meriwether disengaged from the BPA in order to build a sociomaterial agencement, the 'arb desk' and later the hedge fund Long-Term Capital Management. A lot has been written by sociologists about the far-reaching effects of arbitrage practices (Beunza et al., 2006, Hardie, 2004, Hardie and MacKenzie, 2007a, MacKenzie, 2006, 2003). This section takes a slightly different approach by looking at the ways in which the sociomaterial agencement was constructed and the practices which constituted it. In particular, it gives special attention to the way in which the yield curve was moulded in process.

We have already seen how bonds came to be seen as a set of cashflows, equivalent claims to a 'singular' future. From the viewpoint of no-arbitrage, assets of similar risk should hold equal expected rates of return. This was, however, a strong assumption that was theoretically attractive because it made derivatives pricing more straightforward. In practice, the law of one price often failed. Meriwether realised that deviations from the law of one price presented profitable opportunities that can be exploited by employing precise trades and hedges. Dunbar (2000) claims that it was Eric Rosenfield who first convinced Meriwether about the potential of solving the yield curve mathematically, which would consequentially lead to identifiable profitable opportunities.

The result was a sociomaterial agencement – the arb desk. In financial markets, the term 'desk' is more than just a physical desk. The term itself as used by market participants is semantically close to the concept of 'sociomaterial assemblage'. A desk is a collection of humans sitting around a desk, a trading terminal involving computers, screens, and bespoke telephones. The arb desk, in this case, was made up of traders, the theory of arbitrage and financial economics, large databases, computer terminals and the like. The cognitive space, as a crucial element of the sociomaterial agencement, within which the desk worked and around which the whole operation revolved was *the yield curve*. In this sense, the yield curve was moulded and reshaped into a new object - an epistemic object. It served as the arb desk's *world*, a mathematical space around which the daily practices of the desk would be framed. Meriwether set up the arb desk on Salomon's fixed income trading floor and 'poached' a number of individuals from the BPA to run the operation with him. The aim was that the operation would be heavily research-based, and that the team would apply theoretical principles and devices from financial economists.

But how was this different from a traditional trading desk? In one respect, the arb desk would not seek to take directional views like a traditional desk would. Their focus was less on the future behaviour of interest rates and more about exploiting predictable, mathematical and mean-reverting relationships which had temporarily dislocated. In line with the law of one price, they identified similar financial instruments which theoretically should be priced close to each other, but which had breached the law of one price. Their positions, therefore, were not outright purchases or sales of singular assets but of *relative* value. By going long one asset and short-selling another, they would be market-neutral. In other words, they would neutralise the directional risk of the market. Once their positions are on, they would wait until the two assets *converged,* which is why it is often referred to as 'convergence trading'. Convergence between the assets would normally take several weeks or months, which is the second respect in which they differed from a traditional desk which had a much shorter trading horizon, often days or even minutes. Thirdly, because they were not going outright on assets, the price differences of the assets would normally not diverge excessively, which meant that the profit opportunity from the trade would be miniscule. As a result, the arb desk required significant leverage, financed via repo operations and collateral, to magnify the profit opportunity.

Such practices of long-term, leveraged arbitrage (or, more precisely, convergence trading or relative value[27]) could be employed to a large universe of financial assets, from government bonds to the most exotic of instruments. The earliest focus by the arb desk was the government bond 'Treasury' yield curve. The traders would desist for a moment from looking at the yield curve as a totality and instead zoom in on a local part of the curve. Just like the Hubble Deep Field astronomers zooming in on a tiny patch of the observable sky discovered new constellations of galaxies, so would traders zooming in on a tiny section of the yield curve make new discoveries and observations of mathematical relationships and anomalies. Unlike an astronomer, however, the traders sought to *intervene* on the world they are observing by kicking anomalous prices back into line, in process picking up profits from the converging relationship.

One of the first trades of this sort, even preceding the arb desk, was the on-the-run and off-the-run trade. In 1987, a sudden high volatility in the equity market resulted in

[27] A discussion on what 'arbitrage' *is* will be reserved for chapter 6. While cognizant that the term in financial economics refers to 'pure arbitrage', I will be using the term here to refer to practices that LTCM followed, which would very probably be termed as 'risky arbitrage' by financial economists.

a ‘dash for cash’ and flight to safety in which market participants look for liquidity in safe asset markets, this case in the government bond market. As market participants scrambled to buy the on-the-run long-term bond (i.e. the newly issued and actively traded 30-year bond), the increased demand for this bond pushed up its price. In contrast, no sudden increased demand was experienced by an (almost) equivalent bond, the off-the-run long-term bond (a 29 ¾-year bond) which did not move as much. The arb desk sold short the former (which was overvalued relative to the nearest bond) and bought an equal amount of the latter. They then waited until the price relationship was restored and racked up more than $100 million in the process (Bookstaber, 2007).

Such a trade, however, was not incredibly sophisticated and did not require complex financial theory and mathematics. Indeed, this trade was also one regularly put on by the traditional bond trader and it is not very far off from what the UK actuaries in the previous chapter would be doing. One of the elements in the sociomaterial agencement which distinguished the arb desk from the rest was its proprietary term structure model, built by William (Bill) Krasker, a Princeton graduate and former Harvard professor who joined Salomon’s BPA group in the 1980s. A former Salomon trader (Interview LP) explained to me:

> [They] thought of the yield curve in terms of the two plus affine model. These people consider the yield curve to be some type of mythical beast that we approximate with mathematics. Their high priest was a fellow called Bill Krasker, who devised the 2+ model so he could evaluate swaptions vol versus caps and floors vol on the same yield curve and thus in the same book.

The previous section has explained how declining interest rates pushed investors to sell call options. These call options, however, were often part of a package, where large companies who required funding would sell callable bonds. As part of this package, the company would issue the bond to the investors but hold an option to call the bond if interest rates decline. While this would enable the company to re-finance at lower interest rates, in practice the company was happy to sell the option to the investment bank as a swaption and realise the value of the option. The sale would involve a swaption[28] between the investment bank and the company. During the same

[28] A swaption is a derivative contract which gives the owner the right but not the obligation to enter into an underlying swap. Often, the term swaption refers to options on interest rate swaps.

period, borrowing companies were demanding interest rate caps[29] so that they could lock in the lower rates (Dunbar, 2000). The result was a complex set of instruments, transactions and cashflows that pushed prices up and down. Other investment banks failed to realise that these markets were all connected. But Salomon's arb desk, acquiring information from the client-facing side of the firm, did.

The arb desk had already built significant knowledge on how to trade and *price* options. Often, the client-facing side of the firm would even ask the arb desk on how to price an option. But the problem of interest rate caps and swaptions was more complex than simply pricing a singular option for which a one-factor yield curve model would suffice. The yield curve required reworking and reshaping. It required a trader to evaluate the volatilities of *two* kinds of options on the *same* yield curve, as my interviewee above told me. The task was given to Bill Krasker whose solution was a 2-factor model which could evaluate caps – as options on the short-term floating rate – and swaptions – options on a long-term rate – *together* (Dunbar, 2000). The sociomaterial agencement was taking shape.

The model "was the citadel of intellectual capital for the group" (Bookstaber, 2007, p. 85). Unlike the short-rate one-factor model we encountered in the previous section, the two plus model is a 2-factor model that treats the yield curve as two factors – the 2-year and 10-year bond rate. The model is a parametric model using stochastic differential equations, involving two main parameters. The first determines the slope from the overnight rate to the 2-year, which effectively models the short-term central bank reaction function as the 'decay factor'. The second parameter, which interacts with the first, determines the slope between the 2-year and 10-year rate (Interview KG). The model also included an additional parameter that adjusts for volatility (Interview CL). The latter was a way to mathematically represent 'gamma'[30], i.e. the non-linearity of convexity[31]. The model would be calibrated to the observed yields for

[29] An interest rate cap is a derivative contract in which the buyer receives payment when the reference rate exceeds the strike rate.

[30] Within the structure of the model, gamma represents the decay on the yield curve slope factor. Once the 2-year and 10-year are fit, the model would be 'distorted' by the effect of convexity. The parameters within the model were generally fixed thus giving the model its stability. Nevertheless, there were instances when the parameters needed to change, which would require major pieces of research and internal debate.

[31] Convexity refers to the non-linear relationship between a bond's price and changes in interest rates. Earlier we mentioned the notion of duration, which refers to how a bond's price changes as interest

the two factors, thus taking the market yield curve as given rather than interpreting whether the market is right or what it is saying. Observable market yields are therefore inputs to the model, and the model itself "will rationalise where things should be based on where things seem to be" (Interview CL).

In the previous section, we have briefly seen how financial economics models such as Vasicek and Cox-Ingersoll-Ross were adopted by quants on investment bank trading floors and transformed into derivatives pricing tools as short-rate interest rate models (e.g. Jarrow, Black-Derman-Toy etc). The two-factor model employed by the Salomon arb desk embodies the same arbitrage-based approach:

> If you wrote a paper on it, it would look sort of along the lines of two-factor Cox-Ingersoll-Ross model. It was a good academic paper that would be adding certain features, namely volatility as another quasi-factor to a two-factor model. Just like the Cox-Ingersoll-Ross model or any others, it was expressed with stochastic differential equations.

As the model migrated to the arb desk agencement, however, it was to be used for a different purpose and thus needed to be transformed into a tool of valuation rather than pricing. Indeed, the model served as "a metric for judging value… because you can't just look at yields as a metric; you have to strip out the curve, the convexity, the risk premia, and the level of rates and then say 'What's left? What's my residuals?'" (Interview KG).

The model served two functions: one as a tool to manage risk, and the second to identify value and opportunities:

> Most of what we did when we talk about relative value, every trade we did, by default was hedged to the level and the slope of the curve. And that model would determine those hedge ratios, and it will also determine what's cheap and rich. So for example, if you trade the 2s5s10s, if you think the five's cheap, you'd sell 2s, sell 10s, buy 5s. That model will give you the ratio of how to trade and there will be 50:50, typically 60:40, something like that, because of the volatility of the points. And it would also be the metric of how cheap or rich is the five year, so it gives you a trading signal to get in and out.
> (Interview KG)

In practice, the model was more useful as a measure of risk. We have already seen how a trader on Salomon's arb desk would not go long or short outright, but would

rates change. Convexity is effectively a measure of the sensitivity of duration (i.e. the sensitivity of a bond's price change to changes in interest rates).

take on ‘pairs’ which would neutralise the effects of market directionality on the specific trade. However, at the portfolio level, a trader would still have accumulated some risk due to the correlations between the multiple trades within the portfolio. Hence, the term structure model served as a tool with which to eliminate the market risk on the whole portfolio by recommending the hedges. What is important is “having it be a measure of risk so that you get a good sense of how much you might lose, if rates, if the yield curve shifts. And you can interpret the interrelationship of different points on the curve.” (Interview CL).

The model was a closely guarded secret. In part, this was due to a strong sense of intellectual property within the agencement. The desk feared that if others outside of the agencement learned all about their practices, they could set up their own desk and eliminate the opportunities themselves, or even worse, trade against them. For instance, interviewee RQ remembers:

> There wasn't much communication. They insisted that everything they did was proprietary. And if we worked on a project for them... One time I wanted to put a guy on a project. They said, “and then you have to promise me that he will never talk to a customer again. Because he might tell them something”. So there was really a line.

Bookstaber (2007, p. 80) recalls that they would frequently use a special kind of paper “used by the US government for sensitive documents: dark red with a zigzag of fine black lines that made the text almost unreadable but prevented it from being photocopied.” Information flowed in more frequently than out. The arb desk, therefore, created strong boundaries around the agencement and a culture of secrecy. There was a sense in which the arb desk was like an independent firm within Salomon – traders had different salary and bonus levels and structures. This culminated in 1991, when Meriwether left Salomon following a scandal when Salomon was outed as having been cornering the market for Treasurys, and he set up an independent firm by the name of Long-Term Capital Management.

In 1994 LTCM started trading. Once again, Meriwether had poached several star individuals from Salomon and its arb desk, amongst which were Victor Haghani, Myron Scholes, and Eric Rosenfeld. The influence of Salomon was so strong that the firm would frequently be referred to as ‘Salomon North’, the ‘North’ referring to the fact that it was based in Greenwich, Connecticut, i.e. north of Salomon. Dunbar (2000) reports that the LTCM agencement was made up of traders and models, but also of quant strategists who design models, junior traders who execute the trades, risk managers, and outsourced pit traders and back office.

LTCM replicated a lot of the trades that were successful on the arb desk. For instance, they frequently put on the on-the-run vs off-the-run trade in different bond markets and with bonds of various maturities. At times, they stepped back from the minute examining of the yield curve and looked at it as a totality. A common trade of this sort was the ‘yield curve trade’, and specifically what is known as a butterfly or three-legged trades. Interviewee KG tells me that these trades were the core of what LTCM would do in the fixed income space. Yield curves are often smooth, but at times they become humped or exhibit a kink. This could be due to an idiosyncratic reason, such as bond issuance by the Treasury or financial regulation. This could present an opportunity for a relative value trader who wishes to exploit the kink or hump depending on the trader’s view. In the UK market, for instance, LTCM would go long the 10-year and short the 5-year and 30-year sector using swaps in order to be able to lever it up. Buying the ‘belly’ of the butterfly and selling the ‘wings’ implies a trade that would be successful if the middle section (belly) becomes more expensive relative to its wings. In other words, it implies a view that the yield curve will become less humped. Unlike a traditional trader or investor who would simply go long the 10-year, LTCM shorts the wings so that it eliminates its exposure to a parallel shift in the yield curve where it moves up or down in its entirety, and to a steepening or flattening of the curve, where the yield curve becomes steeper (more vertical) or flattens (more horizontal).

Unlike the view of LTCM as a model-deterministic agencement, my findings show that practices within it were much more nuanced. A model would be set up by a team of researchers who would test it and run it. Portfolio managers would interact with the model daily, write time-series of the expensive and cheap parts of the curve. They would identify value, put on a trade, and adjust it upwards or downwards and tweak it continuously. At times, the trade itself would make the traders question the model who would then return to the researchers and discuss it.

> It was a bit of a blend of a research department at university and a trading firm at times. It kind of got into very philosophical debates sometimes, but obviously the purpose was to make money. So it's

> whatever works.
> (Interview KG)

The same environment was created at JWM Partners, the fund Meriwether set up after LTCM collapsed:

> It was helped by the fact that JWM, in particular, where I was more senior, it was a very collegial atmosphere. So it wasn't like I had my risk book, I lived or died by that. People would, you know, if a trade was going against you, you'd be encouraged to increase it. People would be coming out, the partners saying you've got a great opportunity to increase the trade. And it was very much that kind of atmosphere. Rather than a siloed 'here's your capital, you make up do whatever you like, if you lose X you're fired'. It wasn't that kind of place. So that encourages these kind of discussions of the models. I'd talk a lot to my US colleagues, European colleagues about trading those markets, about how we should set the models up.
> (Interview KG)

An interesting case that brings this to light is related to the two-plus term structure model we encountered earlier. At JWM, the traders and researchers working in the European fixed income space would model and fit the European yield curve. Their practice was to fit the 5-year point so that on average over time the 5-year would be expensive roughly the same amount of time it was cheap to the model. In effect, this would mean that the 5-year is, on average, fair across the European markets. The UK trader, who replaced Haghani when he left, felt that the model's universal parameterisation rendered the model not an adequate representation of the UK market, since idiosyncratic reasons in the UK market made the 5-year persistently cheap to the model, while the long-end of the market persistently expensive.

> Sometimes as I was managing the UK book after Victor left, I was arguing for changing the parameters to be different to the Euro book because of the shape of the UK curve. I thought it was better to represent that persistent cheapness and richness by changing the parameters. And then we got into arguments about consistency across the world. And does it make sense to have the UK parameters so different to the others? Or would we keep it the same? So we end up in those kind of discussions from time to time. That was the tension. And so that was a philosophical debate.
> (Interview KG)

The argument presented by the rest of the traders against this trader's view was that because JWM was a global firm, it made more sense to maintain constant and universal parameters across markets. The debates, therefore, highlight how central the role of expert judgements was in the practices of these hedge funds. Such an interpretation differs from a simplistic view in which a model is constructed and determines decision-making. In practice, there is a constant and iterative process between the traders themselves and between the traders and the models. Trader and model interact – a trader may impose his expert judgement to discipline the model into certain behaviour just as much as the model may 'determine' certain behaviour of the trader. Within this context, the yield curve is not taken as given (or a 'fact') but is constantly the subject of judgements by actors whose collective decisions rework and reshape the yield curve in consequential ways. In some cases, for example, changing the model's decay parameter at the front-end of the curve for a better fit, implied that the central bank "was just gonna go gangbusters and be doing 200 basis point every few months… which was just unrealistic". In this case of the UK market, the UK trader ultimately failed to convince the other traders to change the parameters of the model. The trader had to impose some qualitative overlay and his tacit knowledge onto the model's own judgements:

> Interviewee: Because we were running Japan, UK, US and Europe, with all roughly the same parameters, you could tell, just by looking at the numbers, you had a sense as to what was going on in the markets, what was dominating at the time. So you could see where there was, so it was really telling us very clearly that something's gone in the UK that wasn't going on in Europe, or in the US as it happened. And you had that very clear metric.
>
> Dylan: Did you ultimately change the way you parameterize the model?
>
> Interviewee: Ultimately no, but it ended up being roughly the same thing as if… let's say you had a market like the European market at the time that the five year was normally zero, and you'd go long if it was +10 and you'd go short if it was -10, the cheapness and richness. In the UK you would say, well it's always 20 cheap. So I'll go long when it's 30 cheap instead, and I'll sell it out when it's 10 cheap to the model, even though it still is cheap to the model. You just end up moving your targets.
>
> Dylan: So your interpretation in a way leads you to make some changes to the way you would otherwise trade with the model.
>
> Interviewee: Precisely. Because there's no point waiting for the 5-year points to get paid in the UK because my view was that it never would.

The term structure model, therefore, provided a guide or input information for making decisions that were still to an extent qualitatively-based. The traders would try to understand and *make sense* of what was going on in the markets and whether the ways they conceived of the modelling might be off. For the traders, the model "was sort of a repository to codify their thinking, where their thinking was based on understanding what was going on in the markets" (Interview CL).

> The key thing is that it's not like they mechanistically put on trades based on that model… it's not like they had some magic model that was mysterious, and, you know, just turn it loose in the computer, and it crunches away and out comes money. It helps them understand the dynamics of the market better. So they had a canon, a structure on which to put their judgement. And when they observed something new about the market, they could sort of update and solidify it to improve their model, as opposed to keeping it all in their brain, like 'Oh, yeah. Remember when this happened?' So the approach that they used was sort of half quantitative and half realising that the markets were an organic thing. And so they would look at something, they would look at the exposures and so on, based on two plus model framework to understand, you know, how far things are off and where in theory they should be? How much risk is there up or down? But then they'd be making judgments of what to do based on intelligence.

4.4 Further on the yield curve's multiple ontologies

Underlying the previous sections of this thesis was a subtle argument that agencements often differed in the way they are organised, what they do and what they know. We have seen how the architecture of an investment bank floor in specific and financial markets in general are constituted by multiple agencements – from the derivatives quants, government bond desks, to arbitrage desks, and hedge funds. We have also seen how the yield curve was repurposed, reshaped, reworked and moulded as it became a core part of different agencements. In line with Star (2010, p. 603), "An object is something people … act toward and with. Its materiality derives from action, not from a sense of prefabricated stuff or "thing"-ness." In this section, we will travel across the investment bank floor and beyond to explore briefly but more explicitly the multiple ontologies exhibited by the curve across these different agencements.

Our first stop is the government bond desk, sometimes known as the ‘linear rates desk when markets for swaps are made on the same desk. The notion of no-arbitrage has not taken over these desks and traders are in the ‘real-world’ probability (P-measure[32]) rather than risk-neutral. They interpret the curve as a representation of the bond market – of market expectations, and of market demand and supply. Traders within these agencements are generally-speaking not ‘quants’, i.e. the ‘rocket scientists’ that constitute the derivatives quant community. “The bond traders never really fully bought in to the arbitrage-free. They don't care.” (Interview EX).

They often take directional views on the curve against market expectations while dealing with customer flow. Interestingly, individual traders are often specialised in a tiny segment of the yield curve (for example, from 1-year bonds to 3.5-year bonds). Traders who specialise in adjacent segments of the curve sit next to each other so that the desk also ‘emulates’ the curve – the desk is organised ‘along’ the yield curve. Each trader has expertise on her segment of the curve, but as an *agencement* they share what Hutchins (1995) calls ‘distributed cognition’ and they can construct knowledge together about the curve as a totality.

Our second stop is the agencement/s of non-linear and exotic derivatives market-makers and quants. The yield curve, reworked and repurposed into the model object of a discount curve, within this agencement is primarily an infrastructural object that feeds into the no-arbitrage models studied by Spears (2014). In contrast to the government bond desk, these desks are staffed by quants, the vast majority of whom would have been sitting in the quant research team prior to moving on this desk. These desks have been swept by no-arbitrage theory, and practices on this desk and the devices that constitute it are firmly in the Q-measure, i.e. the risk-neutral world. No-arbitrage interest rate models, for instance, are pricing tools through which a derivative can be priced. But they are also a tool to manage risk because they suggest how a trader should go about setting up the hedges. As one interviewee told me: “They calibrate the model, they think that’s reality’. (Interview EX).

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[32] P-measure (real-world) refers to an approach of evaluation in financial markets where probability is calculated on the basis of historical data of an asset/security/instrument’s price or value. In contrast, the Q-measure (risk-neutral world) refers to an aproach of evaluation which measures an asset/security/instrument’s value based on assumptions of a risk-free rate and absence of arbitrage. See Rebonato (2018) for a discussion.

In the early days of the period in question, swaps traders would also attempt to enforce no-arbitrage principles on their practices. A quant (Interview KG) whose experience spans various desks recalls an anecdote:

> I can give you a quote from 1999. An emerging markets bonds trader talking about the head of emerging market swaps. Emerging market swaps was a fellow called Jamie[33] who's a PhD… And he said "Jamie doesn't understand risk. He's just a swaps trader. He thinks he can go home hedged every night." So that was a bond trader who's not a PhD. [Bond traders] were more apt to want to look for relative value. They were more apt to want to use the models as a rule of thumb. So they didn't necessarily trust the models enough that they are going to try to do it exactly. They weren't quite there yet. But that was their demeanour… it was that if I think there's an opportunity there, I can make money on it.

However, more recently swaps traders have been known to take regular active positions and views rather than attempting to hedge perfectly. While the exotics are simply 'users' of the yield curve - primarily of the discount curve that is fed to the model – bond traders and increasingly swaps traders would attempt to intervene on the curve by taking active views.

One final agencements which we have not encountered so far is macro hedge funds. In practice, the work of relative value hedge funds such as LTCM and macro hedge funds often overlaps. In fact, LTCM itself had taken on several positions which could be classed as (Global) Macro. In the Global Macro space, hedge funds put on positions to take advantage of the relative value of two or more markets based on the economic and political outlook. Traders engaged in relative value macro trading compare two markets by comparing the respective yield curves. Traders rework the yield curve into the spread – i.e. the difference between yields of the two markets, a metric which we have encountered in chapter 3 – so as to be able to have a singular metric on which to compare and make judgements.

Often, the traders make framing judgements. They put on relative value positions between US and Canada because that neutralises and disentangles the similar qualities which the two markets experience – tax, labour markets, housing markets etc – and the trade would be framed around, for instance, central bank policy (Interview

[33] 'Jamie' is a pseudonym.

AX; Interview FV). Other traders put on trades between Germany and Italy because that neutralises many qualities which the two markets share (e.g. the same central bank), but it also frames the trade around ‘credit’ and ‘credit spreads’ (Interview KG). Similar to MacKenzie and Hardie’s (2007a) argument, in effect this speaks to the yield curve’s powerful function of rendering assets and markets easily comparable. Yields, yield curves and spreads engage in a constant process of singularisation that brings global markets into direct interaction with each other onto the trader’s screen, with the help of judgements by the traders themselves. In such an agencement, the yield curve is also an object of representation, but one which disentangles, singularises and renders assets and markets equivalent.

In this chapter, we have explored the process by which the yield curve became embedded within a process of quantification in the US Treasury market, as it was transformed into multiple objects. We have seen the wide-ranging effects of the adoption of financial theory and no-arbitrage models in markets, and how this gave rise to new agencements in the form of arb desks and then hedge funds such as LTCM, as well as assisted in the development and rise of derivatives. Finally, I have argued that the yield curve exhibits multiple ontologies as it is (re)shaped, moulded, and (re)worked into different objects within multiple sociomaterial agencements. In the next chapter, I will extend this argument by shedding light on how a market device can be adopted by a non-market agencement, that of central banking, thus becoming a policy device.

Chapter 5

Assembling a policy agencement and a ‘policy device’ at the Bank

This chapter switches attention to the construction of another agencement, that of central banks, and the way in which the yield curve came to sit at the heart of this arrangement. Current literature has provided two explanations for the construction of the specific form of pre-crisis monetary policy, what some have referred to as the governance of expectations (Braun, 2015, Wansleben, 2018). On the one hand, a strand of the literature has taken a performativity approach, in which monetary policy can be explained by reference to the performative functions of macroeconomic theory, models and techniques (Braun, 2015, 2014, Holmes, 2013). On the other, another strand of the literature has laid emphasis on the ways in which central banks and markets have become entangled within wider processes of institutional change such as financialisation (Braun, 2018b, Krippner, 2011, 2007, Walter and Wansleben, 2019, Wansleben, 2018). In this chapter I aim to integrate this literature by proposing that for the pre-crisis policy arrangement to be successful, it required not only the assistance of economic theory and models, and the crafting of particular techniques such as communication, but also the enrolment of financial markets themselves (the gilt-market in particular) as the infrastructure through which monetary policy is implemented and channelled to the wider economy. Indeed, the policy sociomaterial arrangement that settled in the 1990s and 2000s was first and foremost the result of a long process of (re)configuration of the ways in which a state agency, in this case in the form of the Bank of England, related to markets.

However, enrolling the gilt-edged market as an infrastructure of policy required that the right institutional arrangements be in place – what Wansleben (2018) calls ‘felicity conditions’. I argue that, while as we have seen in chapter 3 the markets were developing novel practices which laid the ground for the policy sociomaterial arrangement in the 1990s, particular institutional and structural factors precluded these from developing into a coherent arrangement between the Bank of England and the gilt-edged market. These conditions also gave different meanings to the yield curve, which was not able to be repurposed as a coordination device in the way the inflation targeting by the Bank of England in the 1990s did. In laying this out over a period of 50 years between 1945 and the early 1990s, I distinguish between three broad periods.

In the first period (1945 – late 1960s) covered in 5.1, I show how despite the key innovations developed by gilt-edged market practitioners (see chapter 3), the market's infrastructure was fragile. The latter fragility manifested itself in periods of low liquidity on account of the low capital resources of jobbers (market-makers) and their inability to deal with price volatility. Such market failure was constantly patched by the Bank of England which acted as a market-maker of last resort so as to provide the necessary liquidity in the market. Indeed, the switching techniques, explored in chapter 3, developed during this period by market participants were only possible because of the existence and intervention of the central bank acting as counterparty in these operations. Furthermore, this necessary action by the Bank of England also exposed the Bank to frequent contradictory situations wherein it was providing liquidity by purchasing gilts, but attempting to fulfill its debt management function by selling gilts. In this context, particularly when fiscal demand management took precedence over monetary policy, the yield curve was purely an artefact of borrowing costs in the context of debt management. As such, it could not yet develop into a coordinating device between the Bank of England and the gilt-edged market, primarily because the institutional conditions for this to be successful were not there.

The second period (1970s and 1980s) covered in 5.2, looks into the monetarist experiment in the UK. With the fall of the Bretton Woods agreement and a first attempt at liberalising financial markets through Competition and Credit Control, the gilt-edged market participants became increasingly concerned with government's ability to deliver its promises. With the help of some of the practices already explored in chapter 3, such as the role of epistemic practices in the market including the role of Weekly Bulletins by some of the major stockbrokers, market participants rallied around the monetary targets as a measure of government policy success. Hence, the latter became a crucial piece of the puzzle in the increasing susceptibility between states and financial markets as the latter grew in stature and became an engine of the real economy. In this context, expectations started to gradually take centre-stage in the policy arrangement. However, expectations for the macroeconomic executive remained ungraspable as the yield curve had by then still not been repurposed as a tool with which to measure and govern them. The various actors were indeed less concerned with the yield curve than with the monetary aggregates and the money supply. During this period, the yield curve became instead a weapon via which the gilt-edged market could exert power on the government, as market participants engaged in collective strikes thus hurting the borrowing capacity of the British government.

Finally, the period in the 1990s was one in which a coherent arrangement – inflation targeting and expectations management – came into being. I claim that this came on the back of several institutional developments: a deeper and more liquid market aided by the new infrastructure and higher capitalisation of the gilt-edged market following the Big Bang in 1986, the development of an index-linked markets, zero-coupon market, derivatives markets, and a reform in taxation on gilts, as well as central bank independence. The Bank of England, following decades of nurturing the gilt-edged market, saw the latter's newfound role as one of the engines of the real economy and sought to enrol it into its policy arrangement. I also show how economics was influential within the Bank and shaped monetary policy by providing the legitimacy for the sociomaterial agencement of central banking. Economics embraced and lent support to changing institutional conditions in the UK and elsewhere (primarily in the US) including an end to active debt management in monetary policy and the liberalisation of financial markets (James, 2020).

In this context, the yield curve was repurposed by the Bank as it travelled across departments, thus taking a new ontology. Within this arrangement made up of particular relations with financial markets and novel techniques of policymaking, the yield curve as a representation of a core financial market – the government bond market - took a central *coordinating* role in the Bank's practices of governance: as a material device that renders fictional expectations (Beckert, 2016, Beckert and Bronk, 2018) measurable, calculable and governable.

In this sense, I follow Wansleben (2018) by suggesting that we read the two explanations – of the technical practices of monetary policy and wider institutional configurations – of monetary policy not as 'rival' ones, but as explanations that lay focus on two important elements that are constitutive of the policy arrangement and its practices. In this chapter I therefore hope to lay out the ways in which the agencement of the Bank of England in the early 1990s (and the policy devices and practices making it up) was assembled on the groundwork of a historical (infra)structural entanglement between itself and financial markets honed over decades prior. This entanglement emerged as the core of monetary and economic governability when institutional change in the UK placed financial markets at the centre of the economy. On these institutional foundations, Bank personnel could operationalise the turn towards expectations, credible commitments and central bank independence, supported by economics as a body of knowledge, and thus craft novel techniques of policymaking. Such an arrangement was then to be transmitted across changing institutional contexts and the central banking community (Wansleben, 2018).

I conclude this chapter by claiming that, while the second half of the 20th century exhibited a waning of financial repression[34] and a simultaneous process of market liberalisation and financialisation, this did not place complete power in the hands of financial markets. Rather, both financial markets and the Bank benefitted from their respective growing roles within the make-up of the economy and macroeconomic policy as they co-produced each other. On the one hand, financial markets found in the Bank of England a focal point that not only supported and defended their interests as they accelerated the process of financialisation, but later an ‘ally’ which crafted for them a special role as mediator in the process of governance (i.e. one in which monetary policy is transmitted through the gilt-edged market as *primary* channel). On the other hand, the Bank of England spent decades nurturing and supporting financial markets, ultimately finding in them a stable infrastructure and ‘ally’ via which it could govern the economy. As the liberalisation of financial markets and the financialisation of the ‘real economy’ rendered financial markets a core engine of economic activity, the Bank capitalised on those very same markets which it cultivated (Dutta, 2018, Lagna, 2016), thus gaining ‘infrastructural power’ (see Braun, 2018b, Walter and Wansleben, 2019, Wansleben, 2020, 2018) through which it could govern the economy.

[34] Financial repression involves a number of restrictive policies on financial markets by which government would maintain a low cost of financing and reduce its debt burden.

By focusing on the historical construction of the policy agencement, I seek to capture the multiple processes and elements which gave form to it and rendered it possible. The specific structural entanglement between the Bank and markets in the context of institutional change made possible the establishment of a specific agencement made up of material devices, techniques, and practices of governance. Its construction in this chapter will serve as a historical backdrop for chapter 6 in which I will explore the sociomaterial 'interactional alignments' within and between markets and central banks through which order was established, at least until 2007/08.

5.1 The central bank and the gilt-edged market: A history of co-production

This section focuses on the Bank's historical entanglements with markets as one important element that eventually shaped the sociomaterial monetary policy agencement. It lays emphasis on the ways in which the relationship between the Bank of England and markets was in many ways one of co-production[35]. Financial markets - both money markets and the gilt-edged secondary market integrated within the Stock Exchange as its infrastructure – were beset by a persistent lack of liquidity and benefitted from the Bank of England's support as market-maker. These made possible market innovations (e.g. switching techniques via the yield curve) that would eventually find an important place in the post-1990s arrangements, but also exposed the Bank to fundamental contradictions that it could not reconcile without the right institutional conditions. Through this support, however, the Bank produced (together with the social and material practices we explored in the previous chapters) an actor which it would eventually enrol into its policy arrangement and via which it would govern. Indeed, the post-war economic governance in the UK is in many ways a history of the construction, struggles and reconstruction of the boundaries between state and market (Coombs and Thiemann, 2021).

[35] I borrow this term from Callon and Latour (1992) whose idea of co-production in their passage refers to the ways in which society and nature produce each other. I extend its meaning to the processes by which agencements construct other, and to how their modes of ordering flow into each other as in Law (2009a). The notion of co-production has been popularised by Sheila Jasanoff, whose work traces a similar genealogy to the social studies of finance, both of which bodies of knowledge having been influenced by sociology of scientific knowledge and actor-network theory. Jasanoff's (Jasanoff, 2011, 2012, 2004) idea of co-production is however restricted to how scientific knowledge is shaped by and shapes the very representations, discourse, institutions in which it itself is located.

5.1.1 The central bank as mediator between government's executive and market

The enlarged deficit and debt programme in the UK post-1945, the result of World War II and the nationalisation programme of the Labour government, provided an incentive for government to be active in its debt management by seeking to maintain low cost of funding via lower interest rates (Fforde, 1992, Phillips, 1996). In this context, the UK's monetary policy was effectively carried out via (and subservient to) debt management (Goodhart and Needham, 2017). During the war itself and the following years, the government engaged in a form of financial repression - using its state power to cajole investors to invest in its newly issued debt as a matter of national and moral duty, together with using its 'tap sales' infrastructure by varying issuance to fix yields. The Bank, in its role as government's debt manager, intervened more directly in the secondary (gilt-edged) market at the end of the 1940s when, seeing yields rising, it entered the market and was reported to have said "I will buy any stock you have to sell" (Allen, 2019, p. 71). The Bank, through the Government Broker, thus bought bonds in order to put downward pressure on yields.

But the Bank did not only carry the interests of government. Rather, precisely due to its role as debt manager, the Bank also held an interest in maintaining a functional gilt market through which it managed this debt, particularly given the fragility of the market which suffered from light capitalisation and liquidity. And herein becomes clear the element of co-production between the Bank and markets. Insofar as the Bank operated in and through the market to sell government debt, then markets were an important element in the Bank's very success of its operations. In this case, for instance, while the Bank was trying to push yields down at longer maturities for monetary policy purposes, it was providing additional liquidity as a buyer to counter the liquidity shortage the market itself was experiencing. During the course of the 1950s and 1960s, as we will see, the Bank often found itself caught between its role as debt manager and its concerns of market structure and market liquidity, and often chose to uphold the interests of the market. For instance, Sir Kenneth Peppiatt, the Chief Cashier of the Bank, was adamant that while the Bank should be interventionist for structural and liquidity purposes – in what today is known as lender/market-maker of last resort[36] – it had “no such duty to control the price of Government securities” for fear that it would “destroy the very market which [it was] trying to maintain.” (Peppiatt, 1952 in Allen, 2019, pp. 78-79).

Similarly, during the 1950s, the Bank implemented a set of measures on the clearing banks that would redirect savings and deposits into the gilt-edged market. These were intended to avoid ‘a continual state of anxiety as to how the Government’s requirements for finance for the following week were going to be met’ (Radcliffe, 1959 in Goodhart and Needham, 2007, p. 338). Monetary policy was therefore subservient to debt management, as the Bank sought to absorb Treasury bills and replace them with longer-term bonds, an operation known as ‘funding’ (Howson, 1993)[37]. Because banks required a minimum of 30% liquid asset ratio, and because they held mostly bills (only bills and not gilts were classified as liquid assets), transforming bills into gilts constrained the banking system in its capacity of credit provision[38] (Howson, 1993) while pouring liquidity into the gilt-edged market (Goodhart and Needham, 2017).

As such, in line with Peppiatt’s view, the Bank objected to *direct* intervention on market prices in the gilt-market[39] and instead turned to the ‘funding policy’. The ‘funding policy’ had the additional side-effect of raising demand for longer-term bonds. Indeed, it was the policy of the Bank at the time to actively enlarge the gilt-edged market. As the main concern for Treasury and Bank was the existing but maturing bonds, the Bank as the debt manager embarked on a policy to extend the average debt maturity by issuing longer-dated bonds. These actions “greatly encouraged the development of the *long-*

[36] It is interesting to note that although the term 'market maker of last resort’ is often attributed to Buiter and Sibert (2007) (see, for instance, Hauser, 2021), the term ‘jobber of last resort’ was already part of the lexicon at the Bank of England at least as early as 1965 (Allen, 2019, p. 112). The term refers to jobber, rather than market maker, because as we have seen in Chapter 3, jobbers made markets in the Stock Exchange under the single capacity system.

[37] An important element of this operation was the Serial Funding programme of 1951, where £1 billion in bonds were issued as replacement for bills. The Bank engaged in ‘moral suasion’ over banks to secure demand for these bonds (Allen, 2012) such that banks’ balance sheets would be switched from liquid assets (bills) to relatively less liquid assets (gilts).

[38] Despite this direct pressure put on the banking system, the Bank often chose to defend their interests, as we will see. For example, the Bank was averse to more direct quantitative restrictions on the banking system and when the Treasury in 1955 wished to impose a 10% reduction on bank advances, the Bank of England initially refused to apply it. It was only after it met with the banks’ representatives that they accepted after the banks had agreed among themselves (Howson, 1993).

[39] This stood in contrast to the scene in the US where the Fed had pegged interest rates (Garbade, 2021).

dated market in the UK" which was "the opposite to what happened in the US where there was a statutory limitation on the level of interest rates that could be offered" (Pepper, 2008, pp. 5-6). In fact, Pepper himself attributes his claim that the British market in long-dated bonds was more developed than that in the US to the actions undertaken by the Bank during that period. The way the Bank shaped the gilt market thus provided the raw material and conditions of possibility for the rise of quantification and the resulting performative processes we studied in chapter 3.

But the long-standing debate on whether the authorities should fix yields resurfaced most prominently at the end of 1959 with the establishment of the Radcliffe Committee. It is during this period that the yield curve becomes an important topic of *discussion* as a matter of policy in the context of the Radcliffe Report of 1959. The Radcliffe Committee was set up in 1957 to assess the monetary system in the UK and the effectiveness of monetary policy over the decade prior. Following a long review which included hearings from Treasury and Bank of England representatives, the Committee concluded that monetary policy is only one element of "one general economic policy which includes among its instruments, fiscal and monetary measures and direct physical controls" (p. 337). It is evident from the report that the (Keynesian) Committee saw the monetary policy tool of Bank Rate as too weak to influence the level of aggregate demand.

The Committee argued that during the 1950s the authorities, especially the Bank of England, were "entirely passive, indeed fatalistic, in their attitude to the movement of long-term interest rates." (Radcliffe, 1959, p. 205). It assessed several instances in which the Bank of England refused to influence market yields or to oppose market rises or falls. In the hearings, Bank representatives rebutted this criticism by arguing that their policy was based on allowing market forces to shine through. The Report claims that the Bank of England was wary about influencing (or being seen as influencing) market pricing:

> [O]ver most of the period the authorities have not been prepared to force interest rates on the longer bonds upwards in order to tempt holders of short bonds to switch to long bonds. At least until 1957, their policy was to press sales of long bonds whenever they could do so without forcing gilt-edged prices down. … Their view that demand could not be stimulated by dropping prices—a view not easy to accept—was based mainly on the belief that the market for gilt-edged

> securities is dominated by expectations (as any market in long-term securities must be) ... But their attitude has also been strongly influenced by a 'belief that the long-run interest of the Government as a debtor was best served by orderly markets, and that orderly markets implied abstention from disruption of ruling prices just as much as it demanded official intervention to steady a demoralised market.

By relying on market expectations, therefore, the Bank attempted to let the market discover its own prices. Market participants formed their expectations by seeking and interpreting information related to the authorities' decisions: from statements and announcements about gilt issuance, the size of issues and their pricing. As a result, the Bank paid attention to the formation of market expectations, primarily by gathering information from the Government Broker. In turn, the Bank would react according to these expectations (Wormell, 1985). In the context of a falling market in which gilt prices are falling and interest rates are rising, for instance, the Bank would refrain from selling gilts on the rationale that the market would form an expectation that the market will fall further and thus it would be beneficial for market participants to wait until the market reaches its trough before buying. Selling in a falling market, the Bank believed, would entail the Bank cutting gilt prices on tap, which would further sustain the market expectation that a further price fall might ensue especially if the market interprets this cut as information about government financing. The Bank, therefore, preferred to sell in a rising market (Allen, 2014). Interestingly, the Bank was already by the 1950s attempting to harness the role of market expectations. However, at that point it had no material means by which it could calculate those expectations, nor a deep and liquid market that would render the calculation of market expectations possible. Furthermore, monetary policy via Bank Rate was only one, peripheral, technique within the wider practices of a macroeconomic executive[40], an executive in which the Bank of England was only the central banking arm and thus not central to policymaking, and in which Keynesian demand management took precedence.

In spite of the 1950s being a period of financial repression, the gilt-edged market was thus in many ways left to its own devices when it came to price discovery. The authorities were criticised for accepting market yields with little resistance and for

[40] I borrow this term from John Fforde who argues that macroeconomic policy, of which monetary policy made part, was in the hands of a centralised set of actors within the government's executive.

being concerned about impairing market prices discovery. The Committee went even further and was more scathing in its critique by alluding that the market held power over the Bank. It claimed that the Bank was often "unwilling to give any lead to the long term market" (p. 205) and that in certain instances it "fulfilled these market expectations" (p. 141). The claim implies that the Bank Rate, and thus the authorities, follow the market and fulfil market expectations (see Blinder, 1999).

Nevertheless, the Committee conceded that in the years immediately preceding the assessment, "the attitude of the authorities towards the long market changed somewhat." Through the Government broker, the Bank had attempted to control rising prices by getting in the market and selling as much long-term bonds "as the market would absorb." (p. 205). But the Committee recommended that the authorities do more in terms of influencing market prices. It argued that the authorities "thus have to regard the structure of interest rates rather than the supply of money as the centrepiece of the monetary mechanism. This does not mean that the supply of money is unimportant, but that its control is incidental to interest rate policy." (p. 135).

This discussion, as evident by reference to the 'long term market', implies that the gilt-edged market was still conceived of as segmented. Indeed, even from the macroeconomic executive's perspective, the yield curve was not yet an artefact that represented the market as a totality. It could not, therefore be employed as an epistemic tool by which the executive could read the market's aggregated view or expectations, and therefore the structure of the market precluded the yield curve from acting as a coordinating device in terms of expectations. Rather than as a measure of expectations, the Radcliffe Committee proposed the yield curve as a tool of debt management which the macroeconomic executive could control directly via direct intervention.

In fact, the Committee followed Kahn's[41] evidence and argued for a re-evaluation of the policy target and for authorities to shift away from the supply of money and towards the general state of liquidity of the whole economy to be governed by controlling the yield curve. The Committee suggested that the Bank, *as debt manager*, should have

[41] Richard Kahn studied economics at Cambridge University as a student of Keynes himself. Kahn would later become renowned for his work on the multiplier approach in Keynesian economics.

a policy for the whole structure of rates and to put its debt management functions into use towards implementing this policy. In doing so, what the Committee was effectively suggesting was a more central role for the gilt-edged market in the policy arrangement via debt management, but concurrently for the Bank to use its own structural power as debt manager in order to control the yield curve. Recalling in 1978, in the first Mais Lecture, the Bank's Governor Gordon Richardson acknowledged that the Committee did influence[42] the Bank's thinking with respect to "the importance attached to operations in the gilt-edged market having a wider objective than merely financing Government…" (p. 32).

5.1.2 The ontological blurriness of the central bank-market nexus: The Bank of England as market-maker of last resort

The above picture seems to reproduce a myth which this chapter attempts to overturn. The Bank of England did not shape markets as an 'external force', from the outside. Rather, it played a direct and active part *in* the market and *as* a market actor. Indeed, at times it *was* the market. The conceptual argument I am attempting to advance is one in which the very idea of 'co-production' is not of a simple mediating relation between two separate and well-defined entities, but of a more complex and nuanced form in which the boundaries of 'entities' - or more precisely 'agencements' - were often blurred. This is an argument that we will come back to especially in Chapter 7 when we discuss post-crisis quantitative easing and the central banks' functions as market-maker of last resort. For the purposes of this chapter, however, I would like to focus on the Bank of England's role as an ever-present 'market operator' (Radcliffe, 1959, p. 109) during the 1950s and 1960s.

In spite of the Radcliffe Report's claim that the Bank was especially concerned with the market reaction to its own intervention on market prices, the Bank did intervene with increasing frequency during the 1950s and 1960s in an attempt to maintain 'orderly markets' (Wormell, 1985). For this purposes, it calibrated its intervention – stepping out of the market when the market is steady, and intervening when the market

[42] While it is difficult to estimate the Report's influence on actual practices of monetary policy and economic policy at large, the Report provided some legitimacy and support for a heightened form of financial repression which included limits to and quantitative ceilings on bank advances, and hire purchase restrictions.

lacks confidence – in a similar manner to the Fed's activity in the US (Mehrling, 2011). This is also an important element of co-production, where the Bank's role is one that is especially concerned with maintaining order in the market so that it is rendered itself more powerful by having the right infrastructures and conditions through which it operates. The Bank's action in the market extended beyond selling gilts in its role as debt manager and underwriter of gilt issues. Rather, the Bank also purchased gilts from the market, which Allen (2019) estimates as equivalent to 85% of its secondary market sales in the 1950s. In other words, the Bank's purchases of gilts amounted to only a slightly lower volume of its sales as debt manager. In doing so, the Bank acted as a major source of liquidity for the gilt-edged market during this period. The Bank, therefore, maintained orderly and well-oiled markets by acting as a 'market-maker of last resort' (Mehrling, 2011). The weak levels of liquidity in the market were a result of the fragile microstructure in the Stock Exchange. Jobbing firms, who acted as market-makers by quoting two-way prices (together with discount houses at the shorter end of the market), were limited and did not have vast capital resources to be able to withstand market volatility (Allen, 2019).

The Bank's agencement consisted of, amongst others, a tight relationship with the senior partner of a stockbroking firm, Mullens and Co., which took the role of Government Broker. The Bank's market intervention was therefore intermediated by the Government Broker, whose functions were multiple: it executed the Bank of England's requests with respect to the management of the Bank's portfolio, it maintained close interaction with the Bank of England by providing knowledge on market action, and it advised the Bank on matters related to gilt issuance. Wormell (1985) details that the Government Broker would meet with the Stock Exchange's jobbers three times a day and would relay the information gathered to the Bank after every meeting and daily at the end of business. In its dual role as commercial stockbroker and government broker, Mullens and Co. separated its own government business from the commercial side of the same firm (Phillips, 1996). Through the Government Broker, the Bank calibrated its intervention by purchasing and selling gilts whenever required. Allen (2019) details several interventions by the Bank in the 1950s and 1960s, where it sought to rescue jobbers from volatile prices, and following the Radcliffe Report, it also intervened more frequently in the longer-dated market.

It would be easy at this point to dismiss the Bank's defending of the interests of the banking system and gilt market as regulatory capture by market interests. It is perfectly possible, of course, that the Bank was so tightly entangled with the City of London that it was captured materially and/or cognitively. Indeed, this is also implicitly the accusation by the Radcliffe Committee and explicitly by Gordon Pepper (1998). But this conceptualisation would render the Bank of England as a passive entity at the mercy of the markets. I suggest that there is a sense in which the Bank sought to defend the interests of markets – including by attempting to place the locus of power in economic governance onto the market – and to simultaneously shape the markets so that it *itself* is rendered more powerful. The Bank's own associations with the banking system, discount houses and market participants in the secondary gilt-edged market and beyond, established a sociomaterial arrangement that the Bank sought to actively construct.

A former Bank of England staffer (Interview PX) put it to me this way:

> The state intervention in the gilt market wasn't really a kind of *demonstration* of power. It was rather a reaction to weakness in the market that reflected the state's weakness because the state needed the market. And therefore, it really had to support it in one way or another.

The Bank therefore sought to mitigate 'the weakness in the market' which manifested itself as weakness of the Bank. By rendering the market more robust, the Bank could benefit as it would itself be rendered more powerful. This susceptibility between the Bank and the gilt-edged market – where the two rely on each other in a symbiotic relationship - is a prime example of the infrastructural entanglements (Walter and Wansleben, 2019) that potentially grants 'infrastructural power' both ways (Braun, 2018b).

Despite this, the Bank was also necessarily entangled with Treasury and the wider government. As such, therefore, it was caught between its role as debt manager on the government side and its role as market-maker on the market side. During the 1960s, in particular, the Bank started using its structural power as debt manager to push gilt prices as required. In 1960, for instance, the Bank wished to induce a rise in yields to control rising inflation and the exchange rate. It therefore bid for and purchased gilts and later sold gilts at below market prices so as to induce the desired price fall. In practice, the Bank was acting as both a market-maker for the purposes of liquidity provision to the market, but also as the monetary policy setter by pushing yields according to the wider economic policy.

It is from this conceptual viewpoint that we can appreciate the connections between the roles of the Bank just explained and the rise of quantification - primarily of switching techniques - in the market as explained in Chapter 3. The Bank of England, in its functions as debt manager and market-maker, was the largest operator in the market by turnover figures. Allen (2019) estimates that by 1966 the Bank was counterparty to about 75% of the market's transactions. Because as we have seen in Chapter 3, the market was largely constituted by switching trades, the Bank therefore *enabled* such switching by acting as counterparty. In the absence of the Bank, switching would have been an improbable form of trading in the gilt-edged market and the performative effects identified earlier would have been difficult to achieve. In a co-production sense, the Bank (as market-maker) allowed market participants to engage in switching which led to the performative shaping of the market. In turn, switching allowed the Bank (as a policy entity) to transmit its credit/monetary policy by influencing one point on the yield curve and letting the market do the rest of its work via switching.

> Rightly or wrongly, this willingness to intervene, which has developed into the accepted convention that we will always be prepared to deal at a price if the market so requests the Government Broker, has rendered gilt-edged securities much more 'marketable' than any other securities in the U.K. This marketability is due entirely to the fact that we are prepared to deal in very large sums; such that any large holder of gilt-edged knows that he can buy or sell very large quantities in one day without disrupting the market or driving prices very far against himself. All this renders gilt-edged more liquid to the holder; and also gives the opportunities for profitable switching operations. (Fforde in Capie, 1968, p. X)

In attempting to maintain gilts' marketability, the Bank also engaged in an unsuccessful struggle to resist the Treasury's decision to introduce a capital gains tax on gilts. The Bank was concerned that such a tax on gilts would render the gilt-market less marketable, and would restrict the volume of switching in the market. After the capital gains tax was introduced in 1964, the Bank argued that the tax had reduced the gilt-edged market's transactions volume and thus impaired the jobbers. By 1968, it was putting further pressure on the government to exempt gilts from capital gains tax, as explained by the then-Deputy Governor (in Allen, 2019):

> The imposition of long-term gains tax on gilt-edged, as the law now stands, has produced the phenomenon of 'locking in'. This has greatly restricted worthwhile switching operations in gilt-edged operations which have nothing to do with tax avoidance, and has reduced activity in the market below what it would otherwise have been. One of the principal attractions of gilt-edged, in particular to large institutional investors, is the opportunity offered for active management through large-scale switching operations that seek to gain advantage from anomalies in the yield structure. 'Locking in' has, in our opinion, damaged the market. The effect, which I agree cannot be quantified, is that less money is attracted to the market and that the cost of Government borrowing therefore becomes marginally higher.

The pressure proved successful, and gilts held for more than a year became exempt from long-term capital gains tax in 1969 in order to render the gilt-edged market attractive to investors.

But the Bank's market-making actions needed to be synthesised with its role as debt manager. Indeed, the arrangement in which it would act as both market-maker and debt manager with monetary policy considerations was fundamentally fragile insofar as it frequently led to internal contradictions. At various points during the mid-20th century, for instance, the Bank was faced with a decision on whether to sell gilts as part of its debt management operations (and monetary policy) or to buy gilts to support the jobbers and market liquidity as a market-maker. This contradiction became especially pronounced at the end of the 1960s when the Bank increased its intervention, at times to gain hold of interest rates for debt management purposes and at other times to support various market actors, including discount houses, jobbers, and clearing banks.

Furthermore, the arrangement established between the Bank and the gilt-edged market was fragile on a political level as it was frequently challenged by other actors, including the IMF – as part of what Goodhart and Needham (2017) call the 'Seven Years War' with the IMF - and some Treasury officials. The Governor defended the entanglement between Bank and markets by warning of the "consequences which so radical a change in the marketability and status of gilt-edged would have on financial institutions which have acquired stocks on the presumption that H.M. Government's concern for their marketability would be maintained." Nevertheless, the Governor was also worried that "[i]f the Bank were to acquire large sums of gilts the Government would be placed in a very difficult position in negotiation with the I.M.F" (O'Brien in Allen, 2019, p. 150) and he suggested that the Bank should temporarily refrain from making any large purchases even if this would mean temporary rises in interest rates.

Political pressures intensified in 1970 following an election won by the Conservatives. As 'money' became increasingly central to the economic governance of the new administration, Cabinet put pressure on Treasury and the Bank to ease up on gilt-market intervention. The Government Broker, concerned about the structural weaknesses of the gilt-edged market, and no doubt about its own interests as an intermediary between the Bank and markets, suggested a reversion to the pre-1962 arrangement where the Bank would be less interventionist "so as to avert 'orders from on high' to abandon the Gilt-Edged Market in toto." (Goodhart in Allen, 2019).

In this section we have explored the Bank's entanglements and relations with the gilt-edged market in the 1950s and 1960s. While the proposal by the Radcliffe Committee to put the yield curve at the centre of its policy arrangement foreshadowed some of the elements of post-1990s sociomaterial policy agencement, the institutional foundations for this to be enacted earlier in the 1950s and 1960s were not there. The market's infrastructure was still deeply fragile, thinly capitalised and segmented. The Bank was impelled to provide liquidity to maintain the market's marketability, but this exposed it to contradictory actions between its market-making role and its debt management role. This fundamental contradiction precluded the coordination (via the yield curve), as practised in the 1990s, to be enacted in any way, shape or form. Additionally, the Bank was largely peripheral to the Treasury within a macroeconomic executive that was largely concerned with Keynesian demand management. Therefore, a proper alignment between the infrastructural entanglements (between the central bank and markets) and the techniques and devices of policy was still not yet possible (Walter and Wansleben, 2019).

5.2 The sociomaterial arrangement of 'monetarism' between the 1970s and 1980s

In September 1971, the Bank of England introduced Competition and Credit Control. In effect, this entailed a redrawing of the boundary between state and markets in which the state would attempt to govern the economy without *directly* intervening in financial markets. Krippner (2011) argues that the monetarist experiment by the US Federal Reserve was the start of an arrangement in which policymakers would "govern the economy 'at a distance' through varied techniques" (p. 108). Similarly, the Bank of England had already by 1971 eliminated quantitative controls on the banking system – credit ceilings and minimum liquidity ratios - as part of what some have called a process of neoliberalism or financialisation of markets and policymaking (Krippner, 2011).

The result was, in the words of Gordon Richardson (1978, p. 32), who would later act as Governor of the Bank, "a move towards a system in which market forces could play a predominant role". As Goodhart (2014, p. 1) argues:

> [CCC] was a landmark occasion, representing a decisive break with the prior system of maintaining direct controls over the, main components of the, UK banking system; the intention was now to achieve the monetary authorities' objectives of policy via the operation of market mechanisms, notably adjustments in interest rates and open market operations… the direction of travel towards a more liberal, market based system, remained, despite a partial reversion towards a partial direct control system in the guise of the 'corset', introduced at the end of 1973, and finally laid to rest in June 1980.

But unlike the Fed's intention, the experience of the Bank of England with monetarism did not insulate it from public scrutiny. Indeed, with the fall of the Bretton Woods agreement, gilt-edged market participants in the 1970s rallied around monetary aggregates as a metric with which to judge government policy. The yield curve turned into a core tool via which the market could impose its views and pressures on government, thus constraining its ability to make policy decisions. In turn, government understood that if it needed to do policy, it had to control or work with market expectations. We observe, therefore, a period in which states and markets become increasingly susceptible to each other, and where expectations gradually take centre stage. And yet, the authorities still had not discovered the role of the yield curve as a measure of expectations, and were therefore not able to coordinate via the yield curve as coordinating device.

In the 1980s, then, we observe financial markets growing in stature as they became a core engine of the real economy. As the potential of financial markets as infrastructure of policy – by virtue of their now central role in the real economy – was starting to be realised, the Bank sought to support them through reforms that would eventually imply their full-fledged development such that they no longer required intervention by the Bank. These reforms included developments in its infrastructure (e.g. Big Bang in 1986), novel markets that would support the gilt-edged (e.g. strips, and index-linked), liberalisation and increased competition, and higher capitalisation. These developments cleared the ground from the institutional factors that impeded coordination via the yield curve.

In this section, I will show how this arrangement was the result of a complex process in which new market entanglements and entrenched material devices shaped the idiosyncratic and pragmatic form of 'practical monetarism' (Pepper, 1998, Richardson, 1978) in the UK. This will serve as backdrop to the next section (5.3), which will show how the Bank leveraged on these developments and on its relationship with the gilt-edged market as it enrolled them into a new arrangement known as inflation-targeting based on expectations management. Within such an arrangement, the yield curve took on a coordinating function allowing expectations to be measured and governed.

5.2.1 Away from financial repression in Britain

The introduction of Competition and Credit Control (CCC) in 1971 came in the context of what some have termed financial repression (Allen, 2014). We have seen how financial repression involves government attempting to maintain low cost of financing and to reduce its debt burden via restrictive policies on financial markets. The form of financial repression in Britain, however, took a distinctive form that reflected the institutional structures of financial markets. In part, quantitative controls were implemented via moral suasion (as we have seen in the case of the 'Serial Funding Programme') and a set of banking cartels – the clearing banks and the discount houses (Needham, 2014). As such, even during the period of financial repression, markets (gilt-edged and banks) were never stripped of power. The British form of financial repression thus was not practised as a top-down approach in which a power imbalance was established between the state and markets in favour of the former.

And yet CCC marked a move away from financial repression, stemming from years of unease with the institutional structure of the banking industry, and with the effectiveness of quantitative controls (Capie, 2010). In part, it also stemmed from epistemic developments within the Bank, particularly the work done by the Monetary Policy Group within the Bank (Needham, 2014). But the more immediate drivers of CCC seem to have been ‘crises’: on the one hand, a current account imbalance crisis; on the other, increasing competition from offshore finance which threatened financial markets in the UK (Wansleben, 2018).

As a result, Competition and Credit Control was introduced as a response to such crises, doing away with quantitative controls such as direct lending ceilings on banking groups. Ever since the Radcliffe Report, there was a general feeling that lending ceilings of this sort were distorting on the banking sector, and that these constrained competition. There was also a sense in which these turned political, as their imposition strained the relationship between the clearing banks cartel – which necessarily decried quantitative controls – and the Bank. Indeed, according to Fforde (1992), the cooperative relationships and moral suasion which characterised the British form of financial repression had been pushed to the limits. The banking system could collapse if it was unable to meet the targets, and so would the Bank’s powerful position as a regulator. It was therefore in the interest of the Bank to ease pressure on the banking system, which CCC did by removing quantitative controls.

Another aspect which according to Capie (2010) played a major role in the crafting of CCC was the competitive structure of the banking system. Banks in the UK were feeling the competitive pressure from the American banks, and they were slow to adapt to such pressures and higher costs. But the Bank felt that until an alternative to direct quantitative controls was found, together with an alternative to the way in which these were implemented (cooperation and moral suasion with the cartel), it would rather keep in place the institutional structure of the banking system made up of cartels (Needham, 2014). Indeed, once CCC was devised as an alternative, pushing the Bank away from direct controls, it also allowed for the disruption of the long-standing cartels.

Interestingly, the first element of CCC to be implemented in May 1971 involved the retreat of the Bank and government broker from the gilt market where the Bank would largely restrict itself to open market operations. It refrained from standing ready to purchase gilts outright - with the exception of gilts with maturities of less than a year - but retained its ability to conduct switches when favourable to its debt management mandate and to sell 'tap stocks' as part of the same mandate (BoE, 1971). As we have seen, the Bank cherished its ability to intervene in the gilt-market in order to reduce volatility in prices and therefore to maintain the marketability of gilts. But its actions proved contradictory to the larger policy of the post-devaluation credit squeeze in the late 1960s: "In stabilising the market, the Bank had pumped money into the economy at precisely the wrong time." (Needham, 2014, p. 25). The Bank thus succumbed to pressure, largely from Treasury and the IMF, and agreed to retreat from the market as deemed appropriate. In effect, as argued by the then-Chief Cashier John Page, this also meant that the Bank was now paying rather more attention to the quantitative effects of its activity on monetary aggregates rather than interest rates (Needham, 2014).

CCC thus marked a first step towards overturning financial repression and liberalising financial markets. But it was *not* a steady process of market liberalisation. Indeed, CCC failed within a few years when, in 1973, authorities started seeking for new tools to control the money supply beyond the tool of interest rates. The so-called Corset was introduced, which was a partial return to quantitative controls in which bank's interest-bearing deposit liabilities were now controlled (BoE, 1982a). As part of this arrangement, the authorities put a requirement on banks stipulating that if their interest-bearing liabilities grew more than the agreed limits, they would need to make deposits at the Bank. The Corset was intended to control banks' growing deposits which inflated M3 (Needham, 2015, 2014).

Despite the CCC failing rapidly (Wansleben, 2018), it also marked an important step towards the *monetarist* experiment in which credit and monetary aggregates would take centre stage, although it was not a direct application of monetarist tenets into British policymaking. Rather than any economic model prescribing policy, the experience of the early (and arguably even the later) monetarist experiment in the UK was an outcome of multiple processes: from the institutional structure of financial markets in the UK, the increasing attention given to monetary aggregates by gilt-edged market participants, political pressures and struggles between Bank and Treasury, and the sociomateriality of research and data. It is to these that we now turn.

5.2.2 The sociomateriality of ‘practical monetarism’ in Britain in the 1970s

At a conference hosted by the Federal Reserve of New York in May 1982, John Fforde, then Bank official and adviser to the Governor of the Bank of England, delivered a paper laying out the rationale of British monetary policy since the early 1970s. Almost apologetic in tone, Fforde seemed intent on justifying why the UK’s monetary policy did not strictly follow monetarist tenets as proposed by Milton Friedman. His paper claimed that “[w]hen discussing our monetary problems among ourselves, we have come to distinguish rather sharply between the 'political economy' of a money supply strategy and the 'practical macroeconomics' of a money supply policy.” (p. 200). British policymakers themselves, therefore, did not attribute their policy set-up strictly to monetarist economics. The sociomaterial arrangement constructed in the 1970s and 1980s owed more to a mix of ‘social’ factors, termed ‘political economy’ by Fforde and including questions of materiality and legitimacy, than the influence of monetary economics per se.

As we have seen in this chapter, what came to be known as ‘financial repression’ relied on a centralised form of macroeconomic governance. Despite the close association the Bank held with markets, which it would later operationalise, it nevertheless held a functional role as a central bank within the macroeconomic governing structure. As Fforde argues, this structure was also part of the executive arm of government, and it was therefore subservient to parliament and dependent on public support. As such, the macroeconomic policymaking in the UK was not enacted within an independent institution as the Bank of England would turn into in 1998. Combined with conditions of stagflation in the 1970s, this arrangement was under heavy scrutiny by its various audiences – the public, the IMF, markets, parliament and the media. Fforde’s discussion at the Fed made clear that the arrangement’s legitimacy concerns loomed large with the Treasury and the Bank.

Indeed, the material set-up of 1970s macroeconomic governance in the UK was shaped heavily by the need to acquire and safeguard legitimacy for the arrangement, and in part (together with institutional and structural factors explained in the earlier section), stemmed from the development of statistical accounting practices in the 1960s. The Radcliffe Committee in 1959 had proposed that the Bank set up a research department that would start collecting statistical information tracing the aggregate movement of funds, rather than of singular financial institutions (Radcliffe, 1959). The Bank developed an accounting framework, made up of four sectors which were eventually extended to six - personal, public, banking, other financial institutions, industrial and commercial companies, and overseas – that would be linked to the central government's national income and expenditure statistics (BoE, 1969). Despite several shortcomings, the statistics provided a framework that enabled the forecasting of flow of funds across sectors which would feed into economic policy (Hotson, 2010). The first full matrix was developed in 1963, and quarterly data published from 1964 onwards (BoE, 1972a). The statistics also allowed analysis of economic relationships within and between financial markets and the 'real economy'. By 1969, the Bank was also collecting data on the money supply as an indicator (BoE, 1969). The accumulation and analysis of these statistics allowed the Bank to identify relationships between the money demand (M3) and nominal income, as well as between M3 and nominal interest rates.

While monetary economics was less influential on the sociomaterial arrangement of the 1970s, there is a sense in which the quantification of policy was employed for legitimacy purposes. Knowledge, in the form of statistical relationships between M3 and inflation, "underpinned professional economic support" (Fforde, 1983, p. 203) for monetary governance in the 1970s. Fforde claimed that "[t]he initial results being promising, they served to reinforce a natural enthusiasm. For it now looked as if the combination of econometric method and adequate statistics would enable monetary policy to acquire a positivist or 'scientific' flavour in place of the qualitative and 'artistic' nature with which it was thought to have been tainted." (p. 202).

Given the 'political economy' in which macroeconomic governance was subject to the scrutiny of multiple audiences, the central analytical, statistical and accounting framework would make visible in numerical terms the indicators and relationships over which Treasury and Bank held sway. Fforde (1983, p. 201) argued:

> The use of such a framework helps to achieve a proper consistency and coherence of fiscal and monetary decision-making within the wider governmental apparatus, and to provide a convincing and persuasive public presentation of such decisions, at least to Parliament, to the 'informed' media and to financial markets. Indeed the practice of intermediate targetry in the United Kingdom is due only in part to its associated and often 'monetarist' economics. It is as much due to the evolving political and administrative needs of a macroeconomic executive that has to maintain control in the environment mentioned above, and to do so in a democratic society with a relatively free and open economy.

Within this context, the conditionalities attached by the IMF to their loan provision to the UK could be layered over easily onto the material assemblage of the accounting framework. The IMF expected the macroeconomic policy of the borrowing country to be ‘internally consistent’ in order to be able to control deficits, financing provision and the broad credit aggregate: “they could thereby be made analytically consistent and visibly interrelated” (Fforde, 1983, p. 201). As such, adopting *quantities* of money as a monetary target for monetary policy was considered to be more tractable than the price of money (interest rates) within this material assemblage.

The central material framework that related financial accounts with national statistics pushed the Bank to adopt a ‘broad money target’ (M3) rather than a ‘narrow money target’ (M1). In spite of the fact that M3 could not be modelled (Hotson, 2010), it was more easily linked to national statistics in a way that narrow money could not. Practising what was known as ‘the counterparts approach’, the executive could attempt to control M3 (or, more accurately, the components of M3) via a host of tools such as fiscal policy, debt management and monetary policy (Goodhart and Needham, 2017, Hotson, 2010, Wansleben, 2018). On top of its materiality, the adoption of broad money could be interpreted in terms of a wider conception of liquidity and credit, which could assuage Keynesian economists within “a climate of thinking… in the United Kingdom in the early 1970s [which] was more eclectic than monetarist.” (Fforde, 1983, p. 201).

One intended effect of the increased importance given to statistical and flow-of-funds data was also to assign the financial sector a more relevant role in the epistemic practices of policymaking. The flow of funds data aimed “to help identify both the role of finance in the generation of incomes, savings and expenditures, and the influence of economic activity on the financial markets" (BoE, 1972, p. 9). In short, it put increased emphasis on the relationship between financial markets and the 'real economy' within policy practice itself. Secondly, the choice of a money aggregate as an intermediate target and the statistical relationship observed between money and nominal interest rates meant that monetary policy could do away with quantitative controls over bank lending. The process of liberalisation of markets, specifically financial markets, made this "a very attractive suggestion" (Fforde, 1983, p. 202) that would ensure competitiveness and efficiency of financial markets (Coleby, 1983).

Another important consequence of the adoption of the flow-of-funds approach and the shift towards monetary aggregates was that gilt-edged market participants became increasingly concerned with monetary aggregates themselves. As we have seen in chapter 3, the work of professional gilt-edged market participants (such as stockbrokers) primarily revolved around government action; after all, it is government bonds in which investors are investing and in which traders are trading, and therefore it is the actions of that government that matter for an investor or trader in government bonds (Mosley, 2001). As such, given that the behaviour of government was increasingly influenced by the role of monetary aggregates, then it stands to reason that the market participants themselves would start giving attention to those same aggregates. In fact, the regular Bulletins and circulars written and disseminated by stockbrokers such as Greenwell's and Phillips and Drew featured monetary aggregates as one of the main topics of discussion during the early 1970s (Davies, 2012, Hotson, 2010). Gordon Pepper, one of the most influential individuals in the gilt-edged market at the time, was also one of the leading proponents of a monetarist interpretation of government policy and frequently analysed developments in the monetary aggregates.

As Davies (2012) notes, this process was also supported by the fall of Bretton Woods system. Fixed exchange rates under this system used to provide a clear anchor for governments, and it was therefore straightforward for market participants to evaluate and assess government's performance on the basis of this anchor. The abandonment of the exchange rate as anchor exposed market participants to the question of how exactly governments were behaving with respect to inflation, and more importantly, how exactly to assess those government decisions. This view is exemplified by the following assertion by Gordon Pepper (Pepper in Davies, 2012, p. 17):

> "the discipline of a fixed rate of exchange is one of the few factors which ensure that Governments react to excessive inflation. A Government may be reluctant to take unpopular measures to control excessive inflation. A deterioration in the balance of payments and foreign exchange pressures often force a Government to take early action. A movement towards either floating exchange rates or more flexible fixed exchange rates relaxes this most important discipline on Governments"

Monetary aggregates quickly took the place of fixed exchange rates as a way by which markets could hold government to account, assess its commitment to inflation, and evaluate its creditworthiness.

At the same time, the changing structures of financial markets – with the introduction of inflows of (international) funds into institutional investments and the developments of international currency markets (such as Euromarkets) – impeded the government from being able to control the exchange rate while also assigning increasing power to financial markets as creditors of government. Indeed, gilt-edged market participants became increasingly vocal whenever they disagreed with government policy (Davies, 2012).

This earlier monetarist experiment proved a failure because banks engaged in heightened lending following the introduction of CCC, while the Bank was prevented from using the interest rate weapon to control credit growth. Additionally, the knowledge practices through which Bank officials would forecast monetary aggregates and understand the relationship between variables such as inflation, credit growth and interest rates also failed (Wansleben, 2018), thus exposing the government to a loss of credibility particularly in the context of stagflation.

Wansleben (2018) argues that this arrangement was eventually repurposed in 1976, in which the macroeconomic executive turned towards a *published* governance programme following the experience of West Germany, US, Switzerland and Canada in the previous two years. But unlike these cases, the British 'macroeconomic executive' did not assign policymaking powers to an operationally independent central bank, nor did it switch to a Friedmanite form of monetary policy targeting *narrow* money (Hotson, 2010). Rather, the published governance programme retained M3 as its target over a stipulated period, despite pressures to shift to narrow money (M1) from various sources (Needham, 2015). This was in part a response to the failure of the notion that there existed a trade-off between output and inflation (the Phillips Curve) which stagflation made amply clear.

At this point, Friedman had suggested that actual changes in inflation and unemployment would lead to economic agents to adapt their expectations about future inflation and unemployment rates. As such, expectations themselves have a hold on the relationship between inflation and output. This idea in the context of the failure of the Phillips Curve infiltrated British macroeconomic policy thinking, the Bank of England's in particular (Interview TE). But it would be easy to overestimate how much such epistemic developments led by Friedman were influential on British policy in the 1970s. As Healey (1989, p. 491) recalls, "[i]n 1976, before the IMF negotiations, I decided to publish these monetary targets, largely to placate the financial markets. But I never accepted Friedman's theories. Nor did I ever meet any private or central banker who took them seriously." This was therefore a continuation of 'practical monetarism' derived from eclectic thinking in the UK that was more a result of the 'macroeconomic executive's' institutional entanglement with financial markets and political struggles within the macroeconomic executive itself than epistemic influences.

Nevertheless, this shift was a *first* step towards the rearticulation of the state-market boundary in which the state would govern 'market expectations' that would reach its culmination in the arrangement of expectations-management in the 1990s and 2000s. There is a sense in which, as Wansleben (2018) argues, the turn towards an arrangement of expectation management would benefit the Bank as it gained an influential position as the government bond market's expert. Indeed, as we have already seen, ever since the Radcliffe Report, the Bank had recognised the wider implications of the government bond market beyond its functions for debt management. In 1978, Richardson (1978) claimed:

> The Radcliffe Report failed to establish a consensus. It did, however, provide a focus for monetary debate, and one strand of the Bank's thinking-and indeed practice-which found an echo in the Report was the importance attached to operations in the gilt-edged market having a wider objective than merely financing the Government-though the objective suggested was couched in terms of the long-term rate of interest rather than, as today, in terms of the monetary aggregates.

By publishing the programme, it attempted to shift to an arrangement in which expectations were managed, particularly via the expectational effects of official declarations and the performance of monetary policy (Wansleben, 2018). Markets would be enrolled in the arrangement so that, on the one hand, they would refrain from acting against policy and seeking to overturn policy, while on the other, the market could find its own price without overbearing intervention by authorities (Pepper, 1998).

Leigh-Pemberton (1987) would later argue that while both the influence of the Bank and markets is "always present" on market pricing, the former "need always therefore to try to work with the grain of the markets to achieve the required effects" (p. 369). Simultaneously, markets follow and form expectations about what the Bank's policy will be in the near future (Miles and Wilcox, 1989). Or in the words of Hotson (2010, p. 25), a former Bank of England economist, "the role of publicly announced targets [were] a means of framing an intricate dance between the monetary authorities and market practitioners".

The very act of publishing monetary targets meant that the authorities would be disciplined in the way they go about policy decisions. The published targets placed a constraint on the policy-makers who now had to self-enforce a sense of permanent commitment to the published targets[43]. The intended effect of this, if successful, was that it would make the policy-maker more credible, which would anchor expectations and establish some stability in financial markets against the volatility experienced over the years (Richardson, 1978). But as Fforde (1983, p. 204) argues, the new form of governance "altered and intensified the 'political economy' of M3", and although this arrangement meant that market forces would play a more central role (Coleby, 1983), the flipside meant that it also put a spotlight on the macroeconomic executive's ability to govern and thus on the credibility of policy.

Indeed, the macroeconomic executive suffered from a loss of credibility as it failed to meet its targets. In large part, this was due to the fact that the actors whose

[43] In 1977, the question of published targets became political insofar as the Permanent Secretary to the Treasury, Sir Douglas Wass, was concerned about the constraint such published targets could impose on discretionary macroeconomic policy decisions. But a few years later, published targets proved to be the perfect argument for politicians such as Margaret Thatcher, who desired to restrain public spending. Targets for money growth also implied targets for public spending and the borrowing requirement, an argument which provided support for the curtailing of public expenditure (Pepper, 1998).

expectations it was trying to govern were multiple, sometimes in contradiction with one another, and increasingly fractured (Wansleben, 2018). Despite work being done on it and its publishing since the 1960s (BoE, 1967, 1976, 1972b, 1973), the yield curve had not yet been repurposed as a tool of measurement of expectations. The macroeconomic executive had no way by which they could measure expectations, and no means by which they could understand and tame those very same expectations. At the time, in 1978, the Governor of the Bank could claim:

> We can, if we like, think of the nominal interest rate as having an 'expected inflation' component and a 'real' interest element. **But we can never observe expectations, which are in any case likely both to differ from person to person, and to be volatile.** The real rate of interest is an abstract construct. **This has made it very difficult to frame the objectives of policy in terms of nominal interest rates**. For these reasons we were led to pay increasing attention to the monetary aggregates as a better guide-though not of course a perfect guide-to the thrust of monetary policy. (Richardson, 1978, emphases mine)

As a result, the executive found it impossible to coordinate these expectations and the more it failed to meet the monetary targets, the further it lost control of expectations.

Indeed, the yield curve itself was transformed and repurposed into a tool by which market participants could constrain government in its decisions. Faced with a situation of monetary growth spiralling out of control, market participants would strike – i.e. they would refrain from buying on the expectation that rates will increase. The effect of this is that interest rates rise, thus worsening the borrowing costs of government. This could also push government to borrow from the banking system. The latter, particularly, was a more significant concern for government since the very act of borrowing from the banking system would mean that the money supply would inflate further, thus deviating even further the monetary indicators from their targets, with potential recursive loops through expectations. By 1977, Harold Lever – a Labour minister - put his finger on the increasing problem of gilt-edged strikes and the inability of government to control expectations (Davies, 2012, p. 29):

> when we commit ourselves to fixed monetary targets, we commit ourselves to accepting the rates of interest determined by the market in absorbing the required amount of gilt-edged stock. These rates depend crucially on market expectations and the only control we have over them arises from any ability we have to affect these expectations. Without such ability we would be obliged to accept interest rates however high or unstable and whatever their

> consequences for exports, unemployment, finance for industry and housing costs

His proposed suggestion, which partly foreshadowed the developments in the 1990s, was for government to turn to an interest rate policy so as to establish an alignment between government's aims and market expectations. But the yield curve was by then not yet a tool with which to measure expectations, and therefore the control of expectations via the yield curve was not yet possible.

Failure in gaining hold of M3 proved consequential on public legitimacy and the governing credibility. The fact that the accounting framework was intended as a convincing device in a Goffmanian (1956) performance[44] towards its audiences damaged the credibility and legitimacy of the governing agencement when the accounting framework's outcomes were constantly wide off the mark. The published programme of governance was intended to anchor market expectations and provide some stability to interest rates. However, because this "strategy seemed to require a demonstration of quite close control" (Fforde, 1983, p. 204), the wide discrepancies between targets and outcomes not only did not anchor expectations but put increasing strain on them (Pepper, 1998).

On top of scathing critique from financial markets and actors such as trade unions, the practical monetarist arrangement was challenged on the epistemic front due to its eclectic nature. Monetarists in the tradition of Friedman were unwavering in their critique of the *practical* form of monetarism in the UK from the outset. At the heart of this debate was an argument on whether policy-makers should target M3 (broad money) or switch to M1 (base money). The 'pure' monetarist argument made the case for the latter while the sociomaterial arrangement in place, as outlined earlier, targeted M3. Howe (2001, pp. 53-55), former Chancellor of the Exchequer, recalls:

> Hence my astonishment, indeed dismay, at the gusto with which some monetary theologians are still seeking to determine which, if any, of those who managed economic policy in the 1980s now

[44] A Goffmanian performance refers to Goffman's idea that social interaction involves a performance by an actor (in all its senses: an actor as an agent, as well as an actor on a stage) towards their audiences, which includes tools and props to render that performance convincing. For instance, a lawyer in his office achieves legitimacy not simply by their being a lawyer, but also by the qualifications hanging on the wall, the layers of books behind them, the title on the table, dress, talk, mannerisms and so on. Similarly, the accounting framework was used as a conviction device in a Goffmanian performance by the authorities to gain legitimacy.

> deserve to be categorised as 'genuine monetarists'. Leading this hunt, alas, is Professor Gordon Pepper, whose insights more than two decades ago were so influential in guiding Margaret Thatcher, Keith Joseph, myself and many others towards an understanding of the monetary imperative…. Pepper distinguishes the 'genuine' sheep from the 'political' or 'pragmatic' goats … The only 'genuine' true believers are identified as Margaret Thatcher and Keith Joseph – perhaps significantly the two who were furthest from the coal-face of economic policy management… For their central conclusion is that policy under Thatcher was no more than 'an exercise in political monetarism'. Why? Because, in their view, money could not and cannot be controlled by existing instruments. They conclude, re-affirming, one suspects, their long-revered premise, that 'the only remaining solution [is] monetary base control' (MBC).

Monetary base control was the 'obvious' alternative option which the Bank frequently revisited but always rejected (see BoE, 1979). MBC was at the time practised by a number of other central banks, including the Fed. It becomes clear, then, why Fforde's paper at the Fed's conference was of such an apologetic and defensive tone, arguing that "many of us in the Bank of England have at one time or other undergone road-to-Damascus conversions to M1; only to find that the new faith soon loses its apparent attractions". His paper was a defence against the challenge that 'practical monetarism' lacked scientific coherence because it did not follow strict monetarist tenets. This becomes even more evident in Richardson's (1978, p. 37) speech, who concludes by saying that "[w]e have not, it is plain, adopted a wholehearted monetarist philosophy. But what we do is likely to give a monetarist a good deal of the prescription he would recommend, which may be what Mr Volcker, President of the Federal Reserve Bank of New York, implied in his phrase 'practical monetarism'."

5.2.3 The 'High Water-Mark of National Monetarism' in the 1980s

The Thatcher-led Conservative government came into power in 1979, in part owing to the fundamental contradictions and losses of credibility of macroeconomic governance in the 1970s and especially during the second half of the decade (Hall, 1986, Walter and Wansleben, 2019, Wansleben, 2018). While in opposition, Thatcher and her policy entourage had devised a plan to dismantle the corporatist regime of the Labour Government and to shift away from incomes policy towards monetary policy as the main tool with which to fight inflation. The plan also included a state with a much limited scope, lower taxation, liberalisation of markets, monetary discipline, and deindustrialisation (Hotson, 2010, Needham, 2014). During this period, financial markets (particularly the non-bank sector) became a core engine of the real economy. The Bank of England could capitalise on its historical entanglement with the gilt-edged market, and enrol it in its policy arrangement. It had, however, to go one last step in honing the gilt-edged market, as it oversaw its reform in the Big Bang of 1996 and other important developments such as index-linked and zero-coupon markets.

Nevertheless, as Walter and Wansleben (2019) argue, while Thatcher's incumbency is often credited (and often notoriously so) with the start of neoliberalism, her government's policy programmes were marked by experimentation and were in certain respects contradictory. As they took government, the conservatives placed once again the control of monetary aggregates in the pursuit of controlling inflation at the heart of their policy. But this depended on the government's ability to control the money supply (in the form of broad money, M3) and the predictable relationship between the money supply and inflation. These, however, turned out to be strong assumptions, as M3 repeatedly overshot the target in the context of a breakdown in the money demand function (i.e. the relationship between private sector money and macroeconomic variables such as price levels) (Needham, 2014). Simultaneously, measures such as raising the VAT level and the removal of exchange controls rendered the government's ability to control the money supply even weaker (Goodhart, 1989). Indeed, the effects of the latter measures meant that the Corset – controls on banks' liabilities – had to be abandoned because such banks could now turn to offshore disintermediation to avoid nationally-based controls (Hotson, 2010). In turn, abandoning the Corset meant that banks would engage in higher lending which caused a spike in M3, the effects of which thus ran counter to the Medium-Term Financial Strategy (MTFS)'s aims which defined a pre-set *declining* path of M3 (Goodhart, 1989).

The Conservative government now had two tools with which to control M3 and inflation: funding the PSBR via the gilt-market, and raising interest rates to discourage credit demand. The latter, however, was a politically contentious decision for any government, let alone for a Conservative government presiding in the context of interest rates which were already at a high of 12% in June 1979 and rising up to 17% by November 1979 (Hotson, 2010). After allowing a temporary overshoot of M3, the Conservative government decided to *decrease* interest rates. These policy contradictions internal to Thatcher's resolve to fight off inflation in the early 1980s, prompted a number of influential economists from British universities, known as the 364 economists, to challenge Thatcher's governance. They argued that "[t]here is no basis in economic theory or supporting evidence for the Government's [policies]. . ." and claimed that "[t]he time has come to reject monetarist policies and consider urgently which alternative offers the best hope of sustained economic recovery." (letter reproduced in Wood, 2006, p. 138). Although inflation was controlled, monetary targets were not, to the extent that there was often a contradiction between monetary targets and ultimate targets. As a result, monetarist tools (and the whole monetarist arrangement) were targeted by Keynesian economists over the 1980s.

There is, however, a sense in which even "[t]he High Water-Mark of National Monetarism" (Goodhart, 1989, p. 302) in the UK was not full-blown monetarism in the sense of Friedman or at least as was experimented with in other central banks. Indeed, the changes to operational techniques at the Bank were in many ways the result of compromises borne out of long-standing political struggles between Treasury and Bank. In 1977, for instance, the Bank had produced a paper suggesting a turn towards the dual targeting of M1 in addition to M3. The Treasury, however, resisted this suggestion because it was interpreted by the Treasury as a move by the Bank to gain more discretion in macroeconomic policy (Hotson, 2010, 2017). "The Bank was seen as the problem, rather than a potential solution." (Hotson, 2017, p. 147).

Similarly, in the first years of Thatcher's government, the self-declared 'genuine sheep' of monetarism surrounding Thatcher (amongst which were Gordon Pepper, Keith Joseph and others) proposed the introduction of a new monetary policy. Known as monetary base control (MBC) or targeting, the policy implies that the monetary base (M0) - monetary authorities' liabilities held by banks and the nonbank public (incurred during the money market operations) such as banking system's cash reserves - would be controlled by the authorities in order to steer the broader monetary aggregates as well as nominal incomes (Goodhart, 1989, Goodhart and Needham, 2017, Hotson, 2010, 2017). Given that the Conservative government was seemingly running out of policy options, but especially due to the support MBC held with policy advisers such as Gordon Pepper, the Bank anticipated this proposal and sought to pre-empt it. Indeed, in 1979 Charles Goodhart asked Michael Foot and Anthony Hotson, two Bank economists, to write a report outlining why monetary base control should not be the path to follow (Hotson, 2010), which was eventually published in the Bank's Quarterly Bulletin (BoE, 1979). The paper irked the Treasury who wished to keep controlling the debate on the issue (Hotson, 2010).

But ironically, it was the Conservative government itself which led to the downfall of MBC as a potential policy option. MBC required controls over residents' offshore financing if it was to work, but the abolition of exchange controls "killed MBC as effectively as it had killed the corset" (Needham, 2014 p. 145). The contradictions inherent in the British Monetarist experiment were visible from the very start. Nevertheless, the Conservative government wished to keep open the possibility for an eventual return to MBC. As a result, the Bank had to make some important concessions in the way it operated. How so?

As part of its open market operations (OMOs), the Bank acted as a lender to a relatively limited set of market institutions, primarily the discount houses in the money market. In this role, the Bank held control over a policy rate, known as Minimum Lending Rate (MLR) which had replaced Bank Rate in the 1970s, which determined the rate at which money market actors could borrow from it. The projected and actual path of M3, the intermediate target of the Bank and Treasury, was the primary indicator to which the Bank responded. The Bank thus periodically set its official discount/lending rate in an attempt to influence M3. But this was only rendered effective by the Bank's influential role in the money market whereby it varied the cash availability to the banking system and at times "putting the market 'into the Bank'" (Tucker, 2004). By relying on open market operations (OMOs), the Bank historically provided the necessary liquidity or left the market short, depending on what was necessary, so as to bring market rates in line with Bank Rate itself. In effect, OMOs did not set rates but were only the means with which Bank Rate was made effective.

In the late 1970s and 1980s, however, a series of changes were instituted in the Bank's operations in the money market, which were shaped by the need to allow market forces to shine through. Firstly, Bank Rate was replaced by MLR, in part to depoliticise decisions around rate changes (Coleby, 1983) similar to the US (Krippner, 2007). Later, the Bank also suspended MLR and switched to an unpublished band, a switch aimed "to make shifts in the official interest rate objectives less obtrusive, thereby reducing both the political sensitivity of a shift and the extent of official influence over longer money rates" (Coleby, 1983, p. 214). Secondly, instead of relying on Bank Rate as the main monetary weapon (and OMOs only used to render it effective), the new arrangement downplayed Bank Rate and relied more actively on the actual OMOs to signal (rather than fix) market yields.

The new framework, the result of compromises and judged as 'confused and silly' by Goodhart, attempted to limit the influence of authorities on (money) market rates but stopping short of enacting a full-blown monetary base control. Indeed, this 'messy compromise' (Tucker, 2004, p. 369) was another instance in which the contradictions and compromises marking the monetarist experience denied the executive (and the Bank) to establish a workable alignment between policy programmes and financial markets' architecture (Walter and Wansleben, 2019). Despite the ways in which the Treasury and Bank had supported the liberalisation of financial markets, they failed to understand how they could capitalise on liberalised money markets as channels of policy.

Opting to do away with controls and failing to use interest rates as a tool of policy, the Conservative government had one last tool: funding the PSBR via the gilt-market. As a result, they turned towards debt management as the principal policy tool which was perceived to have a more direct and immediate effect on M3 (Coleby, 1983, Fforde, 1983). Within the accounting framework, the Public Sector Borrowing Requirement (PSBR) was the main counterpart to the intermediate monetary target of M3, and it was through the Bank's operations in the gilt-edged market that public debt was funded and monetary growth (meant to be) controlled. The Bank employed a technique of overfunding, in which it would sell more gilts than required by the government (as measured by the PSBR). By selling more gilts to the non-banks, the Bank would absorb the 'excess' liquidity brought on by banking intermediation (Coleby, 1983). But this had the side-effect of producing cash shortages in the banking sector (because the public would invest in gilts rather than deposit their cash in banks). The Bank itself would thus repay Treasury bills held by the banks and then buy commercial bills directly. Although the policy of overfunding may have brought about a shift in the yield curve, Goodhart (1989, p. 306) argues that the authorities were not "acting directly on the yield curve for that purpose", suggesting that by that time the yield curve had not yet been repurposed for monetary governance.

Nevertheless, the result of overfunding and the practices surrounding it was one in which the Bank supported a process whereby corporate financing would be intermediated by non-banks rather than the banking system through bonds rather than bank loans (Miles and Wilcox, 1989). One could argue, therefore, that the Bank was performatively constructing an arrangement in which non-banks were more central to macroeconomic governance, *and* to the very structure of the economic system itself. There is a sense in which the state was attempting to craft a market-based economy through a market-based form of governance (see also, BoE, 1979). This brought the Bank even closer to the non-banking sector, amongst which were institutional investors and the wider public, as it attempted to restrict M3 by calibrating its debt management operations via the tap system in the primary market, and via its Broker in the secondary market.

In its operations, the Bank continued in its historical role in the gilt-edged market over the 1950s and 1960s, whereby it safeguarded the interest of the gilt-edged market. In the words of Coleby (1983, p. 211), "as by far the largest participant in the market, the Bank established certain conventions in its behaviour in the market, in the interests of developing that market to the fullest extent and of minimising the long-term cost of selling the desired amount of debt". Later, the Bank (BoE, 1989) claimed that the funding policy was precisely a continuation of the

> fundamental long-term objective of the Bank's approach to gilt-edged market management to encourage the development of a broad and liquid market. In adapting its operations to the reduced funding requirement, the Bank has had particular regard to this long-term objective and has sought to reflect it in its approach to day-to-day market management.

While its money market operations were fundamentally contradictory and resulting from a messy compromise, the Bank had nevertheless constructed the material infrastructure for monetary governance via the (over)funding policy following decades of harnessing and shaping the gilt-edged market over decades prior. This is not to say that its actions were part of a long-term strategy or plan to introduce this form of governance via debt management in the UK. Rather, the Bank ensured its own relevance within macroeconomic governance by supporting the gilt-edged market.

When a specific sociomaterial arrangement took form (monetarist governance) that required the *re*-enrolment of the gilt-edged market, and which assigned the market an important role in the arrangement, the Bank had established for itself an obligatory passage point, in the Callonian (1984) sense, through which governance had to flow. Indeed, between the mid-1970s and mid-1980s, the monetarist governance came to rely on the gilt-edged market to restrict monetary growth.

But the Bank had one last step to go before turning to inflation targeting and expectations management in the 1980s: the Big Bang of 1986. The Big Bang has been interpreted in the literature as a watershed moment where financial markets gained power through their deregulation (Duménil et al., 2004, Helleiner, 1995, Kirkland, 2015). More recently, political economy scholars have suggested that such an interpretation has exaggerated the power shift that supposedly occurred away from the state and towards market (Dutta, 2018, Lagna, 2016). Rather, Big Bang represented a parallel process of statecraft primarily because it granted states the infrastructural power through which they could govern. I follow this latter literature by suggesting that Big Bang was as much beneficial for the Bank as it was for markets.

As I have argued in earlier sections, the Bank spent decades backstopping, supporting, and shaping the gilt-edged market, and eventually it gained a more central role in macroeconomic governance when the gilt-edged market it co-produced was enrolled in the governance arrangement. But the increasing reliance on government funding to counter the PSBR, and therefore on debt management through the gilt-edged market, meant that the heightened issuance and activity in the market put a strain on the very structure of the market (Dutta, 2018). Mullens, the government broker, argued that “[t]he monetary control period put huge pressure on gilt-edged sales, such that they became the most important workman of economic control, which the old market was not designed to be or to do.” (in Dutta, 2018, p. 3). The Stock Exchange required, therefore, a structural overhaul. This involved the elimination of fixed commission rates and of the single capacity system in which jobbers and stockbrokers were separate, which we encountered in Chapter 3. Together with a relaxing of membership regulations, this unleashed an influx of domestic and foreign capital and a feeding frenzy whereby established stockbrokers and jobbers were absorbed by larger firms, mostly of the investment bank type. Ultimately it resulted in a total of 27 gilt-edged market-makers (GEMMs), amongst which were Phillips & Drew (later taken over by UBS) and Salomon Brothers, as opposed to the eight jobbers under the previous system.

Big Bang also brought about an increase in market capitalisation from around £100 billion to over £600 billion (BoE, 1989). The market-makers now had an obligation to provide liquidity by making continuous two-way prices – particularly in the gilt-edged market, though not limited to it – *across the whole range of maturities*. Deeper liquidity was assisted by stronger turnover in the long gilt futures contract in the London International Financial Futures Exchange (LIFFE). Further developments in the market's structure were the introduction of inter-dealer brokers and the switch from open-outcry to screen-based trading. States were therefore co-architects of a liquid, market-based financial system (Walter and Wansleben, 2019).

While many of these were requirements imposed by the Bank, the latter sought to assist the market-makers in several ways. The market-makers would benefit from a direct dealing relationship with the Bank in the gilt-edged market (the intention being that this would extend to the secondary market as well as the primary market). Indeed, the Bank replaced the tap system by developing the technique of auctions in the primary market and reverse auctions in the secondary market whereby the Bank could sell and buy gilts respectively (BoE, 1987). The Bank ensured that it would only enter the market when it receives bids by the GEMMs and at market prices (BoE, 1989). This particular entanglement with the market inevitably spelled the end of the Government Broker, Mullens & Co, the operations and staff of which were absorbed by the Bank of England. Additionally, GEMMs benefited from direct borrowing facilities with the Bank and from an infrastructural service provided by the Bank known as Central Gilts Office Service which would facilitate computerised book entry transfers and payments systems.

On top of this, the Bank also assisted in the entrenchment of liberalised and deregulated markets by supporting developments in securitisation through the rise of repos and strips markets. As Wansleben (2020) argues, as states realised that liberal markets were a potential source of governance, granting them with infrastructural power (Braun, 2018b), they sought to support them in various ways. Central banks, for instance, lobbied for legal changes in support of repo markets and ensured a repo trinity – liquid government bond markets, financial stability, and free repo markets (Gabor, 2016). Gilt repo trading in the UK was introduced on January 2, 1996, in what the Bank saw as “the most significant change to the structure of the gilt-edged market since Big Bang in 1986” (BoE, 1996, p. 142).

Similarly, in 1997, the Bank would introduce the strip (zero-coupon) market (similar developments we encountered in Chapter 4 came earlier in the US). As a precondition to its introduction, the Bank pushed for a reform to the taxation system which so-nearly invalidated the yield curve during the 1970s. The Bank’s argument was that the then-tax system made it impossible to strip bonds from their coupons: “Tax reform was therefore a necessary precondition for the introduction of strips.” (BoE, 1995, p. 228). The Inland Revenue proposed that the distinction between income (dividends) and capital gains would be removed, thus eliminating the distinction between net and gross investors (see Chapter 3). Serendipitously, the reform in the tax system not only allowed the development of a strips market, ensuring the entrenchment of liberal and securitised markets, but also assisted the yield curve in becoming a more stable ‘descriptive representation’ of the market.

The Bank, therefore, continued working on its long-term endeavour to hone the gilt-edged market as a liquid and deep market. But beyond that, it positioned and entangled itself with the market-makers in such a way that it could benefit from the new market (infra-)structure (see also Gabor, 2016). Furthermore, despite all the contradictions inherent in the monetarist experiment, and the fact that the monetarist arrangement was dismantled around turn of the decade when the UK joined the Exchange Rate Mechanism for a short period of two years, the experiment itself had widespread intended and unintended effects. It provided the conditions of possibility on which the new inflation targeting expectations management arrangement assembled in the 1990s would function. It reinforced processes of market liberalisation, restructuring of financial markets, financialisation and deregulation, which are some of the developments commonly associated with Thatcher’s government.

But the new policy arrangement would need to somehow find a proper workable alignment between its policy techniques and the liberal, liquid, and powerful bank-based and market-based finance with it itself engendered (Walter and Wansleben, 2019). While this chapter so far has elaborated on the ways in which Bank and markets, particularly the gilt-market, co-produced each other and became entangled in multiple ways, I will now turn to the practices developed by the Bank of England as it sought to leverage on these entanglements with the gilt-market by developing an arrangement known as inflation-targeting based on expectations management. It is within such an arrangement that the yield curve moved from the fringes of policy making and took centre stage as a core policy tool with which expectations came to be measured, calculated, and governed.

5.3 Governing fictional expectations through the materiality of the yield curve

The failure of the monetarist experiment in the UK came at a period of political and institutional developments whereby the state receded from financial markets, and where a process of financialisation was intensifying. As we have seen in Chapter 4 and this chapter, these developments were both due to changing market practices (e.g. of arbitrage thinking and the rise of derivatives) and to the ways in which states and markets became entangled. In the British case, the contradictions of the monetarist arrangement led to a loss of legitimacy of monetarist thought and practice. Interestingly, the Bank itself attributed the breaking of the relationship between broad money and demand/inflation to these same institutional developments, particularly to the deregulation of financial markets (BoE, 1990, Miles and Wilcox, 1989).

The Bank realised that these developments presented new opportunities for policy-makers. As financial markets were liberalised, credit provision was rendered more easily available and more widespread for both households and firms. The ‘real economy’ thus exhibited a process of financialisation in which economic activity was increasingly reliant on finance . During the 1970s, but especially after 1981, liabilities in the form of personal debt grew “extremely rapidly” so that the personal sector “moved from being a net creditor to a net debtor (primarily as a result of the growth in borrowing to finance house purchases” (BoE, 1990, p. 200). Given that *households* were now more sensitive to short-term interest rates, and in a clear case in which central bankers ‘learned to love financialization’ (Walter and Wansleben, 2019), the Bank concluded that “it is likely that interest rate effects will be more powerful than in the past given the much greater proportion of households which are affected by changes in mortgage interest rates, and the much larger proportion of their incomes devoted to servicing mortgage debt." (BoE, 1991, p. 202; see also Miles and Wilcox, 1989). In their own right, *firms* had also experienced rising exposure to the cost of credit. In the 1980s, especially, the rapid developments and innovation in financial markets opened new opportunities for company borrowing beyond the banking system, particularly in credit markets, and thus longer-term interest rates. Following this argument, Leigh-Pemberton (1987) asserted that this makes companies more sensitive to changes in interest rates.

In effect, the Bank had co-produced a market that was more conducive and subject to governability through interest rates, both shorter-term and longer-term, that would find their manifestation in the yield curve. In line with the general argument of this chapter, the liberalisation of financial markets and financialisation of the economy did not necessarily assign complete power to financial markets over the state. Rather, the very fact that markets were liberalised led to a process of financialisation in which the so-called 'real economy', i.e. households and non-financial firms, were more dependent on finance, and thus more amenable to being governed through the price of money (interest rates) rather than its quantity. The integration and alignment between financial markets and the non-financial economy granted more power to the governability capacity of the Bank of England as it capitalised on these developments by placing financial markets at the heart of the policy arrangement.

5.3.1 The calculability of expectations within the Bank

Liberalised financial markets and credit-dependent agents meant that greater emphasis was put on the role of expectations in the behaviour of said agents. We have already seen how even in the 1980s the monetarist arrangement relied in part on Goffmanian performances by the authorities which were intended to anchor inflationary expectations (in turn reducing interest rate volatility) (Fforde, 1983). In 1987, Leigh-Pemberton claimed that "[a]s in other areas of economics, behaviour in response to interest rate changes is probably influenced at least as much by people's expectations about the future–relation to prices as well as interest rates themselves … as by perceptions of the cost of money at any particular time." (p. 367). The economic principle behind this is that an economic agent – household or firm – relates to the market according to their expectations about future interest rates and inflation.

An agent will weigh the cost of consumption today against that of a determined future date and defer consumption if today's cost (interest rates and inflation) is too high relative to the future's. Economic action is therefore forward-looking and embodies expectations about the future (Beckert, 2016, Beckert and Bronk, 2018), especially in a liberal and financialised economy where agents are highly sensitive to interest rates.

However, while there was broad agreement that expectations mattered (Capie and Wood, 2012), policymakers were presented with a problem at the heart of which was a question of materiality. Following the Volcker shock, a number of central banks turned towards the targeting of inflation, this being seen as a monetary phenomenon following Friedman (1970). The central question was whether monetary policy should target inflation via some measure of the money supply or via interest rates, i.e. via the quantity or price of money. This is also the question that the Bank had grappled with prior to doubling down on M3 as the intermediate monetary target. Interest rates were a plausible choice, but because only *nominal* interest rates could be observed, these were "a poor guide to real interest rates and thus to the 'thrust' of monetary policy. Money supply, relative to GDP, was a better guide" (Fforde, 1983, p. 202). At the time of this decision, picking apart the inflationary expectations component of nominal interest rates from the real interest rate component was considered a difficult if not impossible task. For at least two decades between the early 1970s and early 1990s, the authorities worked with the assumption that expectations could never be observed (Leigh-Pemberton, 1987, Richardson, 1978). Leigh-Pemberton (1987, p. 367) himself later argued that "expectations … are notoriously difficult to observe, measure or model." Indeed, this limitation derived from the materiality of calculation, measurability and modelling, was a major reason which swung the argument towards the quantity of money rather than its price (Richardson, 1978).

The Bank made several attempts to work around the problem of the measurability of expectations. One of the reasons for the development of the index-linked gilt-edged market by the Bank in 1981, and its selected index of 'the general index of retail prices' (RPI), was precisely to render expectations calculable[45]. However, the attempt proved futile because a proper market-based measure requires broad and deep liquidity for it

[45] An analogous reason stood behind Hetzel's proposition to the Fed in 1990 for the creation of an index bond that would make inflationary expectations calculable (Woodford, 2007).

to become ‘a fact’ (MacKenzie, 2008), and the index-linked market had little and was additionally restricted to institutional investors (pension funds and insurance funds)[46]. More serious attempts at this were however made after the demise of the monetarist arrangement. Under the direction of Mervyn King as chief economist, the Bank restructured its research division in order to develop the internal set-up and expertise that would enable the calculability of expectations and its enrolment in the inflation targeting strategy which we will later turn to. This came on the back of King’s looming concerns about “the way in which markets seemed to have powerful but constantly changing and fundamentally economically inconsistent stories that drove their behaviour and expectations.” (James, 2020, p. 348).

The Bank’s statistical division that grew out of the Radcliffe Report was primarily engaged with the monitoring of statistical data that fed into the larger accounting framework. A subsection of this division was known as the ‘mathematical techniques group’ which was further split up into two groups. The first produced the seasonally adjusted statistics related to the monetary targets and money measures such as M0, M1, M2 and M3. The second group was tasked with technical and mathematical research around financial markets, primarily the gilt-edged market (Interview KG). The latter group had since the 1960s regularly produced representations of the gilt-edged market in the form of yield curve models (BoE, 1967, 1976, 1972b, 1982b, 1973). These yield curves were purely of a statistical nature and involved spline fitting techniques that spliced together segments of the market into a singular yield curve. In a way, these resembled practices and models that the stockbroking firms we met in Chapter 3 were engaged with in the 1960s.

The main function of these models was related to the debt management operations which the Bank conducted. Because debt management involved sales of gilts, the Bank observed yield curves when pricing gilts. As such, the Bank was especially concerned with yield curves during the periods in which it was more active in the longer-end of the market, as we have seen in the first section. However, in the late 1980s the yield curve served the purely operational function by which the Bank could price its debt. In this sense, statistical models and measures of interest rates sufficed.

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[46] See Oliver and Rutterford (2020) for a deeper look into the birth of the index-linked gilt market.

A former staffer recalls that this work was purely mathematical rather than of an economics nature, and the staff "were much more sort of statisticians" (Interview KG).

In the early 1990s, as the subdivision was split up, the first group which dealt with monetary target statistics remained within the Statistics Division, while the second group which dealt with markets data and modelling was merged with the Economics division. This represented a first attempt at bringing together the work that was being done in economics and that of the markets. My previous suggestion that policy had established an alignment between the economy and financial markets thus also took epistemic and material form with respect to the sociomaterial agencement within the Bank itself, primarily by bringing together different forms of expertise in economics and markets. As this group and its models migrated from one department to the other, a new set of practices was established which also implied a new *local* ontology. While previously the staff's work relied on statistical techniques and mathematical modelling, it had now to be embedded within economics. As my interviewee KG recalls:

> When we moved across the economics department, it was very much more 'what are the expectations for interest rates? And what are the expectations for inflation priced in …'. So very much more as an economic indicator. There was still some work with the math for the actual markets area, sort of like how to price things. And so there was bits and pieces we did around that. But the main drive of the other team, it was much more about expectations.

The yield curve, therefore, was a prime candidate as an epistemic and material device that would allow the calculability of expectations. But in order for this to happen, the yield curve itself had to be transformed, repurposed and moulded.

> When I joined it was very much fitting a spline so it didn't have any kind of theoretical underpinning to it. It was very much a mathematical best fit… So if you just splined through, you'd end up with these really wiggly curves. So there was another overlay ... So that's where we started. Now when we went to the economics area, they were less interested in that. And more interested in getting 'what is the long-term equilibrium expected inflation rate'. So having all those wiggles in there, they didn't like that at all. They didn't like if the yield curve was pricing like a curved up or curved down at the end. So there's an awful lot of attempt to try different curve fitting techniques, look at some of the very parametric ones, which at the time were too constrained and couldn't quite get the nuance of what expectations were changing. So there's a lot of attempts to try different kinds of structures.

Rather than being estimated statistically, the yield curve in economics required explicit modelling and theoretical overlay. Additionally, specific characteristics that were useful for debt management, such as a close statistical fit that led to wiggly curves were rejected as the models and modelling practices migrated. The aim of rendering expectations calculable required a smoother curve and theoretical underpinnings which made the yield curve interpretable (Interview PX; Deacon and Derry, 1994a, Deacon and Derry, 1994b).

In this arrangement the gilt-edged market became even more central as the object to be modelled. In turn, its model – the yield curve - became a metric of market expectations which the Bank sought to govern, both in terms of future inflation as well as future interest rates (Interview TE). The Bank economists relied on the theory of the expectations hypothesis which the Bank had argued for three decades earlier to the Radcliffe Committee. (As already mentioned, the theory is based on Fisher's idea that long-term interest rates are essentially averages of future short-term rates, and therefore that longer-term bonds embody market expectations of future short-term rates. The basic premise is that the return on holding a long-term bond to maturity is equal to the expected return on holding multiple short-term bonds to maturity – their aggregate maturity being equivalent to the long-term bond). In other words, prices of long-term bonds depend on market expectations of future short-term bond prices. Given that short-term interest rates are strongly influenced by central bank's monetary policy via Bank Rate, long-term bonds therefore also imply market expectations of future central bank policy).

But despite the fact that the theory was influential within the Bank since at least the 1950s, it had never been formalised into practice. What the 1980s/90s Bank economists did differently was to switch their yield curve modelling techniques to models and model practices which accommodated the expectations hypothesis on a *material* level. Economists could now look at the yield curve and break down nominal interest rates into real rates and inflation expectations, and to derive the implied forward rates that incorporated expectations of future spot rates. "In this way the shape of the yield curve reveals important information regarding market expectations of the future level of interest rates." (BoE, 1985, p. 561). On top of the development of epistemic tools and practices, economists also benefitted from the institutional structure of financial markets – a more developed, liquid and connected set of financial markets. While these markets changed the very working of monetary policy and market behaviour, economists could also look beyond the gilt-edged market, particularly to derivatives markets such as futures and swaps, for novel tools and metrics (Interview CR; Miles, 1989). As a result, the pursuit of developing market-based measures of expectations took precedence within the economics division at the Bank (Interview KG).

Although it is difficult to determine a direct causal chain between the role of economics within such institutional developments and policy arrangements and practices, there is little doubt that knowledge was *increasingly* influential on monetary policy. There did exist significant knowledge gaps within the Bank of England, primarily with respect to monetary transmission mechanisms specific to the British structure (see Miles and Wilcox, 1989). But there is a strong sense in which economics provided the required legitimacy and a blueprint for the *institutional* framework of the monetary policy regime. Within this structure, the Bank of England could establish itself as the obligatory passage point of policy by constructing a new policy agencement that would aim to govern the real economy 'from a distance' (Krippner, 2011, 2007) by leveraging on the (infra)structural entanglements with markets (Wansleben, 2020, 2018). But before we turn to the construction of the new agencement, we need to take a detour into the very model of the new neoclassical synthesis that was increasingly influential in the international central banking community.

5.3.2 Knowledge and models in the construction of a central bank and its monetary policy

The sociology and political economy literature on central banking often takes as its starting point the notion that central banks have undergone a process of scientisation (Claveau and Dion, 2018, Marcussen, 2009, Mudge and Vauchez, 2016) and thus have become the quintessential technocratic body (Abolafia, 2020, McPhilemy and Moschella, 2019) in modern society. Before I turn to the final section of this chapter in which I will outline the construction of an institutional and sociomaterial arrangement that targeted the governance of fictional expectations, I will first trace the intellectual developments in macroeconomics and the adoption – or, more accurately, co-

construction - of these debates in central banks' monetary policy which have shaped and become embedded in the sociomaterial arrangements of central banking. I show how the development of monetary policyxf was influenced in an implicit way by financial economics and explicitly by macroeconomics, which process led to a particular entanglement between central banks and markets that reinforced the institutional developments explored in the previous sections.

During the early 1960s the US's monetary policy body, the Federal Reserve (Fed), came under heavy criticism by some influential economists, including Karl Brunner, Alan Meltzer and James Tobin, for its lack of theoretical basis and empirical analysis in its processes of decision-making. Despite having research departments which collected economic data, the Fed lacked a structured approach which channelled this data into theoretical and empirical techniques and devices that gave structure to the decision-making, and it was thus seen as relying on faith, intuition and feel (Acosta and Cherrier, 2019). The result was a conscious effort to develop such a structured approach, embodied in the FMP model (also known as the MPS model), in the mid-1960s.

The FMP model was a joint effort by MIT's Franco Modigliani, University of Pennsylvania's Albert Ando, and the Fed's Division of Research and Statistics staff. It was an embodiment of what has become known as 'the neoclassical synthesis', first developed by Paul Samuelson Samuelson (1967) and which merged neoclassical thinking with Keynesian principles (Goodfriend and King, 1997). In line with neoclassical thinking, the model adopted a microeconomic view of firms' and individuals' behaviour. Investment and consumption, together with the demand for money, were thus the result of individual choice. On the other hand, the model assumed wage and price stickiness in the economy, implying that markets did not clear instantly. The resulting implication in terms of policy was that markets did not, in the short-run, clear without policy intervention. Therefore, active fiscal and monetary policy were deemed relevant in influencing economic equilibrium in the short-run via aggregate demand management. The transmission mechanism from policy to the economy was based on the IS-LM paradigm as formulated by Hicks (1937) in his formalisation of Keynes' thinking into a general equilibrium model, the Phillips curve, and neoclassical identities of behavioural rationality. Policy effects in this framework could be transmitted through three main channels: the costs of capital in investment, wealth and consumption, and credit rationing in the housing market (Brayton et al., 1997). The model also rested on the idea that interest rates are a powerful policy tool for the policy-maker, but in practice policy-makers believed more in the influence of direct *credit* effects, i.e. the *availability* of credit, rather than in the effects of market interest rates (Goodfriend and King, 1997).

In the background of these developments in economic thought and practice was a long-standing intellectual debate between Keynesian and Monetarist thought. Indeed, one of the aims of Modigliani, himself a Keynesian economist, in developing the MPS model was to resolve that debate by incorporating his thought rooted in Keynesianism within policy practice (Backhouse and Cherrier, 2019) to the detriment of the Monetarist agenda pushed by Friedman. The latter, together with other monetarist economists such as Karl Brunner and Allan Meltzer, were arguing for policy to turn towards the money supply as a policy target and to support this by integrating into the policy-making process a monetarist theory of the process of money supply that focused on the *quantity* of narrow money rather than credit availability or long-term interest rates[47]. These intellectual debates were also central to the Radcliffe Committee's criticism of and recommendations to the UK's experience with monetary policy which we have explored in the previous section.

The criticisms levelled by Monetarists against the neoclassical synthesis were particularly powerful during a period when the latter, particularly as embodied within the sociomaterial arrangements at the Fed, started to fail. Firstly, the reliance on the Phillips Curve, which implied a long-run inverse relationship between inflation and unemployment, came under fire as inflation rose in the late 1960s and with the onset of stagflation in the 1970s. The contribution of the failure of empirical prediction to the crisis of the neoclassical synthesis was also accompanied by a more fundamental attack on the theoretical basis of the synthesis itself. Both monetarist sympathisers and especially economists pushing the microfoundations of economics heavily

[47] We will return to this theoretical debate in Chapter 7 when we discuss Quantitative Easing and the reworking of the sociomaterial arrangement that necessitated it.

criticised the core inconsistency of the theory: on the one hand agents are seen as rational, while on the other markets are treated as inefficient.

The strongest critique which ultimately led to the downfall of the neoclassical synthesis was imparted first by the economist John Muth and later by Robert Lucas, both of whom had found their intellectual home at Carnegie Mellon University in Pennsylvania. The two proposed the idea of the microfoundations of *rational expectations*, in which individual actors within the model are assumed to behave, in aggregate, in a rationally optimal manner and to ‘know the model’ (Lucas, 1972, Muth, 1961). Agents, therefore, form expectations congruent to the model of the economy and, while they make mistakes, they are on average correct. The implication of these microfoundations, as in the Lucas critique (1976), was to render irrelevant the then-structural Keynesian economic models based on stringent and policy-dependent parameterisation of behaviour. In their view, agents’ behaviour adapts to changes in policy such that Keynesian models will fail across shifting policy regimes. This critique held implications for economic policymaking, which could not rely on these models anymore. Furthermore, the rational expectations hypothesis as applied by Wallace in the context of monetary policy implied a policy-neutrality result in which policy would be itself rendered ineffective[48] (Wallace, 1981).

Because such monetarist thinking and REH thinking threatened Keynesian thought, economists in the Keynesian tradition responded by proposing a new set of theories and models which would become known as ‘New Keynesian models’. Interviewee VF explains to me how influential the role of MIT to this intellectual development was. MIT economists, including Fischer, Mankiw, and Summers among others, took general equilibrium models based on the microfoundations of rational expectations and incorporated within them ‘real economy’ frictions such as wage and price stickiness. From this viewpoint, Keynesian insight to policy is not rendered irrelevant. In fact, this development was a prelude to what has nowadays become known as the ‘*new*

[48] Indeed, an additional suggestion by new Keynesian economists was that the overfunding policy of the 1980s breached the rational expectations hypothesis. In a model in which actors are forward-looking and markets are efficient, debt management and funding techniques were irrelevant (in line with the argument by Wallace drawing on Modigliani-Miller). However, as Miles and Wilcox (1989) argue, despite this irrelevance hypothesis, the method of government financing to influence monetary targets was widely accepted in the 1980s.

neoclassical synthesis', the delineation of which is best exemplified in the authoritative work by Woodford (2003).

The implication of the new synthesis was that central banks became concerned primarily with the management of expectations as incorporated in prices (Braun, 2018a) by targeting the *price* of money (interest rates). Following Sargent (1986), because inflation is a phenomenon that is fundamentally linked to long-term government policy, then central banks should engage in credible commitments within an inflation-targeting regime by which they could control inflation via interest rates (Goodfriend and King, 1997). However, the idea that policy is only powerful on expectations provided intellectual fodder to the practice in which central banks limited their operations to the control over a short-term policy rate. As a result, central banks would influence directly and materially the short-term rate, and required a long-winded and complex 'transmission mechanism' from shorter rates to longer rates via expectations.

One of my interviewees (PY), an economist who contributed to the development of the Bank of England's first in-house DSGE model in which the new neoclassical synthesis became embodied, confirmed that macroeconomic models of this sort incorporate frictions in the real economy (frictions such as wage and price stickiness added by New Keynesian economists) but *no* frictions in financial markets. As a result, the transmission mechanism of monetary policy – which puts financial markets at its centre – relies primarily on the influence of expectations in financial asset markets, primarily fixed-income markets. In fact, my interviewee argues that DSGE models exhibit strong reactions to expectations and little reactions to other forms of policy action. The transmission mechanism at the heart of modern monetary policy is therefore couched in a set of assumptions on the functioning of financial markets - assumptions derived from macroeconomic theory and early financial theory. Within a general equilibrium theory of asset prices as outlined in Clarida et al. (1999), financial markets are complete and frictionless such that asset prices reflect the current and full state of information, consistent with the efficient market hypothesis. It is easy to see, therefore, how the new neoclassical synthesis holds affinities with notions prevalent in financial economics which we explored in chapter 4.

Indeed, modern monetary policy has its origins in the earlier work of financial theory as exemplified by Modigliani-Miller (1961, 1958), which itself was an important early component of the rise of the 'no-arbitrage world' of derivatives pricing (MacKenzie, 2006, MacKenzie and Spears, 2014b). Asset prices, in this worldview, are a function of the present value of random returns, based on a stochastic discount function contingent on the marginal utility of a household's income in different states of the world. Markets - money markets, long-term interest rates, exchange rates, other asset prices - are directly linked via arbitrage (Woodford, 2012). Under these conditions – effectively a no-arbitrage Modigliani-Miller in which markets are frictionless and asset pricing is risk-adjusted – a central bank is only as powerful as its ability to engage in credible commitments about inflation in a bid to influence financial market pricing via expectations. The new neoclassical synthesis was a particularly powerful theory that became mainstream in macroeconomics. But in order to be successful, it needed to be adopted by the central banking community and to be enrolled materially within central bank arrangements and practices.

In the next section, I will detail how the Bank of England's sociomaterial agencement became predicated on a carefully-constructed alignment between the Bank's structural entanglements with the gilt-edged market (explored in previous sections) and new policy techniques and devices developed during the 1990s supported by the new neoclassical synthesis. The Bank's agencement was both the result of durable (but reworked and repurposed) elements that formed part of previous arrangements as well as novel developments introduced in the 1990s (e.g. the role of the neoclassical synthesis and New Keynesian economics).

5.3.3 The construction of the sociomaterial arrangement of formal inflation targeting in the UK

Despite its monetarist stance, the Bank's economic and policy thinking during the 1980s had already moved closer to what later was to be christened as the new neoclassical synthesis. It had abandoned debt management as a means through which policy was conducted, in part due to the rational expectations hypothesis which rendered government funding irrelevant (James, 2020). It had also come to a realisation that expectations mattered more than they had previously considered. Monetary policy could not restrict itself to actual indicators (e.g. of inflation) because that would have implied “driving the economy by looking out of the rear-view mirror” (Haldane, 1997, p. 12). Rather, monetary policy needed to be forward-looking and thus to deal with the *expected* values of a macroeconomic variable such as inflation. Expectations, therefore, mattered (Capie and Wood, 2012). Later, the leading proponent of the new neoclassical synthesis, Michael Woodford (2005) would argue that ‘not only do expectations about policy matter, but, at least under current conditions, very little else matters’ (p. 3).

The Bank realised that the influence of expectations relied on a central bank being credible and providing commitments to its target. Instead of discretionary and ad-hoc policy targets, this required a fixed target around which policy and expectations would revolve. These ideas were consolidated in New Keynesian thinking, the first authoritative papers of which being Kydland and Prescott’s (1977) and then Barro and Gordon’s (1983) which made the case for formalised inflation targets, and enforced commitments - rules rather than discretion (see Goodhart, 1989) - in the pursuit of policymaking credibility. Following the UK’s exit from the Exchange Rate Mechanism, British macroeconomic policymaking turned precisely towards such an institutional framework in 1992. The Chancellor established an explicit inflation target of between 1%-4% and pushed for a higher level of transparency by the policymakers towards the public. This came at a period in which central banks were moving from secrecy towards transparency, though a form of transparency which nevertheless required a level of obfuscation (Krippner, 2007).

The idea behind this was that transparency, as opposed to opaque processes of decision-making, would do much to *anchor* expectations. As economic agents come to form cognitive expectations about the future and to construct their actions in terms of these expectations – i.e. fictional expectations in the sense of Beckert (2016) – the central bank is able to govern only if it successfully frames these expectations. As economic agents learn about the reaction function of central banks to particular macroeconomic indicators, the theory goes, uncertainty about future inflation is controlled and economic agents’ expectations would be *anchored*, and therefore the central bank through the management of expectations can now successfully engage in price stability (Blinder, 1999). The constantly changing and inconsistent stories that worried Mervyn King would no longer be a source of worry as they would all be anchored together and possibly rendered consistent with each other.

This relied, first of all, on a performance of depoliticisation. In the words of Mervyn King (1997) himself, “transparency should lead to policy being predictable. It is all part of the view that a successful central bank should be boring, a referee whose success is judged by how little his decisions intrude into the game itself.” (p. 14) But the institutional framework of explicit inflation targets, credible commitments and transparency alone was far from being enough to render policy successful. In prime ANT fashion, the astute Mervyn King recognised that a performance requires concrete social and material arrangements that would make governance ‘socially’ possible. He envisaged an arrangement that would be predicated on a set of structured practices and material devices which would anchor market expectations to central banks’ actions. The governance of fictional expectations required an amalgamation of carefully chosen technologies, devices, signs, lexicon, and rituals.

Under his guidance, the Bank’s economics division went into overdrive in order to craft the first Inflation Report (Interview KG). Purposely titled the ‘Inflation Report’, it served first and foremost as a ‘frame-making device’ (Beunza and Garud, 2007) that would connect fictional expectations of economic agents to *inflation* as a macroeconomic indicator and policy target by disentangling them from other macroeconomic variables. The Inflation Report would become a staple of the Bank of England’s monetary governance and several central bank would follow the Bank’s path and start publishing their own report. Mervyn King wished to develop a scientific and empirically-based form of policymaking that would also shine through in the Inflation Report. For this purpose, the Bank invested in its research department and sought to develop expertise in macroeconomic forecasting. This served two related purposes: in one sense, a forward-looking form of economic policy requires forecasting devices and routines that, despite conditions of uncertainty (Beckert, 2016, Beckert and Bronk, 2018, Haldane, 1997), feed into the decision-making process of policy and further assist in anchoring those expectations. In a second sense, the Bank sought to establish itself as the *epistemic authority* (Braun, 2018a, Rosenhek, 2013) on macroeconomic and monetary forecasting (and governance) and thus as the obligatory passage point of such governance. This they did at the expense of the Treasury whose central role in monetary policy started waning during the 1990s.

Investment in research was not limited to investing in economists as 'unaided humans'. Rather, it also involved a push in material devices such as macroeconomic models. The Bank economists, equipped with dynamic stochastic general equilibrium (DSGE) type of models, could now take that model as the organising framework for inflation forecasts. The forecast was part of a set of practices that would give structure to the way the Bank interacted with its audiences (Interview EF; see BoE 1993) and render stable the sociomaterial agencement. On top of this, over the years the Bank sought to establish a discursive repertoire and highly stylised language in its communication to the audiences for structured sense-making purposes, and a regular and pre-announced schedule of policy meetings (Interview EF; Holmes, 2013).

Although the Bank did keep in mind its communication with the public, primarily via the mediating role of journalists and the media, there is little doubt that its communication was primarily targeted towards financial markets in general and the gilt-edged market in specific. As already argued, the success of this sociomaterial arrangement also required the enrolment of financial markets, at the centre of which was the gilt-edged market. The gilt-market was, for the Bank, not only a localised forum through which it would *measure* its own policy effects, but also the *channel* through which it would actually govern. Both of these forms of incorporation of the gilt-edged market into the policy arrangement rested on a specific model of financial markets. The rise of arbitrage-free financial economics, its adoption in market practices (Hardie, 2004, MacKenzie, 2006, 2003, MacKenzie and Spears, 2014a, b), and some of the more mundane developments we explored in Chapter 3 and 4, led to a model in which financial markets were efficient in the sense of Fama (1970), arbitrage-free and interconnected.

These ideas, which also influenced monetary policy theory over the years, were adopted implicitly but materially *within* DSGE models, the transmission mechanism of policy, and in the way the policy arrangement was constructed. For the Bank, the influence of the gilt-edged market on wider interest rates, asset prices, and on wider economic indicators was enough for it to restrict its purview to this market and let market forces do the rest for the transmission mechanism of monetary policy. We will turn to the precise way in which such financial models allow central banks to govern in the next chapter, but suffice it to say at this point that financial economics as adopted within macroeconomic models provided the scientific legitimacy for central banks to operate ‘at a distance’ to markets and to let the markets do the work for it (Blinder, 1999, Krippner, 2011, 2007, Woodford, 2003).

The ‘final’ element in the institutional framework of inflation targeting was the granting of independence to the Bank of England in 1997 - although it was already being hinted at and pushed for as early as 1993 (BoE, 1993, James, 2020) - which provided the Bank with a mandate to pursue price stability and to implement its own policy independently of the government’s executive. This was also emphasised by economics literature which saw central bank independence as the culmination of a framework that assigned the central bank political and institutional insulation to be credibly committed to the inflation target in order to successfully anchor market expectations. In the same stroke, the Monetary Policy Committee was created, which was to be made up of experts in economics who would make monetary policy decisions within the mandate assigned to it by the Chancellor[49]. Finally in terms of institutional developments, the Bank’s mandate of debt management was allocated to a newly established Debt Management Office which was to minimise Government’s financing costs without interfering in the Bank’s thrust of monetary policy.

Within this sociomaterial and institutional arrangement the yield curve took central stage. For instance, looking back on the previous five years of formal inflation targeting, Mervyn King (1997) could judge the monetary policy framework a success by looking at changes in yield curve’s forward rates in response to changes in Bank rate. “In the limiting case of perfect transparency in which the authorities’ reaction function is known with complete certainty, market rates would not respond to changes in official interest rates. There would be no news in official interest rate announcements.” (p. 14). Drawing on Haldane and Read’s (1997) work entitled ‘Central Bank Secrecy and the Yield Curve’, King (1997) could conclude that the inflation targeting institutional framework, and its supporting sociomaterial arrangement described above, has “made British monetary policy less exciting - and

[49] From this viewpoint therefore, the process of scientisation which central banks exhibited over the past few decades and which is emphasised in the social science literature was less a matter of embedding policy within the science of economics as much as it was a matter of *being seen as* (and thus a Goffmanian performance of) practising a rules-based form of policy that would render predictability and reduce uncertainty in policy decisions.

a good thing too.” (p. 14). But beyond using the yield curve as a metric through which one could judge the historical success or failure of policy, Bank economists were also employing it as part of their action and interactions with market participants. It is to these practices that we will now turn in the next chapter.

In conclusion, following decades throughout which the Bank sought to cultivate, support and shape financial markets, the Bank could now capitalise on a set of well-developed and well-connected markets that were an indispensable financing engine to the ‘real economy’, and on its relationship with them. The felicity conditions absent throughout this period – primarily a deep, liquid, and highly capitalised markets that could function independently of public (central bank) support, monetary policy that was not subservient to fiscal policy, and an independent central bank– were now in place, and the novel practices and arrangements developed in the gilt-edged market throughout the decades covered in this chapter could be enrolled into a new arrangement. Indeed, the Bank had constructed an institutional arrangement, honed its scientific legitimacy and could engage in a Goffmanian performance that depoliticised its own actions – as an independent central bank relying on scientific tools, empirical data and technical procedures in its decision-making and one that lets markets do the work for it and is, as such, non-interventionist.

By assigning policy decisions to a highly formalised *expert* Committee, restricting its actions to open market operations, and by enrolling the gilt-edged market as a core ‘ally’, the Bank could construct and deploy the above arrangement in the pursuit of price stability via financial markets’ fictional expectations. As the Bank manufactured the frame around fictional expectations, the latter became tightly linked to the central bank’s actions and reaction function and reduced uncertainty for market participants. From this point onwards, at least until 2007 and with varying degrees of success along the years, fictional expectations would be tamed and this would only be made possible by the yield curve’s indispensable and sociomaterial function as a *coordinating device* in the interactional alignment between central banks and financial markets.

Part II:
Rendering order and re-assembling agencements

Chapter 6

Interactional alignments and the yield curve as coordinating device

The previous three chapters have underlined the various historical processes by which the yield curve came to occupy pivotal positions within multiple sociomaterial agencements. In line with Star's (2010) conceptualisation of objects, I have argued that rather than exhibiting a 'fixed thing-ness' (p. 603), the yield curve required repurposing, reworking, moulding and reshaping as it was adopted within multiple ontologies. In the same way that the Zimbabwean bush pump studied by de Laet and Mol (2000) was found to be fluid and malleable as it travelled across the rural towns of Zimbabwe, so does the yield curve exhibit properties of a *mutable* mobile (Law, 2009b, Law and Singleton, 2005) as it comes to sit within various arrangements, ontologies, communities.

In this chapter, I turn my focus to the ways in which, rather than these multiplicities leading to chaos or social disorder, they render order by way of a set of routinised, institutionalised practices. The malleable yield curve acts as a coordinating device around which these practices and multiplicities revolve. Despite its malleability, the curve exhibits a level of universality that transcends the locality of specific sociomaterial agencements and, even more crucially, connects them. Various agencements – from central banks to the fixed income trading desk – are connected via the yield curve by a sense of shared cognition, a *distributed* form of cognition (Hutchins, 1995). Actors communicate in terms of the yield curve as the market is not merely replaced (Preda, 2006) but constructed through the yield curve.

As argued earlier in the literature review, both Latour and Callon, as well as other ANT proponents such as Law, conceive of society as a configuration that involves both processes of what have traditionally been seen as *social construction*, as well as *materiality*. I will therefore be drawing on (and bridging) the approaches of the social studies of finance with its emphasis on performativity, calculation and knowledge practices, as well as Beckert's work on imagination, narratives and fictions. I will argue that together these form a powerful analytic in studying how 'the social' is constructed in and around markets.

The first section focuses on the processes surrounding and working through the yield curve by exploring the way market participants and central bankers construct and relate with the market. In doing so, I give attention to the role of fictional expectations (Beckert, 2016), how they form and aid market participants, and how central banks repurpose them as tools of governance. I also show how the yield curve renders these fictional expectations calculable, for both market actors and central banks, without which device fictional expectations would remain ungraspable.

The second section turns to a sociomaterial process in which a multitude of fictional expectations across markets are made consistent with each other. The way fixed-income arbitrageurs (or relative-value traders) employ the yield curve for arbitrage trades connects multiple yield curves and their embodied expectations, thus reproducing *materially* the yield curve's construction of 'the market' as a singular entity. In other words, the work of arbitrageurs renders assets substitutable and equivalent within and across markets. Additionally, arbitrage ensures that the expectations hypothesis of the yield curve is approximated, thus allowing actors to read forward rates in terms of expectations. Indeed, there is a whole underlying (often concealed) process of arbitrage that gives structure to the yield curve, and in this sense, makes markets more efficient. I show how central banks rely on the existence of leveraged arbitrageurs to incorporate this model (of expectations and efficient markets) within their sociomaterial arrangement such that monetary policy and more importantly its *transmission mechanism* are rendered more powerful. As arbitrage makes markets more efficient, arbitrageurs transmit central banks' policy from money markets to other markets and the banking system via the discount rates/curves of the sovereign bond yield curve which serves as benchmark for other market pricing.

The third section looks into how markets and central banks coordinate into the future, central to which coordination is the yield curve acting as coordinating device. Coordination via the yield curve is only possible if the latter achieves a sense of universality that transcends the multiplicity of ontologies explored in previous chapters. The various actors in and around the bond market come to agree on a singular yield curve, built and distributed by Bloomberg through its Bloomberg Terminal. This conventional and standard yield curve establishes shared temporalities, structures, and communication, a process which reproduces ‘the social’, not as a *single* actor-network (Law, 2009b) but as a set of agencements that are entangled in multiple and complex ways but which nevertheless exhibit order, not least with the support of the yield curve as a sociomaterial device that connects it all in meaningful ways. I conclude the chapter by providing an explanation to why the coordination practices elaborated on above proved successful at least up to the financial crisis of 2007/08. Christophers (2017) explains this in terms of the central bank’s ability a) to shape market interpretations of monetary policy and b) to produce the yield curve materially thus assigning it with enduring power. While my argument is congruent with the first element, I contrast his second part of the argument by showing how market participants rely not on the central bank’s construction of the yield curve, but primarily on Bloomberg’s as the authoritative external vendor system. The argument I present is a nuanced sociological one, where the yield curve draws its enduring power not because it exists as a central bank production, but because market participants know that all other market participants read the yield curve in terms of the central bank’s influence on it – similar to what Keynes terms ‘a beauty contest’, a notion that was mentioned unprompted by my interviewees.

While in each of the previous chapters I have restricted my focus to specific and separate agencements, here I aim to foreground the inherent relationality between central banks and multiple market agencements, in line with Latour’s, Callon’s and Law’s conceptualisation of ‘the social’. The literature in the social studies of finance and scholarship of the sociology and political economy of central banking tends to limit their analyses to markets *or* central banks respectively. In this chapter I aim to depart from this traditional approach towards a better appreciation of the sociomaterial entanglements between the various agencements, and how the yield curve contributes to social order across these entangled multiplicities. To this end, the interviews on which I borrow here, carried out with both market participants and central bankers, gain purchase on the process by which central banks and markets interact concretely and in practice. Indeed, I will claim that this entails an ‘interactional alignment’ between central banks and market participants that is entirely predicated on the (infra)structural and institutional entanglements explored in Chapter 5 and in the literature (Braun, 2018b, Walter and Wansleben, 2019, Wansleben, 2018).

6.1 Distributing cognition, fictional expectations, and the making of the market

The social science literature on central banking has explored in great detail the various ways in which central banks seek to anchor, influence and ultimately govern expectations (Braun, 2015, 2014, Holmes, 2013, Wansleben, 2018). In many ways, however, few studies detail in-depth the practices of how fictional expectations form in the market and how they are expressed through trading. This is precisely the phenomenon we now turn our attention to in this section. More specifically, we will centre our lens on fixed income market practices. Fixed income markets, at the heart of which is the government bond market, are the primary focus and audience of the central bank, as we have seen in previous chapters. It is fixed income market expectations that central banks seek to govern and to govern *through*. To that extent, they require further study.

Beckert (2016) has proposed the notion of fictional expectations to refer to the organising feature along which economic actors make decisions. Because economic action is necessarily forward-looking, and given that actors act in the context of ever-present uncertainty about the future, Beckert suggests that actors need to form imaginaries and fictions about the future by which to guide their own decision-making. These often take the form of narratives, frames, or stories as actors seek to build an *imagined* future. In this section, I will adopt this conceptualisation of expectations to lay out the ways in which actors construct their imagined future, or 'view' in the participant's own parlance. I will later integrate this theoretical schema with the ANT-inflected literature in SSF, primarily by reference to work on calculative devices and calculative frames (Beunza and Garud, 2007, Beunza and Muniesa, 2005, Cochoy, 2008). In doing so, I hope to show how the yield curve acts as a *mediator* (Latour, 2005) between multiple fictional expectations and the recursive construction of the market as a singular actor by transforming multiple fictional expectations into a *collective*.

6.1.1 *My job is to have a view*

Directional and macro traders on both the buy-side and sell-side are first and foremost information gatherers. Such traders, whose work is often speculative and who operate on various instruments (primarily futures and swaps), are on a constant lookout for new information which they can incorporate into their 'view', and thus their imagined future. As one of my interviewees told me, "I have a view on everything. My job is to have a view" (Interview FV). By this, my interviewee meant that market participants need to have an overarching narrative or story about the future. More precisely, they need to hold an amalgam of, possibly interconnected, convictions or expectations (Beckert and Bronk, 2018) about specific markets and their underlying drivers. Because fixed income markets, and especially rates markets, are often driven by macro factors, market participants constantly gather and interpret emerging information on macroeconomic drivers. One of my participants (Interview AX) argued:

> Fundamentally rates markets are driven by economic, political, social factors and I think fundamentally the most important thing is to have a strong view on those aspects and what you think it means for what the price of money will be…

My participants referred to a wide and diverse array of what, in their day-to-day practice, they consider as *worthy* information to collect and interpret: UK inflation data; Canadian interest rates; global oil prices; iron stock price; soft forward-looking growth data such as US' PMI (purchasing managers' index); political research; South African pension funds; Donald Trump and trade wars with China; GDP measures and forecasts; business survey sentiment; euro area credit risk research; "oil rig counts in the Permian basin, trying to anticipate how much oil the US is gonna produce" (Interview FV); "discussions between the Italian government and the European Commission" (Interview CC); "big data downloads, literally information flashing all the time about what's moving prices up and down, to see outsize moves and we can react to them and think about what they mean" (Interview VK).

Such a huge range of potentially relevant information necessarily requires an element of judgement on the part of the trader in order to select what to give attention to and what to put aside or discard. A first filter is the trader's own tacit knowledge. A trader with experience in the UK's gilt-edged and futures market is all too aware of the pressure insurance regulation has on the market, while a trader in the South African market can quickly get a feel of the market as prices change and realise that it is a specific large market actor that is moving the market, rather than a piece of macroeconomic news available to everyone. This tacit knowledge enables traders to disentangle pieces of information, to make judgements on the worthiness and relevance of information, to interpret it and to incorporate it within (or exclude it from) the overarching view.

A second filter which functions alongside tacit knowledge is a comparative technique that traders employ in order to render information meaningful. The trader selects two similar markets such that the similarities are neutralised and he is left with the more meaningful factor as comparison. The practice thus involves overlaying two highly similar frames through which a few factors can be disentangled:

> So if you're trying to have a relative value trade, you want to have something that isolates one factor in two markets and all the other things cancel each other out… So, for example, the favourite one of mine is short Canadian dollars, long Norwegian krones [sic]. They're two oil-exporting countries, so you've neutralised oil. You've also neutralised housing markets in both countries… You're trying to pick two financial instruments that have an awful lot of the same characteristics and just one or two things that's different between them so you can narrow in on that and remove the external influences over the thematic exposure. So if the oil price goes up, both Canadian dollars and Norwegian kronas should appreciate. But, because of the state of the basic balance of payments between them – Norway's got 10% current account surplus and Canada's got 4% deficit because of the structure of their domestic economy. So I'll look at that, as kind of easing interest rates and Norway should be hiking. (Interview FV)

Such techniques, therefore, are a crucial element of the way the view is formed and the future imagined. So far, however, we have treated 'view formation' as a largely individual task of the trader as he relates with information, news and data. In practice, the view is constructed within an agencement made up of a collection of humans and nonhumans.

Traders interact with other traders inside the firm, both those working in similar markets and those in less connected markets. They interact with internal strategists and sell-side strategists, sometimes via 'soft dollars'[50] (MacKenzie, 2019, 2017), at other times more directly. One trader on the buy-side (Interview TC) told me how useful the Instant Bloomberg chatroom can be for the germination of views, ideas, news,

[50] Soft dollars refer to the services buy-side firms receive from broker-dealers as part of the brokerage fees the latter charge the former for executing transactions in equities, or via the bid-ask spread in fixed income. Soft dollars may include research reports carried out by a broker-dealer's internal strategists.

interpretations. Even more important in his case is Whatsapp[51] – one particular group of which is made up of himself, a sell-side strategist at a British investment bank, a head of research at a Japanese investment bank, and a head of emerging markets at another bank. “I think the Street is very useful for that kind of cross-fertiliser”.

Although networks, as in the (Granovetterian) new economic sociology literature, are an important factor in the view formation process, there is another sense in which such views are of a collective nature. Often, there are organisational rules that traders need to comply with. One firm imposes a formal system of view formation in which traders and strategists put notes and ratings on markets (e.g. on where they think the German Schatz future will be in the next few weeks) which are made available to all traders. In another firm, a six-person fund needs to reach a simple 3+1 majority as a ‘house view’ following a period of meetings in which traders discuss and attempt to convince the rest. The ‘view’ therefore, is not always at the discretion of the individual trader, but is sometimes an organisational one. In another case, while these organisational rules were not present, implicit practices are followed. In this case, a trader will almost always follow the internal strategist’s recommendations for fear of potential internal sanctions if the market goes against them. In other cases, traders are left relatively or completely free to come up with their own view and act on it:

> As a desk we feed into a house view, so every quarter we write papers and every desk writes big formal research papers, and then we go and we debate them. So various people on the desks - our analysts, traders, typically senior analysts, we go in the room and trash it out, and everyone argues against each other… and we form a broad house view consensus on what we think is likely to work. It doesn't mean that we have to… so if I go in and I argue my corner, and the conclusion of that meeting is that we need to do something that I completely disagree with, I don't go onto my desk and put a position in my portfolio that I completely disagree with… So we have autonomy. But then with autonomy comes accountability. So if a hundred people in my firm tell me I need to do one thing and I say 'No, I'm gonna do this'... if I'm right I'm not actually a rockstar, I'm just right. And my job is to be right, so no one says well done if I'm right. But if I'm wrong, then why didn't I listen? So, people would gravitate towards the house view, comfort in numbers.
> (Interview IN)

[51] Interestingly, chatrooms such as Bloomberg’s, unlike Whatsapp, are internally monitored so that the firm and its regulator could make sure that there is no market moving information or inside information exchange.

There is, therefore, a wide range of rules and practices that go into a view. What is almost always the case, however, is that a view is never the result of an individual trader's work. Rather, it is a collective effort, the effort of an agencement.

6.1.2 How the yield curve materialises and collectivises fictional expectations

Fictional expectations within the agencement are only useful to the extent that they are then acted upon or, in market parlance, *expressed* in their evaluation practices. Market actors express their views principally on and in terms of the yield curve: "[The yield curve] is the market pricing of interest rates, which is at the heart of what we do." (Interview FV). As such, market actors evaluate any fixed income instrument on the basis of the practices explained in the previous section, but invariably doing so *relative to the curve*.

A trader faced with a conventional bond will firstly need to evaluate the bond. The trader knows that the bond's value is a function of its face value, its (fixed) coupon, and its maturity date. So he calculates the series of cashflows (annual or semi-annual) that he would receive from the bond over the term (maturity) of the same bond. But the trader needs to calculate the *present value* of the series of cash flows – i.e. the current value of the cash flows received in the future. The current value of the cash flows is not equivalent to the sum of the actual future cash flows because of the time value of money, namely the idea that money received today is more valuable than money received in the future due to the opportunity cost of investing that money today. The trader therefore applies a discount rate, i.e. the required rate of return for the investment to be worthwhile given the time value of money. Known as the yield-to-maturity (YTM), this is often taken from the prevailing yield curve at any one point in time. In practice, the process of bond valuation does not follow the mechanical step-by-step process as explained. Rather, bond traders make use of a software-based calculator which transforms bond prices into yields (and vice-versa) (MacKenzie and Hardie, 2009).

But the trader may not be content with the prevailing yield curve. As we will see, the current prevailing yield curve is taken by market participants as the market's collective assessment of future interest rates. On the basis of the information gathered and qualitative judgements as explained in 6.1.1, a trader may argue that the yield curve is 'mispriced'[52], i.e. that interest rates may rise more than is implied by the curve, or that inflation will be higher than the curve is pricing in (which would thus erode the purchasing power of the received cash flows). He will therefore demand a higher yield (YTM) than is implied by the prevailing yield curve, and apply this yield in his calculator, such that the price of the bond is now lower. This would ensure the trader compensation for the higher future interest rates or inflation rates he has come to predict. If enough traders come to share this view of higher interest rates and/or higher inflation in the future, the yield curve will shift to reflect those expectations.

As we have seen in chapters 3 and 4, traders or portfolio managers can also employ various trade strategies to express their view at the portfolio level. More often than not, however, they employ other strategies, such as duration management using futures. Known as modified duration, this metric allows traders to measure the sensitivity of a bond, or more commonly a bond portfolio, to changes in interest rates. In doing so, a trader builds a view of future interest rates (fictional expectations) and seeks to express it by varying the duration of the portfolio or a segment thereof. Recall that interest rates and bond prices are inversely related, such that as rates rise, bond prices fall and vice-versa. If this trader comes to predict a rise in interest rates, he reduces the portfolio's duration, effectively reducing the sensitivity (thus, risk) of the portfolio itself. In contrast, an expectation that interest rates will fall incentivises the trader to extend the duration such that the interest rate sensitivity of the portfolio increases, thus profiting from an eventual fall in interest rates as bond prices increase.

Other strategies involve traders employing bullet strategies on the curve, in which a trader concentrates his portfolio on a specific point of the curve, or putting on flattener trades or steepeners to exploit expectations of changes in the level, slope or curvature of the curve. As they build their view by assimilating and interpreting the information gathered, traders seek to build a 'curve view', i.e. how the underlying drivers (e.g. macroeconomic factors) will influence the shape of the curve. Their overarching view

[52] 'Mispriced' does not imply that the yield curve is *technically* incorrectly priced. Following market parlance, 'mispriced' means that the trader disagrees with the current market *valuation* of a security.

is translated onto a curve view through which they will then express their view via ‘curve plays’.

As the trader expresses his view, the yield curve comes to reflect the fictional expectations of traders and their agencements, as distributed cognition (Hutchins, 1995). The yield curve is therefore never static; it is in a state of perennial movement as traders across geographical space express their views. In this sense, fictional expectations which in Beckert’s understanding would reside primarily in the *minds* of economic actors[53], and which we have extended to the set of human and nonhuman associations – as agencements – come to be realised, materialised, and rendered measurable on the yield curve. In process, however, such fictional expectations are *transformed*. Rather than materialising as multiple fictional expectations, the result of multiple economic exchanges and trades, the yield curve collectivises those same expectations. The yield curve plays a role in distributing cognition across geographical space (Hutchins, 1995). “At any point in time [the yield curve] is … a weighted average of the views of what market participants are… the fair price for money across time.” (Interview VK). Another trader claimed that it represents “the general consensus of expectations” (Interview AX). In expressing their view, market participants feed their view into the yield curve, which in turn transforms these actions and expectations into a set of prices that are visible on the curve. It is this sociotechnical process that is at the heart of the expectations hypothesis mentioned earlier.

And yet, as the yield curve comes to reflect market participants’ actions and expectations (Zaloom, 2009), it participates in a process of market construction. This is a different process to those explored in chapter 3 and 4 in which practices around the yield curve shape markets by consolidating them (chapter 3) or by allowing the development of derivatives (chapter 4). Rather, in translating a multitude of dispersed actions and fictional expectations onto a ‘singular’ device, the yield curve assists in the construction of the social, similar to Strum and Latour’s (1987) theorisation of baboon society and the place of technology in the production of ‘modern’ and large-scale society. The yield curve acts as a sociomaterial device by which society (market) is built on a larger scale as it condenses space, crossing physical boundaries and

[53] Even to the extent that Beckert’s work highlights the relevance of material devices, he treats calculation via such devices as an instrument of imagination. Necessarily, such instruments are therefore only a *function* of imagination which ultimately resides in the minds of *humans*.

bringing together actors globally (Knorr Cetina and Bruegger, 2002a). The yield curve not only brings a multitude of exchanges onto a singular device, but itself travels and crosses boundaries as an (im)mutable *mobile*. On the one hand it represents, on the other hand it presents/makes visible across boundaries. An iterative process is in play: the *transformation* of a multitude of market actions and agencements to a singular device, and the *transmission* of this singular device itself to the multiplicities of markets and agencements.

Further, the yield curve *aggregates* actors globally. In doing so, the yield curve gives rise to a collective entity, *the market*. The market takes on qualities of a defined and singular actor, and both market participants and central banks, as we will see, relate with the market as a collective actor. More than a 'simple' process of representation of a multiplicity of actors and actions, therefore, the yield curve does further work by turning them into an aggregate, a new actor that has no life outside of the yield curve as its material representation. In a similar manner to the way in which Preda (2006) observed the replacement of the market by the technology of the stock ticker, so are the yield curve and the market ontologically inseparable as actors interact with the yield curve *as* the device which gives the market material form. But the yield curve is not simply giving form to a pre-existing entity; it plays a core role in the making of that same entity. It performs the market as a sociotechnical construct.

When market participants express views in terms of the yield curve, they are therefore expressing a view relative to the market's expectations. A trader (Interview FV) told me "you may just look at the yield curve and think 'that's totally wrong, I can't see that ever happening'. So I express a contrarian view against it." Traders thus look at the yield curve and derive meaning from it, particularly the expectations priced in by the market. "Not sure what you can read [in it] apart from expectations really… A big part of it is market expectations versus your own expectations.", told me another trader (Interview AX). They calculate what the curve is implying in terms of expectations via forward rates[54] and express a view against it if their own view differs.

[54] Forward rates are the future rates (yields) on a specific bond. Because as we have seen in previous chapters, bonds on the yield curve are fungible and substitutable, and under the conditions of the expectations hypothesis, each bond's yield is taken to reflect the future yield of a bond with a shorter maturity. The 6-month UK gilt six months from now is a forward rate, and it is derived from the yield curve by relating the yield on the 6-month bond and the yield on the 1-year bond. Although forward rates are first and foremost *rates*, they can also be turned into *instruments* (derivatives), such as into

Often, this involves dissecting the yield curve into the forward rates and implied forward rates. One of the traders I spoke with explained to me how he opts to study the 'forward curve matrix' after eyeballing the yield curve. As Figure 2 shows, the matrix collapses the yield curve into a set of forward rates by maturity. Each maturity (tenors, left column) is extrapolated forward by a certain period (forwards, top row) so that a trader can calculate the implied forward rate for each maturity for a particular future point in time.

Figure 2: Screenshot from Bloomberg's GBP United Kingdom Sovereign Curve

GBP United Kingdom Sovereign Cu | Export | Graph | Forward Curve Matrix
GBP United Kingdom Sovereign Curve | Mid | Yield | Conventional | Curve List
Two Curve Spreads
Select a curve under "Curve List" for two curre... | Bid | Yield | Conventional
Forward Curve Date 05/27/19 | OIS Discounting
Spot | Coupon | Zero

		Forwards										
Tenors	Coupon	5/27/2019	3Mo	6Mo	1Yr	2Yr	3Yr	4Yr	5Yr	10Yr	15Yr	30Yr
1Mo	0.7041	0.7365	0.8032	0.7080	0.7080	0.7411	0.7411	0.9222	0.8781	1.7963	2.2941	1.1790
3Mo	0.7808	0.7765	0.8018	0.7123	0.6806	0.7375	0.7970	0.9565	0.8740	1.7892	2.2859	1.1736
6Mo		0.7741	0.7577	0.7051	0.6624	0.7503	0.8715	1.0122	0.8846	1.8230	2.2205	1.1946
1Yr	0.7392	0.7444	0.7254	0.6838	0.6807	0.7443	0.8952	1.0123	0.8774	1.8081	2.1259	1.1851
2Yr	0.7095	0.7146	0.7108	0.7042	0.7124	0.8197	0.9535	0.9451	1.0278	1.9201	2.0898	1.1851
3Yr	0.7255	0.7247	0.7270	0.7375	0.7730	0.8832	0.9284	1.0233	1.1843	2.0499	2.0760	1.1862
4Yr	0.7724	0.7675	0.7785	0.7935	0.8319	0.8817	0.9903	1.1420	1.2627	2.1134	2.0809	1.1859
5Yr	0.8148	0.8169	0.8201	0.8242	0.8408	0.9402	1.0905	1.2119	1.3978	2.1511	2.0878	1.1858
6Yr	0.8300	0.8290	0.8294	0.8471	0.8960	1.0314	1.1575	1.3323	1.4632	2.1472	2.0933	1.1857
7Yr	0.8857	0.8792	0.8958	0.9220	0.9799	1.0967	1.2672	1.3971	1.5404	2.1346	2.0964	1.1861
8Yr	0.9629	0.9546	0.9654	0.9618	1.0430	1.1994	1.3311	1.4723	1.6313	2.1245	2.0988	1.1859
9Yr	0.9393	1.0157	1.0465	1.0802	1.1395	1.2629	1.4041	1.5600	1.7011	2.1216	2.1006	1.2062
10Yr	1.0568	1.1042	1.1239	1.1486	1.2019	1.3346	1.4884	1.6286	1.7570	2.1212	2.0737	1.2261
12Yr	1.1519	1.2308	1.2567	1.2870	1.3514	1.4840	1.6133	1.7175	1.8068	2.1209	1.9354	1.2563
15Yr	1.3807	1.4256	1.4470	1.4682	1.5125	1.6053	1.6951	1.7790	1.8560	2.1023	1.7979	1.2863
20Yr	1.5202	1.5690	1.5831	1.5998	1.6359	1.7111	1.7845	1.8511	1.8993	1.9004	1.6614	1.3160
25Yr	1.6147	1.6490	1.6530	1.6593	1.6742	1.7064	1.7363	1.7605	1.7793	1.7792	1.5932	1.3337
30Yr	1.6079	1.5868	1.5898	1.5953	1.6085	1.6367	1.6631	1.6837	1.6996	1.7089	1.5689	1.3455

Grey values are extrapolated.

Suggested Functions | FXFC Evaluate FX market forecasts | GLCO Track global commodity prices

> The 1.2019 circled in red is what the curve's telling me the 10-year bond yield in one year's time will be. So, if I can buy an 11-year bond today at a higher yield (i.e. cheaper) than 1.2019% then I will make money relative to the yield curve (i.e. the 11-year bond is trading cheap to the curve) if everything else remains the same. Conversely, if the yield on the 11-year bond today is lower than 1.2019% it's too expensive.

Because as we explained in chapter 4, the various maturities are substitutable and equivalent[55], the yield curve embodies a set of implied *future* yield curves. Each column in the matrix, therefore, can be read as the implied yield curve in 3-months' time, 1-years' time and so forth. After studying the matrix, a trader can express his view in the way the above quote explains if he thinks that the yield curve will be stable. Frequently, as we have argued, traders hold a 'curve view', i.e. they will hold a view

forward rate agreements. However, forward rates are also a crucial component of other interest rate derivatives, such as floating rate notes.

[55] Remember that a 10-year bond is a collection of ten 1-year bonds just like a 5-year bond is a collection of five 1-year bonds.

on how and where the curve will shift. On the basis of that view, then, a trader can express a view relative to the curve.

A trader with a view that the curve will flatten - where the short-end and long-end of the curve move closer, either because the short end moves upwards or the long end moves downwards in a positively sloped curve - will put on a flattener trade in anticipation of this. As a strategy, he might put on a barbell trade by shorting the front-end of the curve (e.g. 5-year) and buying the long-end of the curve (e.g. 30-year) in futures or swaps, expecting the spread between the 5-year and 30-year to diminish. Because this trade is not an outright position in one instrument, it does not involve speculation on the (upward or downward) directionality on the absolute level of rates, but rather on the spread between two maturities.

Beunza and Stark (2012) study how traders use the spreadplot as a check on their own expectations and to identify the implied probabilities of whether a merger will materialise or not. For these traders, dissonance - their disagreement with the market's own expectations - is only relevant insofar as it could help them identify potential errors in their own thought-process. In our case, traders hold the yield curve as an axis along or against which they express their own view, thus using it not only as a check but as a direct tool through which they can identify and exploit profit opportunities. This creates a recursive loop between an agencement's action and expectations and the market's own action and expectations as a collective entity, the former feeding into and reacting to the latter (Zaloom, 2009). But there is another sense in which the case of the yield curve is unlike the spreadplot, and that is the central bank as a distinct actor that shapes this recursive loop, the practices and implications of which we now turn to.

6.1.3 The central bank's reaction function as interpretive filter

In this chapter we have seen how market actors gather information and engage in interpretation of that same information, primarily in terms of what it means for the future. For the large part, as Zaloom (2009) argues, they gather information relevant to the future state of the economy, hence they collect and interpret data ranging from GDP growth to underlying drivers of inflation, such as oil supply. As in Beckert's conceptualisation of fictional expectations, they build stories and narratives about the future. In fixed income markets, however, an intermediary process plays an important role through which this information is interpreted, digested and made meaningful. The central bank's anchoring of expectations, the establishment of which we have explored in the previous chapter, links market participant's fictional expectations to the central bank's own reaction function, the latter acting as an 'interpretive filter'.

The narratives, views, and expectations market actors build about the future state of the economy are never isolated from central bank action. Indeed, they are constructed *in terms of* the central bank's reaction function. A drop in oil production is only a relevant piece of information to the extent that the central bank will gather that information and absorb it in its own projection of the economy. The process of anchoring expectations by central banks is thus highly dependent on sending signals to the market about the way in which it might, or will, react to a piece of information. The communicative functions of central banks, long explored in the social science literature, is principally a matter of giving structure to the market's interpretation of information through the interpretive filter of its own reaction function. This is evident in most of my interviewee's responses, but a particular one is illustrative (Interview SI):

> We are a firm that is strong in terms of its macro-economic research, and what we do is very fundamentally based. And so what we would do in the first instance, is we would be looking at the economic cycle, we would be looking at the likelihood of inflationary pressures increasing or decreasing. We'd be making an assessment in the first instance on what is likely to happen to central bank policy. And we always would be benchmarking that against what is priced into the forward path of short-term rates. So, in that first part you are explicitly using part of the yield curve, using the forward path of short-term interest rates, to benchmark your central bank views against. And using my earlier example, we sort of took the view 'Well, the corona virus epidemic is gonna keep the economy in a situation with significant spare capacity, low inflationary pressures for one to two years.' So we think that the central bank isn't going to move short rates very much.

The central bank's reaction function thus acts as a prism, or interpretive filter, through which market actors interpret information, news or data. A successful act of anchoring expectations by a central bank puts it at the centre of the construction of fictional expectations. As a result, market participants engage heavily in 'central bank watching'. At times, the anchorage of expectations is 'too successful', leading market participants to attempt to find and extract meaning from what they deem as a sign, such as Mario Draghi's tie colour as code (see Kaminska's 'Scrutinising the Draghi tie indicator')[56].

> So they look at communication, the signalling of the central bank and they attribute how likely it is for the central bank to move rates. Sometimes you hear outrageous comments. For example, that the ECB will not change rates because it has never done so when it's away from Frankfurt. … [or] because Draghi's wearing an orange tie, and he has never changed rates when he has worn that colour of tie. Outrageous.
> (Interview DC)

Nevertheless, it is through this process that central banks can repurpose market expectations and the yield curve as a tool of governance.

6.1.4 The yield curve as a policy tool

As part of the central bank's governance of expectations (Braun, 2015, Wansleben, 2018), the yield curve acts first and foremost as a *measure* of market expectations. In the engine room of central banks, financial economists decompose the yield curve into its expectational components via term structure models. Within the Bank of England, a whole section known as market-monitoring is dedicated to the monitoring of financial market reactions and what markets are reacting to. Principally, their work revolves around yield curves, and the deriving of implied expectations from the market-derived forward yields. The yield curve provides an estimate of implied future rates (i.e. expectations) as they scrutinise the set of yield curve-derived discount factors. An economist (Interview EF) within this section tells me that "the yield curve is a high-frequency read along a relatively slower-moving data, especially insofar as it permits daily readings and is forward-looking".

Just like the market participants relate with the market as a collective actor, so do central banks. Central banks conceptualise the market as a collective actor and interact with it as an aggregate. The curve takes the place of the market as central bank economists become affixed to the curve's movements and the meanings of the curve. "You wanted to avoid the yield curve whipsawing and having a taper tantrum like effect", told me one former Deputy Governor of the Bank of England (Interview LG) with reference to the Fed's tapering of its quantitative easing policy which

[56] See FT: https://www.ft.com/content/8ac8a68e-b78e-30af-b916-7a2f7e54d02f

destabilised the yield curve. More than in the case of the UK, market participants in the US fixed income space have recognised that the process by which the yield curve collectivises market action and expectations grants them power over the Fed. They express their power by reacting to central bank action via bond sell-offs, especially if in disagreement with it. Fed economists are all too aware of the existence and potential reactions of bond market vigilantes, who have often restrained and forced it to backtrack on its actions. It is this social, symbolic, and technical process which allows bond markets to exert voice on, for instance, presidential approval (Hardie et al., 2020). Nevertheless, my interviewees in the UK's fixed income markets and the Bank of England have experienced less of this market action relative to the US.

Although the yield curve is for central banks an accurate representation of the market, in the view of Bank economists it is not the be-all and end-all. The process of yield curve monitoring at the Bank of England is an assessment which involves judgements, cross-checks with other data and other areas, for example cross-markets. Expectations derived from the yield curve are supplemented with data from surveys (Braun, 2015), as well as direct contacts in the market. As Holmes (2013) observes, the Bank of England has a number of regional agents who hold networks of business contacts that provide direct information to the Bank. More importantly, the Bank through its Markets division has close contacts in the fixed income world, i.e. in financial markets.

Data on expectations - collected from the yield curve and supplementary sources - travel from the section on market monitoring to the forecasting section. The forecasting process is a complex one: five or six meetings between the Monetary Policy Committee and Bank staff, from updating mechanically the previous forecast, to a discussion of key issues on which consensus judgements need to be made. The process also involves views, or fictional expectations, about the future, not unlike the markets' process of view formation. Each member would have a view of the future, which is then discussed and fed into a consensus view of the MPC. This MPC view is then embodied within a revised forecast, which is compared with external forecasts of other professional economists. Expectations from the yield curve are a crucial component of this process, as MPC members and other Bank economists build their forecast according to what the market is expecting of the Bank in terms of future policy.

Yield curve data is not simply discussed, but is incorporated directly and materially within the forecasting process. Because the forecast is not strictly limited to assisting MPC members with making a policy decision, but is also a crucial part of the Bank's communication with its audiences (in the Inflation Report) aimed at influencing expectations, the way market expectations are incorporated within the forecast is also a function of the Bank's desires to govern those expectations (Interview LG). Within the forecast, market expectations function not only as an 'epistemic object' through which Bank staff can read market reactions, but also as a way by which those expectations are governed, as a target of intervention. How might this be so?

The forecasting process is heavily dependent on a small number of conditioning assumptions. Amongst these, the market-implied path of interest rates is one (Christophers, 2017). The forecasted future is necessarily intertwined with interest rates: firms' investment and household consumption are influenced by interest rates, and therefore the future economy is influenced by them. After all, this is what monetary policy is precisely about, and it is why central banks attempt to influence interest rates (via expectations). Any forecast, therefore, requires a set of interest rates as conditioning assumption. Rather than employing the Bank's own desired, or 'correct', path of future interest rates, however, the Bank's forecast takes the market yield curve as a given: "We think that this creates more debate in which markets are involved… there is no transparency of individual members of the MPC, and there is a question on whether this would help or not. But the forecast is about communication more than it is for transparency." (Interview EF). The forecast presented in the Inflation Report, therefore, is predicated on what the market expects the Bank's policy will be in the future. This was not always the case: prior to August 2004 the forecast hinged on a constant set of interest rates (Interview LG, MW; Goodhart, 2009). A former Deputy Governor (Interview LG) explained the switch:

> I was the one who pushed for it. So before I joined the Bank, I was adviser to the Treasury Committee. And one of the problems always if you condition constant rates is, in most cases, you wouldn't expect rates to be constant going forward. So you should expect the central inflation path to be diverging. But of course, there's an incentive to actually publish something where it was coming back on track. And what you can do is say, well, we can put in our best forecast of what's going to happen to rates. But that requires the committee to actually come to a view about what the appropriate path for rates is... But I thought it made sense at least to take the market path as that

> conditioning assumption, because if the market basically has pretty much the same view as you about what's going to happen, understands your reaction function, that should be a pretty good guess of where rates are going to go… And then there might be occasional times… where we thought the market had an inappropriate view about what's likely to happen to the economy. And in that case if we thought it was going to be weaker than the markets, then we would expect the rate path to be lower than the markets priced in. So inflation would be dipping below the target horizon. So it became an implicit way of signalling that we have a different view. But we thought it was better to do that implicitly than actually come out explicitly saying, 'oh, markets, we think you're wrong'.

As this Deputy Governor explained, the market-implied path of rates exempts the Bank not just from publishing its own view of the future path of interest rates, but also from reaching an agreement on a future path of the yield curve. A current MPC member (Interview CC) argued to me how cognitively difficult this practice can be:

> I think it's a confusing aspect of the forecast and one of the reasons that I don't think it's a great way of doing it is because … Your tendency when you make a forecast is to say, 'OK, this is what I think is going to happen to growth, inflation, interest rates'. But we don't do that. We say "No, no, what's going to happen to growth and inflation *if* I give you this path of interest rates, which is determined by somebody else'. And so you have to remind yourself that that's not *your* view of interest rates, it's *their* view of interest rates. Mentally it's not an easy thing to do. And actually, even in modelling terms it's not an easy thing to do. Excessively complicated.

Nevertheless, despite some of the issues this MPC member laid out, market participants have learnt to read the inflation forecast. By looking at the headline forecast figure of inflation, they can assess whether the forecast is overshooting or undershooting the target of 2% at the 2-year or 3-year horizon. If it is overshooting, then "that's a fairly clear message. That means we think interest rates are going to have to go up more than is implied by the yield curve and vice-versa if it's in the other direction." Any over or undershooting of the target implies that the market expectations of future rates are incorrect, to which direction, and by how much. By reading it in this manner, market participants can adjust their expectations of future rates, incorporate this information within their view, engage in the market by expressing their view, thus moving the yield curve. The forecast, therefore, while being based on an incorrect yield curve, holds a communicative function that can lead to a process in which the yield curve is 'corrected'. In a way, we could say that the yield curve is performed through this very complex process. As a result, the yield curve acts as a prism through which central banks and market participants interact, interpret each other's actions and expectations, thus rendering order. We will come back to this in the final part of this chapter. Until then, we will move away from the largely 'Beckertian' process we have explored so far, and focus on a more material process of 'market construction' via fixed income arbitrageurs.

6.2 Performing markets and fictional expectations on the material

In this section we will explore the ways in which arbitrageurs' work in fixed income markets supports the above construction of markets by ensuring internal consistency of the yield curve, in line with financial theory. Further, we will see how arbitrage on the yield curve works against the influence of segmentation and idiosyncratic local pressures on the yield curve. As a result, the yield curve comes closer to the theory of the expectations hypothesis. Additionally, arbitrage work across yield curves ensures consistency in expectations across markets. We will then see how central banks ride on this 'underlying' work as they incorporate it within their models and practices. Arbitrage renders the transmission mechanism of monetary policy, at the heart of which is the yield curve, smoother and more effective.

6.2.1 The practice of arbitrage

Before we turn to the actual practices, it would be useful to spend some time discussing the notion of arbitrage in the context of fixed income. In theory, arbitrage refers to the simultaneous buying and selling of an asset/security in different markets, to exploit a price discrepancy that diverges from 'the law of one price'. The position must be directionally-neutral, not speculative, and is therefore riskless. Upon my mentioning of the term arbitrage, the vast majority of my interviewees were often quick to argue that a riskless form of arbitrage is impossible in today's market, preferring the terms 'convergence trading' or 'relative value'. Just like Hardie's (2004) discussion on arbitrage, my interviewees claimed that hedge funds today perform what is known as 'risky arbitrage' and in most cases they put on trades that would not turn a profit if held to maturity. In this section, I will be using the term arbitrage to refer to trades and positions that exploit relative pricing opportunities between fixed income securities within or across markets, that seek market neutrality by systematically hedging their directional exposure, and that are highly leveraged.

Arbitrage differs from the type of trading explored in the previous section in which traders try to anticipate macroeconomic indicators and central bank's actions. A hedge fund arbitrageur argued:

> So we are not necessarily modelling yield curves as in trying to predict what is the Fed policy over the next one year. That's not necessarily the attitude we take towards the market. We see the yield curve as effectively almost like a physics system or mechanical engineering system, you know, where there are points on the yield curve: the 2-year point, the 5-year point, 7-year point and so on. They're all correlated with each other in some way. So there's effectively buyers and sellers across the yield curve and they may have completely different utility curves or desires to trade. We don't necessarily know what a particular reason for a counterparty trade. The way we approach the problem is that effectively the aggregate supply and demand that may occur at certain points of the yield curve become predictable on addition to what's happening in a holistic sense.

As discussed in chapter 4, the yield curve exhibits a distinct ontology in hedge funds of this sort. Working within a world of no-arbitrage, traders look at the yield curve as a system which should exhibit certain characteristics so that, upon its divergence from those characteristics, they can exploit the dislocations and make a profit. Because all points on the yield curve are linked, financial theory suggests that it should be internally consistent such that each bond's yield on the curve should be equal to the expected average short rate over the period of its maturity. Any deviation from this rule implies that the yield curve is breaching the no-arbitrage principle and traders can take advantage of it.

A trader needs to first identify that part of the yield curve has dislocated. There are multiple techniques and devices that are used for this purpose. A trader I spoke to (Interview EX) argued that he uses a factor model in the spirit of LTCM's 2+ model. His model fixes two points on the yield curve and models the rest of the curve, and he then compares the actual yield curve with this theoretical curve. By observing the deviations between the two, he can make judgements supplemented by statistical analysis on whether the deviation is the result of fundamental or some other 'technical' reason (e.g. as in the quote above, of aggregate supply-demand on a specific part of the curve). If he deems that this is a transient misvaluation that should correct over time, he will implement a butterfly by going long that point (e.g. 5-year) and short a point on either side of the 5-year, for instance the 2-year and 10-year. Shorting the two points would eliminate any exposure to the directionality (level) of interest rates.

Other traders find value in simplicity and prefer using parsimonious models, rather than high-level modelling of the sort that LTCM and some current hedge funds use. One trader invoked Von Neumann's adage 'With four parameters, I can fit an elephant, and with five I can make him wiggle his trunk", implying that the more complex a model is not necessarily the better the model. "The more parameters you add to your model, invariably it will fit better to the data. However, that does not mean that you actually have a real understanding of that model." (Interview EZ). In some cases, a higher number of parameters can prove detrimental to the job at hand. A higher level of parameterisation would make the model hold a closer fit to the observed data. But a trader who is seeking to identify misvaluations on the curve, in the way a trader equipped with the 2+ model is doing, *wants* his model to be 'inaccurate' and not fit the data too well because a high parameterisation (where model fits data accurately) would defeat the purpose of finding those deviations between the theoretical and observed data (Interview SI). In a way, there is a *material* usefulness of what Millo and MacKenzie (2009) call 'inaccurate models'.

With this equipment in hand, a trader has the tacit knowledge of the granularity of the yield curve. He is 'good friends' with around 30 bonds and will know them in detail. He knows the spread between the benchmarks of those 30 bonds and the rest, between the off-the-runs and those bonds, how they fund (e.g. if they are special in repo[57]), what bid-ask is on them. "He will have a feel for how long he'll have to wait to get them back if he sells them and how long they will be decorating his book if he buys them. He will remember how well they did when they were auctioned, who's been buying them and who's been selling them and what broker is in touch with more if he needs them or which broker needs them if he's got them to go. A trader will operate at the granular, bond-by-bond." (Interview LP).

[57] The term 'special' in repo markets refers to securities that enjoy high demand relative to similar securities. By virtue of their being 'special', they also carry low repo rates. Reasons for a security to function as special may vary, but some include that a bond is also in demand in the bond market, or because it has a particular function in the futures market.

For example, one of the traders I spoke to (Interview JF) spends hours every day tracking the bonds as part of butterflies with surrounding bonds and the benchmarks of the bonds he tracks. He knows that there are liquidity issues on specific points of the curve, especially given that a new ’35 OAT (i.e. a French government bond expiring in 2035) is coming out. He thus studies that point on the curve and the surrounding points, but he does not do so on the government bond curve. Instead, he studies it in terms of asset swaps[58] on the swap curve because the swap curve “is quite pure and nice to look at”. In other words, there are less distortions by other traders than on the government bond curve and less idiosyncratic factors for specific bonds. The bond is sitting below the curve, suggesting that it is possibly trading rich/expensive to the curve. (Recall that yields and prices move inversely, and that an expensive bond refers to one which has a higher price compared to other bonds, but a lower yield relative to the curve). “It *looks* a bit rich, and the forwards in that area *look* rich” (emphases mine). But he is not content with making a judgement by sight at this point. So he looks at the Z-scores[59] of that bond – a measure of the historical relative value [(current spread - average spread)/ 1 standard deviation of the spread)] of the bond to a chosen benchmark, such as the 3-month swap or 3-month US Bund. He also compares its own Z-scores with its neighbouring bonds’ Z-scores. Seeing that the Z-score is negative – an indication that the bond is expensive by historical standards – while its neighbouring bonds are not, he concludes that it is trading rich (expensive) to the curve.

He is now presented with a choice: a directional trade or a market-neutral trade. The former involves simply selling the bond short. That would, however, be an outright bet that holds exposure to interest rates (directional risk). So he could, instead, take an opposite position by buying a neighbouring ‘cheaper’ bond. The issue, however, is that such relative value trades are only marginally profitable, thus requiring high levels of leverage to make them worthwhile. Trading directly in bonds does not allow such leverage because of the initial capital that this would require. Instead, our trader operates in derivatives which do not require any capital outflow. So he enters into a

[58] An asset swap is an over-the-counter derivative contract where a trader/investor acquires a bond and simultaneously enters into an interest rate swap. An asset swap spread is the spread over LIBOR received by an asset swap buyer who swaps the bond’s coupon to a floating rate.

[59] Other traders might use different measures and techniques that will assist the trader in his judgement, for example option-adjusted spread.

reverse asset swap, involving the simultaneous short selling of the OAT ’35 and entering into a swap. Because by selling the bond short he would need to pay the bond cash flows, the swap ensures that he receives the equivalent fixed cash flows (cash flow replication) to cancel out the bond outflows. The swap also implies that the trader pays a floating benchmark rate (e.g. Libor) and a spread, rendering the whole structure similar to selling a floating rate note. But paying the floating rate and spread means that he is still exposed to interest rate risk. So he enters into another asset swap by buying the neighbouring ’34 bond and entering into a swap in which he would receive floating, thus cancelling out his floating rate from the reverse asset swap. In effect, the position disentangles between, and excludes other, potential reasons for the anomaly than liquidity and supply-demand effects. The trader is now market-neutral and will be able to profit from the cheapening of the bond when the French Treasury issues the new OAT ’35 and he unwinds his position.

Just like we have seen in the case with the on-the-run and off-the-run trade practised by LTCM, the above trade exerts pressure on an anomalous part of the curve, thus bringing it back into line in a literal manner as it closes in on the yield curve. Relative value (‘risky arbitrage’) of this sort thus seeks to profit from inconsistencies along the yield curve that are not the result of some fundamental driver, and effectively re-establishing a degree of internal consistency. In a similar manner, a forward curve that is not smooth is likely to attract the attention of arb traders who might conclude that there is no fundamental reason why the forward curve does not follow a smooth path. They would put on a similar trade to the OAT ’35 case above, thus kicking the anomaly in the forward curve back into line.

Additionally, leveraged arbitrage hedge funds might put on trades that span a wider range of points on the curve. Here, a position is taken following the identifying of a misvaluation between points on the curve. While still termed as ‘butterflies’ and exploiting movements of the curve, they are put on not on the basis of expectations and fundamentals, but on the basis of a yield curve model or principal component analysis. Similar to the way in which switching (see Chapter 3) eliminated market segmentation along the curve, yield curve arbitrage ensures that mispricings arising from market segmentation and local demand-supply effects, amongst other effects, are reduced. In other words, the opportunity of riskless arbitrage along the yield curve is eliminated with the consequences of ‘actualising’ (or approximating) the expectations hypothesis (Mehrling, 2011). Bonds on the yield curve are rendered fungible as discount rates become unbiased predictors of future spot rates (Cox et al., 1985, Rebonato, 2018)[60].

Finally, other arb trades connect and lead to the convergence of *multiple* yield curves. Fixed income arb traders often exploit opportunities between bond curves and swap curves, and between bond curves and futures. For instance, the bond-swap trade involves discounting the bond cashflows by the swap discount rates so that the trader arrives at the swap-implied price of the bond. He turns this price into a yield and compares this implied yield with the actual, observed yield on the yield curve. Using statistical measures as in the example above, amongst which are standard deviations and Z-scores, the trader can exploit any discrepancy between the yields on the judgement that they will (and should) converge. Once the two do converge, opportunities for riskless arbitrage are removed as the discount rates across the curves become equivalent. A trader may also see correlations across bond markets. Particularly in the European context in which one central bank implements a singular monetary policy over multiple markets, traders may treat two markets – e.g. Bunds and French OAT's - as correlated. In order to exploit anomalous divergences across these markets, traders may employ box trades by putting on butterflies on one curve (e.g. steepener) and taking the counter-position on another (e.g. flattener), often overweighting a specific point, a favourite trade of LTCM.

This is assisted and accelerated by a sociomaterial process in which traders "jump on the same trade" (Interview JF). As traders speak to each other across organisations, trade ideas will flow across social networks in the market, thus leading to prices/yields converging faster as more and more traders converge onto the same trade. This trader argued that over and above classic information flow across social networks is the important role of dealers' research pieces which are disseminated to the buy-side. While my interviews show a degree of scepticism towards advice coming from the

[60] This is the rather simpler story. In fact, the yield curve's persistent upwards slope does not imply that the forward rates are predicting rises in future rates. At the longer end of the curve, risk premia associated with liquidity are present. Nevertheless, in the absence of uncertainty, no-arbitrage conditions and the expectations hypothesis are equivalent (Fisher, 2001). We will see in the next chapter how central bankers have increasingly been concerned with risk premia on the yield curve following the crisis.

brokers, primarily due to the potential conflict of interest within the investment bank, some traders do put on positions suggested by their dealers[61].

The underlying point to be made via these examples is that arbitrage renders order in a material sense. This is not to say that 'Beckertian' processes in arbitrage are inexistent. Rather, it is to argue that the practices employed by arb traders are heavily material and that their effects are also material. The yield curve is rendered internally consistent, bond yields and forward rates move into line *on the curve* as a material object, as dictated by no-arbitrage principles. Multiple yield curves are also connected, and in some cases made to converge *materially*. Social order in markets is thus also a material phenomenon. In the next section, we will see how central banks rely on these material practices and adopt the material 'outcomes' in their policy transmission mechanism, incorporate them within their models, thus making policy-making smoother and more effective.

6.2.2 Central bank's reliance on leveraged arbitrageurs

Despite the vast work being done in the social sciences around central banking, the way in which central banks have come to implicitly rely on arbitrageurs and their work has been largely disregarded. Central banks rely on leveraged fixed income hedge funds in the way they read the yield curve and for a more effective *transmission mechanism* of monetary policy. The success of monetary policy in reaching 'real economy' targets such as inflation and macroeconomic growth relies on the conduit of financial markets. Monetary policy is only successful to the extent that the decisions

[61] A strategist on the buy-side argues that she is often sceptical of sell-side strategists due to the conflict of interest that may arise internally to the sell-side firm. Sell-side strategists, she suggested, may advise on particular trades to get their own traders out of a losing position. While I could not, of course, find any evidence of this practice, a former sell-side strategist claimed that in his experience some strategists were 'spivvy' in this regard, while others would not give buy-side traders the full story of a trade precisely due to this conflict of interest. Because this conflict of interest may influence the quality of research pieces flowing from sell-side to buy-side (including those that may be deemed as soft dollars), the regulator has sought to mitigate this. A sell-side strategist accompanied me to a trading floor and showed me how following MIFID II sell-side strategists are now required to be physically placed in a secluded area on the trading floor – surrounded by glass walls and to which only sell-side strategists have access. Mifid requires investment bank's sell-side strategists division to be purely client-facing and to be self-sufficient in generating its own business. A side-effect, argued this strategist, was that sell-side strategist divisions are shrinking and might soon, in his view, cease to exist in investment banks.

over overnight interest rates and the central bank's communication is transmitted through financial market pricing to the real economy (Woodford, 2003). As we have seen, government bond markets are central and therefore the yield curve as the market's pricing device is also central to monetary policy. In this context, arbitrage has two primary functions: on the one hand, it allows central bankers to read the yield curve in terms of expectations; on the other, it makes policy's transmission mechanism more effective.

Leveraged arbitrage is incorporated in the central banks' model of financial markets (DSGE models) and thus of its own transmission mechanism, as explained in chapter 5. In the model, the work of arbitrageurs renders markets complete and frictionless such that asset prices only reflect information from market expectations as non-aggregate risk is hedged. Other potential sources of influence on asset prices, such as bond demand and supply or market segmentation, are eliminated by arbitrageurs. In this model, therefore, the expectations hypothesis takes precedence and in the words of Woodford (2003), "[n]ot only do expectations about policy matter, but… very little *else* matters." (p. 15, emphasis in original). Arbitrage is also incorporated into the main model employed by central banks, namely the New Keynesian DSGE model. By modelling financial markets as behaving as if there are only two assets - money and bonds -, any frictions within asset markets are excluded, thus making DSGE models especially reactive to expectations (Interview PY; Clarida et al., 1999).

The existence of arbitrageurs and their work, therefore, allows central bankers to limit their purview onto expectations and to ignore other influences on market pricing. The central bankers I spoke to all gave me caveats about their awareness of potential frictions in the market that would make the expectations hypothesis less 'true'[62]. Nevertheless, central bankers took arbitrage, and its performative effects on efficient and complete markets, as a 'reasonable approximation' (Interview PY). As a result, the policy tools employed by central banks (prior to the crisis) revolved principally around the influence of expectations, which is in line with New Keynesian thinking[63].

[62] One has to keep in mind, however, that my interviews were all held after the Great Financial Crisis of 2007/08 when ideas about market frictions were more prevalent. We will return to this in the next chapter, where we will explore these points in the context of unconventional monetary policy after the crisis.

[63] This is not to say that central banks started allowing markets to do their own work *as a result of* New Keynesian thinking. Indeed, in many ways this 'discovery' was a result of the structural alignments between central banks and market architecture (Walter and Wansleben, 2019).

Monetarist tools, such as changing the volume of the monetary base is rendered ineffective and useless because policy-based supply-demand effects cannot be successful in frictionless and complete markets.

The materiality of the practices of arbitrageurs thus shapes the way in which central bankers read, make sense and interpret the yield curve. This is supported by the way in which arbitrage links multiple markets and makes their expectations consistent internally and with each other. Various markets – money markets, bond markets, equity markets, exchange rate markets – are “plausibly linked, through arbitrage relations, to the short-term interest rates” (Woodford, 2003, p. 16). Let us take money markets as an example. The Bank rate is perfectly substitutable with overnight rates in the interbank markets and money markets. Given that banks can choose either to fund themselves via the central bank or the market, the banks will switch to one or the other depending where the two rates are. Therefore, the activity in this domain will shift the two rates and bring them close to each other. If there are any discrepancies or anomalies in money market pricing, professional arbitrageurs will make sure to eliminate these discrepancies by exploiting them.

But arbitrage is also useful, from a central bank’s perspective, *across* markets. Markets need to reflect *consistent* expectations about the future. If different markets have different expectations, then it would be possible for arbitrageurs to make money. If, for instance, bond prices reflect a particular path of forward rates while swaps reflect a different path, then it would be possible for the arbitrageur (who thinks of assets/instruments as substitutable) to make profit off them. In doing so, arbitrage makes expectations consistent – it turns multiple imagined futures into a single future *across* markets. This means that a) central banks can focus on one market in the knowledge that other markets will reflect a similar path of expectations via arbitrage, and b) they can seek to influence a single implied and imagined future rather than multiple ones. Additionally, leveraged arbitrage makes policy smoother and more effective. The transmission mechanism from changing the short-term policy rate through financial markets and reaching the target of inflation is rendered faster via arbitrage, as any effects by central banks on the policy rate will be transmitted quickly by arbitrageurs across markets.

As Tucker (2004) argues, arbitrage in the money market brings expected overnight rates in between each MPC meeting in line with Bank Rate in the operational techniques of the Bank in the money market. But arbitrage practices are also relevant in bridging the money market with the bond market (the main market with which central banks interact) and other markets. Arbitrage is a way to describe the process through which overnight rate today and expectations of where the policy rate will be set in the future gets reflected in the money market curve, the risk-free bond curve, and via the discount rate, into other prices, which affect the economy (Interview VF). This transmission creates a second set of expected effects on asset prices, all simultaneously when market arbitrage mechanisms are working. In a way, therefore, this renders even stronger the claim that "markets [are] doing the central bank's work for it" (Woodford, 2003, p. 16; see also Krippner, 2007, p. 477).

6.3 Coordinating market action and policymaking into the future

The sociomaterial processes explored in the previous sections produce 'the social', in Latourian terms, on a wider scale as multiple agencements become entangled and order is produced. In the previous section, we have explored how arbitrageurs ensure consistency in expectations across markets in a material sense and that central banks embrace this 'underlying' work as they incorporate it implicitly within their models. In this section we will explore further how it is exactly that the yield curve allows a sense of coordination between central banks and market actors revolving around expectations. Indeed, I argue that the mutual susceptibility developed over time between markets and central banks (see chapter 3 and 4) reached its culmination in the form of coordination of expectations via the yield curve in the context of the monetary policy framework of inflation-targeting post-1990s.

And yet, we have also argued in previous chapters that the yield curve holds multiple ontologies as it becomes embedded in different sociomaterial agencements. So how is it possible that different and *multiple* yield curves act as a *singular* coordinating device? I will argue that if the yield curve exhibits a level of universality that renders order, allowing it to act as a coordinating device around expectations, this is only possible if there is some form of consensus around a singular yield curve. I show how this singularity and universality is achieved by way of a sociomaterial process in which

Bloomberg, an authoritative vendor system, popularises *a* yield curve on which actors in the market and central banks converge.

The analysis diverges somewhat from Christophers (2017) who argues that the yield curve embodies the power of central banks because it is the central bank's yield curve that market participants use. Because it is Bloomberg's yield curve that achieves widespread acceptance, as a convention and standard, we cannot explain the fact that the yield curve embodies the power of the central bank by virtue of the latter's construction of the yield curve. I claim instead that the power of central banks is produced and reproduced in a more 'traditionally sociological' process similar to Keynes' beauty contest – a central bank gains power by virtue of market participants knowing (or believing) that other market participants are following the central bank. This, in turn, becomes reflected in the yield curve and its functions as a coordinating device. This section will therefore explore how the universality of the yield curve is achieved and how coordination across markets and central banks is enacted. We will see how the yield curve establishes a distributed form of cognition, intersubjective meaning and shared temporalities, and how as a result it seems to hold predictive power over the future, having predicted the majority of recessions in the past few decades.

6.3.1 The universality of the yield curve as coordinating device

Although there are many sources of data, software tools, and trading platforms in financial markets, my interviewees agree that Bloomberg is by far the most influential external vendor system and holds extensive coverage in fixed-income markets, amongst other markets. Developed in the early 1980s by Michael Bloomberg, a former employee at Salomon, Bloomberg offered a computer terminal – an amalgam of software and hardware – that brought to the trader's desk instantaneous data (prices, news etc). The Bloomberg Terminal, as it soon would come to be known, became a staple of sociomaterial agencements in financial markets across the world. Bloomberg is "recognised as an authority" in fixed-income markets, one interviewee argued (Interview JZ). As another of my interviewees claimed when asked which source of data and analytics he relied on in his daily practices, "Bloomberg. Everybody uses Bloomberg. Bloomberg is the backbone of the bond market. It started the life of the bond market." (Interview AX).

The universality and importance of Bloomberg, therefore, allows a sense of distributed cognition (Hutchins, 1995) as traders are confronted with practically the same set of data travelling across distances via Bloomberg. As part of this data, Bloomberg also distributes a ready-fitted yield curve that becomes the standard and conventional yield curve which most traders would be looking at at any one point in time. The yield curve becomes singular: an immutable mobile, in Latourian terms, that travels but remains unchanged. This universality and singularity of the yield curve allows coordination. It performs classificatory work, it establishes a singular temporality, and it provides a communicative repertoire for actors in and around the market. Furthermore, by virtue of these functions, the yield curve acts as coordinating device between central banks and financial markets as a measure of market expectations around which market and central bank actors revolve in their trading activities and monetary policy decision-making respectively.

The very construction of a singular yield curve provides a sense of structure in markets as a standardised system of classification. There is classification at work when Bloomberg's staff, as the producers of the yield curve, construct the yield curve. This work requires making active decisions and judgements over which bonds to be included and which to be excluded, from on-the-runs to off-the-runs, risk-free or credit, inflation-linked or not, spots or yields. In process, the yield curve not only gives structure but also constructs markets. Disentangling between bonds – between German Bunds and Italian BTPs – reinforces those market boundaries that are often taken as given by market participants. Classification work of this sort helps establish benchmarks (e.g. the Bund yield curve) or what is deemed as risk-free and what is credit (for instance, 'Greece became credit[64] and you're no longer comparing apples with apples' told me one interviewee AX). It provides structure by assisting in classification and standardisation and it makes it more straightforward to compare different standardised yield curves – government vs corporate, benchmark vs periphery.

[64] By credit, the interviewee was referring to assets that are no longer considered as risk-free but contain a risk of default. In this case, Greece was re-categorised to 'credit' because of its credit rating downgrading by credit rating agencies following the Eurozone sovereign debt crisis. Often, desks in investment banks are organised along these distinctions. For instance, a 'Rates desk' will often trade risk-free bonds such as Bunds, and will be distinct from a desk that trades credit, such as Greek bonds.

The yield curve establishes a sense of a *singular temporality* in terms of the future. As we have already seen, the yield curve classifies bonds in terms of maturity, thus making it easier to compare like with like on the chart itself, to derive forward rates and expectations (e.g. what the one-year forward rate is in two years' time). A trader, a central banker, an investor, can each look simultaneously at what the forward rate at a specific point on the future is implying (and therefore what the market is expecting at that point), and *derive the same figure* from Bloomberg's terminal. It places market expectations on a plane that actors have access to, and to which they can compare their own fictional expectations and 'imagined future'. As the standard yield curve travels across agencements, the market's 'imagined future' as a collective becomes the fixed cognitive infrastructure, or distributed cognition, around which agencements revolve

Thirdly, the yield curve becomes a communicative tool in terms of which the various actors interact. Rather than speaking about the market, actors often speak about the yield curve as if the latter substitutes the former. Actors speak about 'the short-end' and the 'long-end' of the curve, and about movements in the curve. The element of universality that it holds makes possible a mediating process across these several worlds, within and across markets (e.g. among traders, or between traders and economists), as well as between central banks and market participants.

But while Bloomberg Terminal is the central material arrangement through which the singularity of the yield curve is achieved, this is not to say that the acceptance of the Bloomberg's yield curve by market participants is automatic. Traders sometimes question the accuracy of the yield curve by constructing their own yield curves as a check on Bloomberg's, because "forward rates can be a bit off" (Interview VK). In other instances, local knowledge is required, despite the universality of Bloomberg. One trader (Interview FV) recalls a time when no yield curve in the South African market had achieved standardisation, and in which Bloomberg was not accurate due to the lack of liquidity in the market:

> Back in the day when I was trading lots of these curves, I started off trading South African bonds where there wasn't really a liquid market, no general accepted yield curve, and Bloomberg wasn't accurate back then, so you had to build up your own yield curve using rate agreements and some swap rates. Although now I probably just use Bloomberg's.

Similarly, another trader (Interview VK) argued that liquidity in specific markets is essential for data accuracy, and his rule of thumb is to accept Bloomberg's representation only if the market which is being represented is liquid enough. Liquidity is a prerequisite for the yield curve to become conventional, a standard, and a fact (MacKenzie, 2008):

> Sometimes the way Bloomberg get sources can pick up what is not necessarily… maybe like a dead price they're picking up on one of the brokers or the interdealers brokers, which is not actually a price that someone's gonna actually trade at but it's been picked up on the Bloomberg system. So relatively, the rule of thumb very simply is that the less liquid a market is, the more sceptical you have to be about any price at a point in time.

Once the yield curve becomes a fact and a standardised representation, actors such as market participants converge onto it. In certain instances, the presence and employment of the standardised yield curve across sociomaterial agencements may lead to trade convergence. One trader (Interview QI) claims:

> So you have literally a trader sitting in front of the screen trying to analyse complex data. They are using data representation provided by the application that they're using. And if those applications are mapping complex price data into something that's measured relative to a parametric curve, there'll be a natural tendency to pull back to that curve… There'll be a convergence in that moment, like in group psychology… Bond traders are collectively converging on a certain format.

This is similar to another trader's experience who claimed that even market-makers often converge onto a standardised price (Interview TY):

> I mean, one thing that a lot of banks would price their bonds, for example, over CBBT [Composite Bloomberg Bond Trader], which is a consolidated price. And, you know, if everyone prices on CBBT then you know, everyone follows each other. That means, if one person prices outrights and starts to differentiate, you know, that will slowly skew CBBT and everyone is following it, everyone looks up. So it becomes kind of a self-reinforcing.

But, as we have seen, it is not only market participants who follow the yield curve. Indeed, central bankers are part and parcel of the coordination that is enacted via the yield curve as coordinating device. Christophers (2017) argues that the yield curve embodies the privileges of central banks, thus granting them more control over its performative powers. He attributes this to the fact that, in his words, "[c]entral banks 'own' yield curves in the sense that they officially produce and publish them" (p. 75), deciding *which* curves to provide estimates for and which estimation methods to be used. He concludes that, because the yield curve is a central bank artifact, "it endows [it] with some of its power to perform" (p. 76). While my evidence confirms the first part of the argument, namely that central banks stand behind yield curves, I depart from Christophers' claim about the method by which this is achieved.

Although, as we have seen, yield curve construction is every bit as relevant to the way in which social order is established, market participants do not rely on central banks' production of the yield curve. According to one MPC member and former hedge fund trader (Interview CC), "no serious bank out there would use ours…". This was corroborated by all market participants I interviewed. While sell-side strategists tend to construct their own yield curve (mostly statistical and spline-based in nature, such as Vasicek and Fong (1982)), buy-side firms tend to use overwhelmingly Bloomberg's. Therefore, the fact that central banks *produce* yield curves cannot explain why central banks control the yield curve's performative powers.

Instead, I explain this by way of a more traditional sociological argument. We have seen in previous sections how anchorage of expectations by central banks requires the anchorage of market participants (and their expectations) to the central bank's reaction function. I am claiming that market participants believe in the power of central banks because (they are aware that) others' expectations are anchored to the central bank. One may argue that the power of central banks lies in the fact that they hold control of the policy rate. However, the policy rate does not hold automatic sway on market interest rates, at least not on those rates beyond the money market. Additionally, as we have seen, central banks influence market interest rates (and thus the yield curve) only through their influence on expectations within their inflation-targeting and expectations-management framework. There is therefore an additional factor at play granting power to the central bank.

Participants in fixed income markets read the yield curve in terms of the central banks' reaction function because they know that everyone else is reading it in the same manner – a form of Keynes' beauty contest. Then, the power of central banks in the pre-crisis arrangement of inflation targeting lies less in the technical practice of yield curve construction and more in its own semiotic power of shaping meaning, primarily via the interpretive filter through which market participants interpret economic activity and indicators (e.g. inflation, growth etc) in terms of central bank action. Anchoring market expectations to its own reaction function is a way by which it constructs intersubjective meaning, particularly with respect to the way in which the yield curve itself is read, which meaning becomes tied to the central bank's future policy path.

The reflexive phenomenon is supported by the practices explained in the first section of this chapter, and is precisely how coordination between central banks and market participants is enacted. Because market participants are particularly attentive to central bank action, and because they read the yield curve largely in terms of what the central bank will do and what *other* market participants think the central bank will do, central banks can exploit this reflexivity in the market to their own advantage. They can observe the signals being sent by the market – as market actors price in expectations of future interest rates and inflation – and they can talk and communicate and let the markets do their own work for it (Blinder, 1999, Krippner, 2007, Woodford, 2003). The latter implies that by communicating, central banks can influence the yield curve without having to intervene directly via policy changes. The yield curve here coordinates as central banks can read the collective view of the market – expectations become measurable and calculable - and influence it.

In certain instances, however, an *inverse* process is at play. By reading what the market is pricing in in terms of expectations about future policy, central banks may decide to simply 'follow markets' and fulfil their expectations. Here, it is the demands of the market that prevail. As markets price in, say, a rate hike of 25 basis points in the next 3 months, central banks could fulfil those expectations by raising rates by 25 basis points over the next 3 months, rather than attempting to shift about those very same expectations. In doing so, central banks end up performing the very 'predictions' embedded in the yield curve, and thus making those predictions come true. It is this form of coordination that stands at the core of the interaction between central banks and markets, and it is to this form of coordination that the yield curve contributes as a coordinating device.

And yet there is and additional element in this coordination that underscores and reinforces the mutual susceptibility between central banks and markets. For while the yield curve allows central banks and market participants to observe the collective view of the market (of future interest rates and inflation), there is a sense in which when central banks read the yield curve to extract information about market expectations, they are not only reading market expectations insulated from the central bank action and communication. Expectations on the yield curve are now heavily entangled with central banks' own actions via the interpretive filter and the central bank's own influence on the yield curve, and therefore when central banks read the yield curve they are also reading, in a refracted manner, their own expectations and actions. This is precisely what Samuelson (1994, p. 231) argued:

> When Dr. Greenspan says he must do this or that to be in accord with the bond market, I am reminded of a monkey who for the first time has seen a mirror. He sees an image of himself in the mirror and thinks that by looking at the reactions of that monkey--including its surprises--he is getting new information. Well, what Greenspan is getting from the market is what the market heard Greenspan say before, that the Fed is getting worried about inflation, independently worried.

Interestingly, this becomes a matter of further entanglement when considering that the central bank's forecast is, firstly, relying on the market's expectations (as conditioning assumption) of the central bank's future path of policy (and thus of a monkey in the mirror), but also as a mode of communication by which central banks signal their future policy path. Since it is read by market participants in this manner, the feedback loop becomes even more convoluted – what Goodhart (2009, p. 8) himself called "an incestuous exercise" between central banks and markets (see Braun, 2015).

Unlike the relatively straightforward interaction between governments and financial markets, in which government is held accountable over its policy decisions on, say, macroeconomic growth (Mosley, 2001), markets' disagreements with central banks are expressed via the yield curve – the one and the same channel through which monetary policy is effective on the real economy. For central banks' control of inflation is only possible by influencing the yield curve (through expectations), and thus financing conditions in the real economy. Therefore, if markets express their demands by moving interest rates, they are effectively also shifting about the principal channel (and tool) with which central banks attempt to influence those indicators which markets are attentive to. This, then, is an incredibly convoluted form of coordination reflective of the mutual susceptibility developed over the years between central banks and markets, that is only made possible by the process explained above in which central banks gain relevance only because of a form of Keynes' beauty contest and the yield curve as coordinating device.

6.3.2 Yield curve predictions and self-fulfilling hypotheses

In spite of the convoluted nature of the relationship between central banks and markets with the yield curve as prism between them, I will conclude this chapter by arguing that this very same process is what grants the yield curve its power of prediction. I argue that it can be explained by the central bank standing behind the curve, as Christophers (2017) argues, but only in terms of the social process in which market participants believe that others believe that the central bank is behind the yield curve.

It is this self-referential and feedback loop that creates the predictive power of the yield curve. In their ability to stand behind the curve, central banks are able to shape expectations and thus macroeconomic outcomes by influencing market pricing. If central banks stand behind the curve, then the yield curve becomes reflective of the central bank's own policy – be it accommodative or less so. If the current monetary policy is accommodative (i.e. pushing short-term interest rates downwards), it has a steepening effect on the yield curve where the spread between the short and long-rates increases, leading to an expansion in macroeconomic growth. Vice versa, a central bank which intends to constrain economic growth would push short-rates upwards, possibly leading to an inversion in the yield curve, and therefore a slowdown in economic activity.

In turn, when market actors disagree with central bank policy, they will express their view on the yield curve. If the market collectively feels, for instance, that the central bank is not doing enough to contain inflation (e.g. by not raising rates quickly enough), markets may react by picing in compensation for inflation in bond yields, thus raising the yield curve. In doing so, because it is the yield curve that holds sway on the financing conditions of the real economy, markets may by themselves send a tightening effect to the real economy in the central bank's stead unless the latter does not act to the contrary. In turn, central banks may decide to follow the markets by fulfilling those expectations as implied in the yield curve, thus acting subserviently to the market's demands (Blinder, 1999).

These arguments are similar to the theory by Estrella and Mishkin (1997) who see monetary policy as 'the common factor' in the yield curve's predictive history. From the viewpoint of this theory, the yield curve is largely external to its own prediction. The yield curve is only predictive insofar as it is a 'sign' of monetary policy, i.e. of a process whereby it signals 'the future' as determined by central banks. In a way this is close to Holmes' (2013) argument that central banks, through narratives and stories, "*create the economy itself as a communicative field and as an empirical fact*" (p. 1). And yet, I want to argue the yield curve is materially relevant to this process. Without the yield curve, 'the social' would be vastly different from the way in which it is structured with the yield curve. The yield curve is central to this process, not as an intermediary but as a mediator (Latour, 2005). Interviewee AX told me:

> Maybe I'm biased because I'm in bonds, but I'd say [the yield curve is] pretty much the most important thing in financial markets really. It's really important, for government bonds obviously, it describes expectations. But everybody looks at it, whether its corporates or equities. The yield curve's the starting point for everything else after that… I might be out of a job if it didn't exist.

It is the coordination between central banks and markets, with the yield curve as the device rendering this possible *directly*, if only in the complex ways explained above, that may explain the predictive power of the yield curve. The way in which the yield curve is sociomaterially entangled within the relationship between central banks and markets allows it to be predictive, even performative, not just on social order as argued in the previous sections, but also over the future (Christophers, 2017). The multiplicities of fictional expectations and imagined futures, the process by which they are collectivised on the yield curve (in terms of distributed cognition) as a sociomaterial device, and how markets and central banks act and interact through the yield curve, are brought to bear onto the actual future. There is a sense in which the yield curve is therefore performative over the future, or as a number of market participants argued unprompted, self-fulfilling: "[It has] almost a 100% predictive power... you saw recently when 2s-10s did nearly invert, equity markets collapsed. So it kind of has psychological power to scare and it might be self-fulfilling" (Interview OV). Another market participant (Interview AX) argued:

> I guess part of the question is whether perhaps it is a self-fulfilling prophecy… Because the inversion of the curve is such an ingrained

> part of behaviour. Also because non bond investors look at the curve as well… equities and so on. And just seeing that the curve inverted itself is perhaps a dent to their own sentiment… It affects their behaviour to the extent that it becomes self-fulfilling.

6.4 Conclusion

In this chapter we have seen how, rather than the ontological multiplicities of the yield curve hindering social order, social order is established as the yield curve acts as a coordinating device on a universal level via Bloomberg as the sociomaterial arrangement turning the yield curve into an immutable mobile. Agencements become connected via the yield curve through a sense of distributed cognition. The yield curve constructs 'the market' from a set of dispersed fictional expectations to a singular entity able to act as a collective actor. As a result, central banks and markets become entangled in a reflexive, self-referential feedback loop at the centre of which stands the yield curve. The yield curve is thus a mediator capable of rendering structure, of affixing universal temporalities and providing a communicative register. Finally, the yield curve is also capable not just of predicting the future, but also of performing it as it brings multiple imagined futures, and the actions and interactions these give rise to, to bear onto the actual making of the future.

It would be useful to reiterate, in conclusion, that what I have described in this chapter as an 'interactional alignment' within and between markets and central banks is necessarily a historically contingent construction resting on infrastructural alignments between them, and on institutional foundations of free, liquid and connected markets as well as a particular arrangement of monetary policy. It would, therefore, be erroneous to treat it as a natural process which has been *discovered* and *unearthed* by central bankers via New Keynesian thought – tantamount to the Whiggish view of history - in the manner of the technocratic euphoria criticised by Wansleben (2018). Rather, on the lines of ANT, such social order is necessarily an attempt, a programme and a construction that is always fragile and prone to disassembly. Indeed, it is to this fragility and potential disassembly that we now turn to in the next chapter.

Chapter 7

Times of crises: Reassembling a policy agencement and the yield curve

In the previous chapter we have explored how the yield curve as a coordinating device contributes to the construction of 'the social' and to social order. In this chapter, we will take a look at the ways in which crises threaten to disrupt that social order, the attempts to restore it, and the reassembling of 'the social' as a necessary condition for its restoration.

The first section will show how, as crises feed into the 'real economy', central banks need to provide accommodation via policy. However, as in the case of 2007/08 Great Financial Crisis, central banks seemingly hit the limits of their policy toolbox. I argue that given the interpretive filter in which market's expectations of the economy are framed around the central bank's own action, then the central bank *appearing* to have hit the limits of its firepower can decouple market's expectations from central bank policy, thus dismantling the interpretive filter the central bank had built. As a result, central banks reworked their policy agencement so as to accommodate new policy tools and thus safeguarding the interpretive filter and the management of expectations, though this did not come without internal struggles especially in a context of widespread uncertainty.

Section 2 will argue that the yield curve became even more prominent post-2008 as a target of central bank intervention. The policy of forward guidance represents an attempt to extend the governance of expectations by providing communication about future policy, thus seeking to influence risks surrounding the formation of fictional expectations. However, forward guidance comes with its own risks, such as a loss of central bank credibility, which threaten to weaken the central bank's ability to govern. Secondly, the yield curve moved 'downstairs' and became an evaluation device with which central banks could implement monetary policy, specifically quantitative easing. While this provided market participants with opportunities to 'game the system', communication and cooperation between central banks and market participants established a set of expected and accepted practices that made quantitative easing socially possible. Furthermore, the policy of yield curve control represents a more direct way of conducting policy by controlling the yield curve. Despite this, the increased prominence of the yield curve for central banks has led some market participants to express concerns about the semiotics of the yield curve.

Finally, in section 3 we will explore how crises can lead to the failure of arbitrage as arbitrageurs find themselves exposed to higher margin calls as their ‘convergence trades’ experience sharp widening. As market-makers refuse to quote, central banks enter as a market-maker of last resort to restore conditions of normality in financial markets. In the way chapter 5 argued that central banks have an interest in shaping and maintaining financial markets because their own policy works *through* financial markets, and especially fixed income markets, during times of crises when markets seem to be breaking down central banks step in to prevent it. We will see how the failures of arbitrage have made the model of ‘complete and efficient markets’ and the ‘expectations hypothesis’ no longer a plausible approximation of reality. As central banks have turned towards quantitative easing and forward guidance, there is a question about whether central banks have abandoned this model. I will conclude the chapter by arguing that quantitative easing is increasingly viewed as state-contingent, i.e. only as effective as the state of the world within which it is practised. Rather than central banks abandoning the model of complete and efficient markets, and the expectations hypothesis, the very practice of quantitative easing has been an attempt to perform that model as a reasonable approximation of reality – as a state of the world - so that central banks can return to the pre-crisis social order.

7.1 The interpretive filter under threat and the reworking of a policy agencement

In the previous section we have seen how crucial the interpretive filter of market expectations before the crisis of 2007/08 was to the rendering of social order. We argued that the anchoring of market expectations by central banks gives structure to the market's interpretation of economic data by filtering it in terms of the central bank's own reaction function. We have also seen how central banks stand behind the curve, and are thus powerful in governing expectations, by way of a social process where market participants look to the central bank, and form expectations in terms of it actions, because they are aware that other market participants are also looking to it and forming their expectations in those terms.

In this section, we will show how the interpretive filter established by central banks, and the social process just referred to, came under threat during the Great Financial Crisis of 2007/08. As central banks were seen to have reached the limits of their policy toolbox, market's expectations threatened to decouple from the central bank's reaction function, thus leading to the diminishing of central bank's power of expectations governance. Aware of this possibility, central banks necessitated, and worked towards, a rearrangement of the agencement in order to safeguard the structure of relations honed over decades with markets, and thus to safeguard their own power and relevance in policymaking.

7.1.1 A challenge to the interpretive filter and restoring confidence

> After the collapse of Lehman's, our agents were saying 'Our business contacts, they're all using the same phrase: 'Orders have fallen off a cliff.' We knew within a couple of weeks after Lehman's collapsing that there was a pretty sharp downturn in activity underway. We didn't have to wait for the GDP numbers, or even the PMIs, to come out to tell us.

The Great Financial Crisis of 2007/2008, although starting in financial markets, quickly spread to the 'real economy', i.e. non-financial firms and households. As a then-Deputy Governor at the Bank of England recalls in the above quote (Interview LG), the Monetary Policy Committee and the rest of Bank staff quickly realised the aftermath the crisis would lead to in economic terms (see also, King, 2009b). The Bank of

England was not alone. Indeed, a number of major central banks – amongst which were the US Fed, European Central Bank, Bank of Canada, Sveriges Riksbank, Swiss National Bank - hastily agreed on a coordinated policy rate cut in order to provide some easing to the real economy and diminish the protracted effects of the crisis. This coordinated action marked a critical moment for monetary policy. Unprecedented in nature, in that never before in recent history had central banks engaged in concerted monetary policy action, it also represented the start of a global low interest rate environment that has, at the time of writing, persisted for more than a decade.

In the final quarter of 2008, therefore, central banks had cut rates aggressively and by the start of 2009 had quickly reached the well-known zero-lower bound, which refers to the floor (at 0%) beyond which there is no more manoeuvre for further accommodation via changes to the policy rate[65] (Eggertson and Woodford 2003; Buiter 2009). Given that the nominal interest rate was the key policy tool by which central banks conducted monetary policy, and because further stimulus was required, reaching the zero-lower bound posed a constraint for central banks. What is now known as conventional monetary policy, then, seemed to have reached its limits during the crisis.

As a result, there was a question in financial markets about whether central banks had enough tools to be able to deal with the crisis and its aftermath. For the Bank of England, for instance, this was a double-edged threat: on the one hand, the very fact that market participants were sceptical about its own powers could itself lead to a lack of confidence in markets, and to a sharp and persistent increase in market yields that would further aggravate the crisis; on the other, it would undermine the central bank's ability to govern expectations as markets start to doubt its effectiveness to influence the real economy. The latter, especially, would imply that the reaction function of central banks would become irrelevant and meaningless, and therefore lead to the collapse of the interpretive filter whereby market participants read macroeconomic information in terms of the central bank's reaction function. If market participants no longer believed that other market participants were watching the central bank, and

[65] Later, central banks started to experiment with negative rates, a scenario in which the zero-lower bound was breached. As one of the first major central banks to do so in 2014, the ECB has recently suggested that the zero-lower bound is a perception and that it no longer constrains market expectations (Schnabel, 2020).

instead believed that they were reading macroeconomic news independently of the central bank's reaction function, then this could very possibly exclude the central bank from the structures and relations across agencements, as proposed in the previous chapter, and thus render it less relevant as a policy agencement to the detriment of the yield curve's coordinating function across agencements. The same Deputy Governor recalls:

> After Lehman's collapse everybody thought the world economy was collapsing. And part of restoring confidence of private agents and households and businesses hinges around, first of all, sending a message that the authorities are on the case. Secondly, that their instruments work, whatever they're doing… And thirdly, that the authorities know what they're doing. So, ok, this is a big shock. But the authorities know what they think, they're acting together. That is quite important to underpin confidence. And we actually thought… that part of the story was all in this business of restoring the confidence of private agents in the future because we were on the case… At the time, it was very important that governments and central banks were [seen to be] reacting strongly and aggressively. And we certainly did have the view that it was important that we went in big. This is all to do with this confidence.

It is clear that by confidence this interviewee meant something wider than the economics's definition of it, which refers to the optimism and conviction (and therefore, lack of uncertainty) about future economic scenarios. It also refers to confidence of market participants that central banks are able to deal with the crisis and that they *would* act. Therefore, market participants needed to be convinced by central banks that the latter have not run out of firepower to counter the effects of the crisis. By sending clear messages that they will act, primarily by acting 'strongly and aggressively', central banks would not only influence expectations about the future, but could also safeguard their role as a policy agencement and therefore the anchoring of expectations to the central banks' reaction function and the interpretive filter with which expectations were governed.

Central banks consequently expanded their toolboxes by resorting to a set of unconventional tools which they deployed immediately (Goodhart et al. 2014; IMF 2013), though various central banks experimented with different combinations and forms of these new policy tools (BIS 2019). The Bank of England, which implemented a policy of quantitative easing (QE) in 2009, sought to solidify their communication and actions in 'restoring confidence' (in the wider sense of the term) by emphasising that unconventional policy tools such as QE were “a natural extension of the Bank’s conventional monetary policy operations” (Benford et al., 2009, p. 91).

> From a communications angle we really did want to stress… because I think people were already using the term unconventional policy at that stage and we really wanted to get across: ‘No, this was a perfectly natural thing to do.’ We got as far as we could, lowering short term rates and doing things that pushed interest rates down further along the yield curve, which is a natural extension.
> (Interview LG)

7.1.2 Shifting agencements and the turn towards unconventional monetary policy

In practice, however, the design of monetary policy following the crisis, and the rearrangement of the policy agencement that came with it, was far from straightforward. The case of the Bank of England illustrates this, as the yield curve was briefly supplanted by a measure of money growth as a diagnostic and calculative device of QE’s success.

At the end of 2008, a team from the Monetary Analysis Division was assembled and asked to dust down some earlier material (Yates, 2002, 2003) on policy options at the zero lower-bound to eventually make recommendations to the MPC. The team came up with a lengthy policy strategy document, which was to include *forward guidance*[66] and balance-sheet policy in the form of private sector asset (e.g. corporate bonds) and government bond purchases (Interviews AP, VF). A third recommendation, a member of the team tells me (Interview AP), was quasi-fiscal policy tools, primarily helicopter money[67]. The policy document irked some of the senior staff, particularly the Markets Division[68]. The Governor, on his part, concerned about the political implications of other policy options such as helicopter money and private sector asset purchases

[66] Forward guidance involves the central bank communicating information about its future monetary policy.

[67] Helicopter money is an unconventional monetary policy, suggested by Milton Friedman (1969), in which central banks bypass financial markets and make direct payments to households and businesses in the real economy.

[68] Unlike the Monetary Analysis team who were trained in New Keynesian economics in which only expectations matter (though they were aware that temporary market frictions were present due to the crisis), the make-up of the Markets Division consisted of members more likely trained in earlier monetary economics in which markets were permanently incomplete and segmented, and where money mattered.

sought to impose a mechanistic-monetarist frame of QE, a version of QE disconnected from the New Keynesian model that was so influential on monetary policy in the previous two decades.

The Governor and a Deputy Governor sought to pre-emptively frame the discussion around QE while excluding any other potential policy option (Interview VF). One of the team members (Interview MW) explained the process of policy exclusion to me:

> Well, the way it went was that, initially we were given the kind of terms of reference, which was to look at the state of knowledge and to make recommendations. But then, as we got closer to the meeting that we would have with the MPC to present the work, we were notified that what we would be presenting was a slideshow that explained that the question would be not 'what would we do?', but 'given that we are going to do QE, how much would we do?' The work that we had done explaining our thoughts on the different options available would just be… not even really tabled, but be available on an internal Internet site that the MPC would have access to, if they were interested enough to look. Now, I think at the end it was referred to in a footnote, while the note that was actually written for the meeting was just, you know, how much QE should we do.

He went on to argue that the policy channel emphasised was essentially a monetarist one, which in the context of a New Keynesian model in which assets are perfectly substitutable would be ineffective due to the neutrality result explained in chapter 5. This is precisely what Ben Bernanke (2014, p. 14) meant when he famously said "Well, the problem with QE is it works in practice but it doesn't work in theory". The same team member (Interview MW) argued:

> [A]t the time the channel that was emphasised really was just, 'Well. This is just more money. We used to vary the price of money, now we're varying the quantity.' That's how Mervyn [King] emphasised it. Of course, that's exactly the channel that we didn't really think existed. Because the Bank was getting the market to exchange very similar securities. Essentially one zero interest rate default risk-free asset for another. We didn't think that there being more money out there was actually going to have any effect.

Looking more closely at the pre-crisis configuration reveals that the Executive's[69] undertaking was far more formidable. Given that Monetary Analysis were central to the pre-crisis agencement, particularly their New Keynesian DSGE model in the

[69] Prior to the 2012 and 2014 restructuring, the top-level Executive was made up of a Governor and two Deputy Governors.

forecasting process, the Executive needed to exclude a core policy device from the process too. The model itself precludes the possibility of quantitative easing in a very material sense: a change in the central bank balance sheet will have an effect of exactly zero on the forecast (Burgess et al., 2013; Interview 8). And while the MPC members or Bank analysts cannot in any way be reduced to model dopes (MacKenzie and Spears, 2014a), and indeed they often emphasise this explicitly (Burgess et al., 2013, Gieve, 2009, King, 2005), the struggle also had material basis. The Executive's struggle was not simply one against a few individuals or ideas, but also against technologies and material devices. Answering a question about the effectiveness of QE in the context of models, King answered:

> [You] don't have to worry about models; I'm not the slightest bit interested in these fancy models. What I am interested in is understanding monetary economics and financial history.
> (Inflation Report Press Conference, February 2009)

This was therefore an attempt to exclude the model from the policy design, and later policy analysis. In doing so, a potential epistemic machinery was replaced by a different set of practices in which knowledge of monetary economics and financial history, and qualitative judgements on the calibration of the policy, prevailed.

In early 2009, Mervyn King emphasised publicly the monetarist frame of QE[70] as aiming *"to boost the supply of money*" (King, 2009b, p. 7) and argued that "[t]*he problem we face at present is that the supply of money is not rising quickly enough"*. That this mechanistic-monetarist formulation was entirely disconnected from other conceptions of QE is demonstrated by statements of MPC members themselves arguing that the Governor's insistence on talking about QE as *"expanding the money supply, a sort of monetarist type thing, [was] unfortunate"* (Interview LG). Though by no means a binding decision, when combined with the exclusion of the team, this proved a powerful and consequential frame with which to battle other MPC members. A former Deputy Governor (Interview VF) recalls that for the very first time in the Bank's independent history, the 3-person Executive decided, following an internal

[70] It is interesting to note that while Mervyn King was a key architect of the inflation targeting framework at the Bank of England (as we have seen in chapter 5), during the peak of the crisis he resorted to a monetarist approach to monetary policy. There is a sense in which his practice as an expert and economist involved more eclectic thinking than strict reliance on rigid models and theories. Additionally, his shift to a quasi-monetarist approach here may be interpreted as one that was largely influenced during the 1980s' overfunding policy, which we encountered in chapter 5.

debate, to ensure unanimity across all MPC members. This question was ultimately resolved following an implicit struggle revolving around a disagreement on whether QE's intermediate target was the yield curve or the quantity of (broad) money.

The Governor's frame was successful in structuring the MPC discussion and the policy agencement away from the yield curve and around the money supply. For instance, the minutes of the March 2009 (p. 8) meeting during which QE was first voted on by the MPC includes the following:

> [T]he Committee had previously chosen to influence the amount of nominal spending in the economy **by varying the price at which it supplied central bank money** … Under the operations now under consideration, the Committee would **instead be focusing more directly on the quantity of money it supplied** ... (emphases mine)

This was supported by the enrolment of devices and practices into the agencement: the yield curve, as the primary tool through which the MPC used to conceptualise and measure its policy effectiveness, took a secondary role in the first half of 2009 as it was replaced by another device, the 'money growth' measure (Interview TE). As one former MPC member (Interview JI) recalls by drawing on personal notes taken during the MPC meetings:

> [O]n the Committee we had begun to talk much more about why we never looked at the money supply. So, I think about what we were doing … since the early 2000s. And every meeting we were supplied with this huge red book of charts, which we used to go through. And there was a whole set of charts on money supply, but we rarely, rarely discussed [them]… It hadn't really got anywhere when the crisis started. But I think it was the fact that we've been having that discussion and saying maybe the money supply is important that made people think that actually if we do this transaction and push lots of money … then it will solve the problem."

In this case, the shift from the yield curve to the money supply measure, which reconfigured the agencement itself, turned the problem into one of weak money growth (and away from expectations/interest rates)[71], thus leading to a different way in which QE was to be *done* and its effectiveness *calculated* and *measured*. For instance, while

[71] Indeed, the practice of quantitative easing was internally seen by some, including Mervyn King himself, as the inverse of the British overfunding policy of the 1980s (which we encountered in Chapter 5) (Interview VF). Rather than the Bank selling more gilts than the government required in order to absorb liquidity, in this case it would buy gilts to provide liquidity (and thus increase the money supply).

the April minutes do refer to the impact on yields, they mention that these effects might be temporary, suggesting that yield effects are not as important for the success of the programme, while its very first minute states that "[t]he aim of these measures was to increase the supply of money" (p. 1).

Furthermore, although the DSGE model was excluded from the *design* of the new policy, it was still a relevant – though less influential - component of the configuration. Within the reworked agencement, the forecasting staff would first produce a forecast without QE, and then impose the effects of QE on it. However, because the model materially precludes QE effects, the staff decided to impose QE effects in terms of expectations (i.e. a New Keynesian conception of policy in which only expectations matter) rather than quantity effects on risk/term premia or on the money supply (Interview PY).

The agencement thus proved fragile as not only were there inconsistencies in modelling practices, but MPC members had different interpretations of what QE is and how it works (Interview LG). These internal inconsistencies were reflected on the frontstage in public speeches, where some MPC members outlined how the strongest channels of QE were on *interest rates* via the portfolio rebalancing channel, a confidence channel and expectations (Bean, 2009, Dale, 2009), whereas others reiterated a mechanistic form of monetarism measured by *money growth* (Besley, 2009, King, 2009a, Sentance, 2009). The Bank's policy arrangement was put into question during this period. For instance, one Deputy Governor told me how the Treasury was displeased with discordant speeches by MPC members (Interview LG). The solution to this impasse was found in a backstage-compromise transformed into frontstage-consensus, a process which amounted to an exercise in Goffmanian performance driven by the need to preserve its expert authority. "Charlie Bean … was detailed to go off and write a paragraph on how QE worked that all the members of the MPC would agree on in terms of how we were going to describe how QE worked" (Interview TE). A former Executive member (Interview LG) told me: "We tried cobbling something together, saying that [interest rates and money supply] are like duals of each other. Just looking at the same thing from different angles". Indeed, this compromise is reflected in some of the publications which the Bank published during that period (see, for example, Benford et al. 2009).

Despite this attempt at Goffmanian performance, the Bank's communicative shift was picked up on by financial journalists. During the August Inflation Report press conference (p. 16), a journalist from the Wall Street Journal observed that "the communication around quantitative easing seems to have changed at various stages over the last few months" and asked "how much attention the Committee is paying to the short-term price of money versus the long-term quantity of money arguments [it was] deploying a few weeks ago". The Governor responded:

> Right at the very outset, when we launched asset purchases, I actually explained very clearly to a television audience what the aim of asset purchases was, and it was explained very clearly in terms of the quantity effect. Now there are also price effects that go along with that quantity effect … So I don't see any conflict between these two; they absolutely go together. A view about quantities has to be consistent with a view about prices.

The agencement was readjusted around the summer of 2009 after David Miles and Adam Posen, two newly appointed members of the MPC, attacked the monetarist frame. The former argued that "[t]he ultimate objective of QE is **not** to increase some measure of the money supply […] QE can work even if it has very little impact on the money supply." (Miles, 2009, pp. 6-7, emphasis in original). The latter, even more explicit, is a speech titled 'Getting credit flowing: A non-Monetarist Approach to Quantitative Easing' (Posen, 2009, p. 5) which provides "evidence against mechanistic monetarism".

The yield curve became once again the most prominent diagnostic of QE, a device which is more at ease with the conventional New Keynesian framework. For instance, from mid-2010 onwards the section on money supply did not occupy anymore a prominent position in the Inflation Report but was shifted to the middle part, whereas the analysis on asset yields and prices remained prominent. At the MPC level, QE became calculable in terms of shifts and twists to the curve, rather than some measure of money growth (see Joyce et al., 2012, Joyce et al., 2011, Joyce and Tong, 2012).

7.1.3 Recrafting models: Efficient markets and frictions on the yield curve

The vast array of policy tools deployed by central banks after the crisis required a recrafting of the monetary policy model more generally, and models of financial markets more specifically. The New Keynesian model of monetary policy relied on a specific conception of financial markets: complete and efficient markets and the expectations hypothesis of the yield curve. This model of markets is taken as a reasonable approximation due to the existence of leveraged arbitrageurs who render markets complete and efficient, and arbitrage away market frictions. The model of complete and efficient markets is also operative as a technical artefact in the materiality of models as DSGE models are firmly based on it.

Because of the neutrality result explained in chapter 5, quantitative easing is rendered ineffective in complete and efficient markets. Central banks implementing QE thus needed to resort to a different model of financial markets. One model favoured by central bank economists at the Bank of England, and other central banks such as the Fed, involves a portfolio rebalancing model. Harking back to Tobin (1963, 1969, 1958) and Brunner and Meltzer (1973), the portfolio rebalancing model includes market frictions and imperfect asset substitutability, and assigns relevance to money in the transmission mechanism (Meltzer, 2014). Rather than only expectations mattering as in Woodford (2003), portfolio rebalancing allows conditions in which the central bank can influence interest rates by shifting private actors' portfolios. The ability of monetary policy to influence a wide range of relative prices/rates ensures its potency at the zero-lower bound. It works especially strongly when targeting the *composition* of purchases (Woodford, 2012) by extending them to longer-term government bonds, corporate bonds, asset-backed securities, equities etc. In purchasing less-liquid assets, the Bank provides private actors with a liquid one (money), which they will use to rebalance their portfolio towards other assets, resulting in lower costs of borrowing across-the-board. Portfolio rebalancing, therefore, not only makes QE theoretically possible, but makes it more effective via purchases of private sector assets (which incorporate more risk premia).

This is not to say that the *quantity* of QE should not matter. Indeed, asset purchases generally rely on quantity effects. However, non-government issued assets hold not only duration risk but also credit risk. Given that, from the viewpoint of the portfolio rebalancing, QE works by affecting risk premia, the type of assets purchased is bound to be important. In the words of Bernanke (2010), “[t]he logic of the portfolio balance channel implies that the degree of accommodation delivered by the Federal Reserve's securities purchase program is determined primarily by the quantity and mix of securities the central bank holds".[72]

The existence of risk premia is therefore a crucial component of the model of financial markets which central banks embraced following the crisis. Risk premia are typically presented as *deviations* from the expectations hypothesis. They may include liquidity considerations and risks associated with expectations of the future. For instance, if market participants have developed a view about future policy and future inflation, the *strength* of their conviction on the future path of interest rates and inflation will determine how much risk they are prepared to hold. In simpler terms, risk premia may include the risk and uncertainty priced in assets. Longer-term maturity assets tend to be more exposed to this risk given that they tie up cash for longer periods. The risks involved in constructing fictional expectations may therefore also be priced in into asset prices and the yield curve.

The above model in which risk premia are significant involves a model of financial markets, and thus of the yield curve, in which agents are heterogeneous, assets are *not* perfectly substitutable, and therefore in which there are limits-to-arbitrage. A 10-year bond is different from a sequence of ten 1-year bonds because they may play different roles for different type of intermediaries (e.g. because of collateral constraints, balance sheet constraints), or perhaps because only government securities are eligible as collateral whereas other forms of securities are not (Interview PY). These kinds of frictions stand in contrast to the pre-crisis New Keynesian model of complete and efficient markets where assets are substitutable. The portfolio rebalancing channel, for instance, suggests that there are local supply effects on the yield curve that the central bank can exploit via QE. This involves turning to notions of preferred habitats or market segmentation in markets, models which go all the way back to Culbertson (1957) and Modigliani and Sutch (1966), and recently reworked by Vayanos and Vila (2009). Such models interpret financial markets (and thus the yield curve as its representation) as being incomplete and segmented. If market participants prefer to inhabit local parts of the curve and markets are not well-arbitraged (Interview VF), then assets are no longer perfectly substitutable, and, for instance, rates at the shorter end bear little relation to rates at the longer end. "So then for us central

[72] See Williams (2011) for a discussion on the policy relevance of the size versus composition of purchases.

bankers, this work by Vayanos and Vila is important because for the first time it established a link between quantities and supply effects. And if you look at the Bernanke speech … I think he dwells on it. And the point is that it has reached mainstream" (Interview NF).

Such a shift also expanded the central bankers' remit of governance. As we have seen, prior to the crisis central bankers were mostly concerned with governing expectations and consequently they interpreted the yield curve as incorporating expectations about future rates. And while they were aware of the 'risk premia' that certain bonds entailed beyond the expectational component (especially at the longer-end of the curve), they never turned them into an instrument of governance. The developments elaborated on also pushed risk premia into the sight of the central banker. Risk premia of the term structure of interest rates are now central to discussion internal to central banks and in their external communication, and are actively targeted via both forward guidance and quantitative easing (Lane, 2019). Although these are not modelled explicitly in DSGE models, the Bank of England did introduce some of these frictions in their macroeconomic modelling practices via the satellite suite of models around the DSGE. So while the DSGE model known as COMPASS (which replaced BEQM in 2011) itself fails to include frictions (and still relies on a conception of complete and efficient markets), the satellite models can be used to superimpose frictions on it (Burgess et al., 2013; Interview PY).

The adoption of new models of the transmission mechanism has rendered the work of economists sitting in the engine room of central banks even more crucial to the monetary policy-making process. Financial economists, equipped with state-of-the-art term structure models, seek to study the yield curve, the relationship between the term structure and macroeconomic variables, and the effects of monetary policy on the yield curve. They perform 'autopsies' on the yield curve as they decompose it into several components: real rate expectations, risk premia, and inflation expectations, and they feed this knowledge to the decision-making committee. While macroeconomists and macrofinance economists have historically never engaged in heavy interaction (even in academic circles), developments around the transmission mechanism of monetary policy have led to more regular interactions between the two. This is prominently so in the case in central banks and less so in the academic world, as one central bank microfinance economist (Interview PY) told me:

> But I think that's probably where most central bankers are. I think academics in the macro, the people I've spoken to over the years and when I presented the work, there seems to be more scepticism over frictions in financial markets.

7.2 The yield curve as a target of intervention

Within this arrangement, the yield curve became even more prominent as a target of intervention in the very practice of unconventional monetary policy. Through quantitative easing, forward guidance and yield curve control, central banks seek to influence the yield curve (as the core market pricing device) in an attempt to control the level of inflation. This section will explore the ways in which each policy tool is put in practice and will show how the yield curve is the target to which all these tools are deployed. Beyond acting as target, the yield curve is also used by central banks as a valuation tool with which to engage in asset purchases and as a measure through which to judge the success of policy. Finally, this section will look into how, by the very fact that the yield curve acts as a target of intervention of central banks, market participants start to question the semiotics (and meaning) behind the curve. Rather than a measure of expectations, the yield curve is now a stronger reflection of central bank action, thus making Samuelson's quip about the 'monkey in the mirror' even more true.

7.2.1 Forward guidance, the yield curve and central bank credibility

The attempts by central banks to safeguard the interpretive filter by restoring confidence was supported by a specific policy tool known as forward guidance. By communicating to markets their future policy action, central banks could better anchor expectations to their own reaction function, and to simultaneously influence those expectations. Because forward guidance has most frequently been used as a post-crisis tool whenever central banks have hit the zero-lower bound, it is mostly targeted at shifting the yield curve downwards in order to provide accommodation to the economy after a recession. A former MPC (Interview TE) member at the Bank of England argued:

> So forward guidance comes in only once you've got interest rates low and the yield curve is going up too much relative to your expectations. And we would try and tell people 'actually we're not gonna put interest rates up the way that it's built into the yield curve.'

> You try and talk the yield curve down, the expectations of future interest rates… And that's exactly what forward guidance is. But that didn't come into it until… interest rates were low so they couldn't go down any more effectively.

As this MPC member argued, the yield curve is central to forward guidance. Central banks deploy forward guidance, make statements about their own likely future actions, in order to 'try and talk the yield curve down', by which he meant trying to influence fictional expectations on the longer term. Just like pre-crisis monetary policy, forward guidance involves communication with markets and the target of expectations. In fact, it is perfectly congruent with the New Keynesian model of monetary policy such that the New Keynesian DSGE model "exhibits very powerful effects from forward guidance" (Interview PY). There is therefore a question about whether forward guidance is any different from pre-crisis monetary policy. Some of the old guard of the Bank of England, especially those who were on the MPC prior to the crisis, argued that forward guidance is no different than conventional monetary policy. They were referring, however, to the first type (of two) of forward guidance, known as Delphic forward guidance.

Delphic[73] forward guidance involves communication about a probable state of events (particularly macroeconomic) and the likely reaction of monetary policy to that state of events. This form of forward guidance is therefore a slightly stronger form of pre-crisis monetary policy where, rather than signalling the reaction function implicitly (e.g. through the Inflation Report and forecast), the central bank states it explicitly and clarifies its reaction function verbally. A former MPC member (Interview TE) argued:

> That is now called forward guidance because it's done more explicitly. But it was always forward guidance… We used to talk about being transparent, about our reaction function, trying to explain people how we would act in certain circumstances. Or if the economy did this what would we like to do, if we did that what would we like to do? That's the reason for having the Inflation Report and the forecasts, the minutes and the statements, all of that is about trying to get people to do your work for you by convincing them that you're going to do what it takes to keep inflation at two percent… And the point about forward guidance was to try to tell people, actually, we're not gonna put interest rates back up any time soon. When we do,

[73] The term Delphic is derived from Greek mythology in which Pythia, the high priestess of the Temple of Apollo, made ambiguous statements and prophecies in Apollo's Delphic Oracle (Campbell et al., 2012). Delphic forward guidance refers to a central bank providing statements and prophecies about the future.

> we'll only do it very slowly and they won't get back up to the sort of levels we had before. And that proved actually to be quite a powerful way of pushing the yield curve down further out.

The second form of forward guidance is known as Odyssean[74] forward guidance. Through this form of forward guidance, central banks bind themselves to a specific future policy action, given certain quantitative macroeconomic targets, by a *promise*. A central bank may commit itself to only start pushing rates upwards once inflation has got up to, say, 2% or, for instance, once unemployment has fallen to the 4% figure. In a way, Odyssean forward guidance is a method by which market expectations are further anchored and which renders tighter the interpretive filter of central banks. Macroeconomic indicators - and individual and collective fictional expectations by market participants around macroeconomic indicators - are coupled even more tightly with the central bank's (re)action. A market participant, therefore, will read macroeconomic news about inflation or unemployment in terms of the central bank's reaction function.

Secondly, it is also an attempt to influence expectations themselves and the uncertainty surrounding those expectations. As we have seen in the previous section, a market participant's lack of conviction in their own view will result in higher yields on the yield curve as market actors seek to be compensated for this risk, in the market's terminology. The effectiveness of forward guidance can result both in influencing expectations further out on the yield curve, as well as the 'risk premia' market participants request for the uncertainty they are operating in. A market participant (Interview JZ), speaking about the euro area context, argued:

> On the one hand, forward guidance kills volatility, because if I tell you 'that's what I'm gonna do' and if you truly believe that that's what I'm gonna do, then I'm removing uncertainty. By removing uncertainty, I'm removing risk. So, yes, in terms of signalling… I believe that what actually has really killed risk and volatility has been the forward guidance.

[74] The term Odyssean is also borrowed from Greek mythology in which Odysseus (Ulysses) is intent on listening to the song of the sirens despite its bewitching qualities. He thus ties himself to the ship committed to not throwing himself overboard and to stay on the ship listening to the song. The commitment shown by Odysseus by binding himself is what the term Odysseus forward guidance is referring to, where central banks commit and bind themselves to a future action. (Campbell et al., 2012)

Nevertheless, the conditional 'if you truly believe' in this statement is a crucial one, particularly for the second and stronger form of forward guidance. If a central bank commits today to, say, keeping rates low even if the unemployment rate drops to a specific threshold, then as the unemployment rate reaches that threshold the central bank might have an incentive to not follow through its promise. Known as the time-inconsistency problem, it puts on the central bank the burden of having to choose between the correct monetary policy at any one time and its future credibility. This is precisely what happened to the Bank of England in 2013.

Mark Carney, who replaced Mervyn King as Governor, joined the Bank with an intention to introduce the policy of forward guidance[75]. The MPC's assessment of the economy was that it was still in recovery and that output had been stagnant for three years so further accommodation would be needed. Nevertheless, markets were starting to discuss the possibility of a rate hike as the Purchasing Managers' Index (PMI) had reached the levels at which historically the Bank would be raising rates. The Bank wanted to send a clear signal that it would not be reducing stimulus anytime soon and that there was some spare capacity in the economy. In August 2013, with an employment rate that had stood at around 8% since mid-2009, the MPC decided to link the interest rate decision to unemployment as an indicator of spare capacity, on the view that a rebound in the economy was a long way off. The Committee agreed on the proposition, subject to certain conditions, "*not to raise Bank Rate from its current level of 0.5% at least until the Labour Force Survey (LFS) headline measure of the unemployment rate has fallen to a threshold of 7%...*" (MPC meeting August 2013). A Deputy Governor (Interview LG) recalls:

> And forecasting being what it is, of course unemployment fell very rapidly… and by the following February we'd already gone down below or near to the 7% point. And people misinterpreted what we're saying. 'Oh, they will raise rates when they hit 7%.' Whereas what we had said was that we won't even think about raising rates until we get to 7. The guidance I think it was actually quite well-framed, but it got misinterpreted.

Despite the framing of the guidance, the market's interpretation of the Bank's statement weighed on expectations. As a result, when the Bank failed to start hiking

[75] Two former Deputy Governors claim that this is one of the main reasons why the then-Chancellor of the Exchequer, George Osborne, appointed Mark Carney as the 2015 General Election loomed.

after unemployment had reached 7%, the market interpreted the Bank as having backtracked from its initial promise and, in the words of the Deputy Governor, the Bank "suffered some reputational loss through that episode". The Bank, therefore, failed to influence the yield curve in the way it was intended due to the damage the Bank suffered to its credibility. This is supported by some of my interviewees (Interview IN):

> They can change their minds, they reserve that right… But, the more often you change your mind, the less we think that your word is reliable, the less impact you have. I think central banks ultimately can lose a lot of credibility.

Another market participant (Interview FV) argued that forward guidance is actually counter-productive on volatility:

> All they've done is introduce this huge amount of volatility by saying they're gonna do this and in the last minute they're not doing it… Carney, for example… he's changing his view one day to the next, on Brexit it's going to be massive interest rate cuts, now it's X, now it's… they're trying to be too smart, too busy talking to the media and they've shot themselves in the foot. So no one knows whether they should trust them or not… [It has] destroyed their credibility.

Since that episode, various MPC members gave speeches explaining in detail the conditionality of forward guidance, and that forward guidance should not be taken as a promise or commitment but only as guidance as to what it might do given certain conditions (see, for example, Miles, 2014b). The Bank has therefore realised that, in order to manage the yield curve via forward guidance, it needs to engage in sense-giving practices and framing devices in its communication with the markets.

7.2.2 Quantitative easing and the yield curve

The yield curve also becomes more prominent in the central bank agencement as part of the policy of quantitative easing, or asset purchases. Here, the yield curve is not purely a target of intervention and measure with which to judge policy, but also an evaluation device in the actual *conduct* of QE. By purchasing assets on the secondary market, the central bank uses the yield curve as a tool through which judgements are made with respect to which assets to buy and at which price.

The policy of QE was first intended to influence the yield curve further out and in a more direct manner. As central banks purchase assets on the secondary market, it pushes demand upwards and therefore prices upwards, which results in yields going down. In contrast to pre-crisis conventional monetary policy which targeted a short-term interest rates, quantitative easing involves operating along the whole yield curve. The earlier policy by the Bank of England was to purchase government bonds, and thus to influence directly the risk-free curve, and indirectly via relative pricing other curves such as in swaps, corporates and credit. An investor whose portfolio has just become more liquid after selling government bonds to the central bank, would potentially use that liquidity to invest in riskier assets, such as corporate bonds. This portfolio rebalancing was precisely the method by which the Bank sought to influence riskier markets and their pricing. More recently, central banks have also sought to target multiple yield curves and the spreads between yield curves. In 2013, for instance, the Bank moved to influence these markets directly by purchasing riskier assets and therefore it became more actively concerned with yield curves other than the risk-free curve.

A central bank is sensitive, however, to the local segments of the yield curve in order to craft a particular form of QE. When devising its policy in 2009, for instance, the Bank of England was aware that the banking system operated largely at the shorter-end of the curve. Wanting to exclude the banking system for fear that they would simply store the additional money rather than channelling it to the real economy, the Bank sought to enrol non-banks into the policy arrangement by intervening onto the *middle* section of the yield curve (5y-25y). As it excluded all bonds with a lower maturity than 5 years for the reason just outlined, it also excluded any bonds with a maturity above 25 years in order not to influence the institutional investors' requirements for liability management, and thus distort the curve in that local area. The yield curve was therefore also used as a device that supported the very crafting of the policy strategy.

As the Bank sought to communicate with the markets its decision of QE, markets were surprised because a set of expected practices were not yet in place. It is interesting to see from this episode how much weight the Bank gave the yield curve as a representation of markets:

> The markets reacted very quickly. I mean, we know that because we made a slight mistake when we first announced QE, we hadn't actually got every aspect of the details lined up ready to go at 12:00. So at twelve o'clock, we said that we will do this QE programme and that details will come out in two hours' time. And then two hours later,

> we announced the precise gilts we were going to buy. And what we did was put a maturity limit on it. So we didn't buy any gilts less than five years… And we didn't buy gilts that were longer than I think it's 25… So we went for that middle of the curve. Meanwhile, the market had assumed that we would buy all the gilts. And so the market curve had come down at twelve o'clock. And then when we announced that we had time limits, it kicked back, it sort of dislocated at the two cut-off points. So if you follow the prices on that day, you see quite big dislocations going on. So clearly, the market was very much reflecting our decision through long term interest rates. So that effect you could see. (Interview TE)

Such decisions (e.g. to purchase which bonds at which maturity), however, were only made as the yield curve migrated to the Markets Division of the Bank of England. Though they often scrutinised yield curves and interacted directly and frequently with market participants, the Markets staff only placed the yield curve at the very core of their work once they were tasked with implementing QE. This involved the construction of an agencement, as a former Markets director recalls (Interview TE): from a lawyer dealing with the legal aspects of the policy, to a sterling markets team who designed operations, I.T. people who set up the actual design of the auction. "[Y]ou've got to have phone lines set up, people dial in and give you bids. You've got an I.T. system in which you can take bids, and then the cut-off point allocate the assets to the orders that people bid. You need to have credit systems in place. Credit limits and risk management and all of that lined up. So all of that had to be done pretty much on a shoestring in a matter of days."[76]

The most important question, however, was *how* to buy gilts and the role of the yield curve within that practice. The Markets Division faced two options: either build a yield curve model themselves and then offer to buy gilts at the highest yields *relative to the model*, thus aiming to push yields downwards. The second option is to take the actual observed yield curve at any point in time, wait till the auction and buy the gilts that were cheapest *relative to the observed curve.*

> That was the biggest question. So what the Americans did was they built a yield curve… Now, the problem with that, of course, is model error. You can fit all sorts of models of yield curve and come up with different answers… We didn't take that price. What we did was bought relative to market... The problem with that… was whether

[76] Although the interviewee in questions refers to bids, the Bank would have been receiving offers not bids in its reverse auctions.

> people would game us by trying to shift the yield curve at the earlier point in time and then take advantage. And we did have one occasion...

This one occasion was investigated by the Financial Conduct Authority and eventually the report was published (FCA, 2014). Let us, therefore, take that occasion to study the role of the yield curve in the context of QE, and in the interaction between the central bank and market participants.

Between the 14th and 16th of June 2011, Mark Stevenson, an experienced bond trader at Credit Suisse's London's bond trading desk, purchased £150 million's worth of the '17 gilt (a gilt expiring in 2017). The bond, issued in 1992 with a coupon of 8.75%, was a relatively illiquid gilt. A trader I spoke with (Interview AG) told me:

> [I]t was a really dangerous bond to trade... it used to make me very nervous having a large position in this. I once got a position of 200 million in this one. It was really rich. I don't think I slept very well for the next week, because I just so worried that, you know, every time I traded, I could sell 5 million, 10 million, right at any point it could collapse.

Betting that another round of QE was on the cards, Stevenson purchased more of the bond between July and September. When the Bank announced a further round of QE on October 6, the trader purchased even further amounts of the bond and mentioned to a broker that "we've been loading up with QE trades for months", and that "QE's are … cake…" (FCA, 2014, p. 8). On the first day of the Bank's QE implementation, Stevenson spoke with an interdealer broker and asked for the spread between his bond and a comparable bond, the 1.75% '17. Buying more than £300 million of the 8.75% bond in the space of less than 6 hours, through outright purchases and switch trades, his activity represented 2700% of the bond's average daily trading value between June and October 2011. The intended result was that its yield and its relative yield to other comparable bonds changed significantly in a short space of time. The trader had sought to move the market yield curve deliberately such that he could later profit from selling the bond to the Bank of England at a higher price. Indeed, he offered to sell £850 million of it through the Bank's reverse auction. This is what a trader (Interview AG) recalls of the occasion:

> It sticks out like a sore thumb. Remember, the yield curve is everything. We're watching the yield curve, and then we're watching

> one bond getting more and more expensive. I mean, why on earth would you think the government in 2017 should borrow for 10 basis points less in yield than 2016 and 2018. Makes no sense. And so it stood out like a sore thumb. Everyone in the market would see this. They're moving the screens, you're looking at the price in the brokers… it's shouting at you in red that this is the wrong price. Your model is saying it has never been here. It's two, it's three standard deviations.

Another trader (Interview JF) remembers:

> The problem with the Bank of England, the way they did it, [they] merely looked at the price of the bonds before the auction and decided whether it's [rich] or cheap at that point. They didn't look at an RV [relative value] model of any sort. So they would just get their eyes taken out… And I've never been one to really squeeze bonds or force a bond rich or force a bond cheap. I've always looked at the curve and gone 'where's the opportunity?' because it's cheaper, because it's rich. And maybe that's just a moral thing, I don't know. Maybe it's cost me money over here without squeezing it. But I've always taken a view rather than being aggressively trying to play with the market, if that makes sense... I actually called the Bank of England up on numerous occasions, told them you shouldn't be buying these bonds, because people are doing this. And they listened and they didn't buy them.

In the case of Stevenson, this is precisely what happened. As traders called the Bank to alert it of the squeeze going on in the market, the Bank "decided to reject all offers against UKT_8.75_250817 following significant changes in its yield in the run up to the auction." (FCA, 2014, p. 15). Stevenson was eventually fined and banned from the trading floor.

While the Bank's choice of using the observed yield curve exposed them to potential gaming, they sought to mitigate it by studying price changes between "when we spotted the yield curve and when we sold, to see whether there were any unusual movements going on… that the deviation was never more than the sort of movement you would get in a DMO auction. So that was, if you like, our control that we weren't being gamed." (Interview TE). They also leveraged the relations they had developed over years with market participants, who would alert them of suspicious market movements on the yield curve. The Bank did debate whether it should price-to-model or price-to-market, though it opted instead to stick to the latter and keep a close eye on market movements, supported by market participants[77]. The implementation of quantitative easing thus heavily relied on the yield curve not just as target of intervention, but also as a device with which to devise the policy itself, and as an evaluation tool through which to implement it.

7.2.3 Central bank action and yield curve 'distortion'

In the previous chapter we have seen how market participants have come to read the yield curve as a representation of market expectations. As Zaloom (2009) argues, the yield curve is not purely a technical (evaluation) tool for individual traders, but can also speak for the market as a whole. Market participants extract meaning from the curve as they read what expectations are being priced in.

Although central banks after the crisis study risk premia as a core component of the yield curve, my interviewees working in the market have expressed a sense of disillusionment with studying and extracting these premia from the yield curve. "Risk premia is one of these weird things like the output gap, that you can only really measure in hindsight", told me one interviewee (Interview AG). Another market participant (Interview IN) argued that as a fund they are sceptical about measures of term premia and therefore they do not base any trade ideas on them, suggesting that any shifts in the yield curve are equally explainable in terms of expectations rather than premia. One of my interviewees (Interview VK) put it this way:

> The problem is that none of the outputs are actually interpretable as a kind of economic reality or interpretation of it. It's kind of… exists almost on another dimension. It's very difficult to interpret, and it's not possible in that context.

Market participants therefore seem to have stuck with the expectations hypothesis as the main theory of the yield curve from which to make inferences. As a result, market actors read the yield curve in the way Zaloom (2009) explained, even *after* the crisis, though necessarily through the interpretive filter of central bank's action.

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[77] In contrast, the Fed used a yield curve model that no market participants had access to in order to prevent potential gaming by market actors. It also occasionally but deliberately changed the way it estimated the yield curve as an additional precaution.

Nevertheless, the heavy central bank action following the crisis has raised a question on whether the yield curve is any longer a representation of market expectations. This is firstly due to the permanence of quantitative easing as a central bank policy for over a decade, and secondly as a result of what is now known as yield curve control as a central bank policy tool. The latter is effectively an extension of quantitative easing in which the central bank, rather than stipulating an amount of assets to be purchased and hoping to push down rates as a consequence, it stipulates a target yield for points on the yield curve (e.g. the 10-year point) and purchase however much assets are needed to reach that target yield[78].

Such central bank action raises a potential objection by market participant that the yield curve no longer acts as an adequate representation of market expectations. One of my interviewees (Interview DC) argued that due to there being one big player in the market, namely the central bank, the yield curve has become 'distorted'. He claimed that rates are now disconnected from fundamentals because the expected movements in inflation expectations and GDP growth which feed into one's expectations formation process are no longer adequately reflected in yields. Yields are now a reflection of QE action rather than expectations about fundamentals. And yet, this claim disregards the interpretive filter which stood between market expectations and fundamental prior to the crisis, such that any central bank action was already reflected on the yield curve, as we have seen in the previous chapter.

This market actor's claim, therefore, is born of a strict Hayekian position in which central banks should be non-interventionist in markets. Indeed, he put his argument this way: "Take Adam Smith's invisible hand of the market… now that invisible hand is tied by the hand of the central bank, at least in most developed economies". Another trader (Interview FV) was even more vocal:

> But we're … at a period in history when we've got massive distortions of yield curves… QE, for example. That distorts the inflation signal of the yield curve as central banks starts to buy all the bonds at the back

[78] Beyond yield curve control, there are claims that the ECB is also engaging in 'spread tightenting' whereby it directly targets the variation across yield curves (spreads) between, for instance, Bunds and Italian BTPs. My ECB interviewees were all very cautious about it, but they all claimed that as long as widening spreads affect negatively the transmission mechanism of monetary policy, then spread control is within the remit of the ECB monetary policy. The official line of the ECB has consistently denied that this is an active policy. (see: https://www.reuters.com/article/ecb-policy-bonds-idUSL1N2JW1RL)

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> end, it pulls the curve down. That makes borrowing cheaper. And that's priced in the spread of the yield curve 'cos the rates are lower. So you look at the shape of the curve. I look at the curve of one country and another country, one is steep and one is flat. I say 'Hang on, interest rates shouldn't be as disconnected as that… So is the yield curve reflective of the risk of lending money over time? Not at all. I'd argue that the pricing mechanism is totally broken. There's no relationship between risk and reward at all anymore. [It has] distorted everything. To the point now where, I don't think it worked. They're still talking about doing more if they have to, but it's just throwing good money. It's distorted asset markets, broken the pricing mechanism, caused massive misallocation of capital…

In contrast, my central bank interviewees pushed back against this position by emphasising the fact that QE is 'distorting' by design. While the central bank often claims that it is very careful about not interfering with proper market functioning, such as liquidity (Interview GM), and about preserving market neutrality (van 't Klooster and Fontan, 2020), the very aim of QE is to move the yield curve:

> So if someone says we're distorting the yield curve, if they mean by distorting that I'm pulling down yields because I buy bonds, then I will not dispute that. That's the point by design. I wouldn't call it an accusation, I would call it a compliment. If someone came to me and said, this particular bond here is ridiculously mispriced because of what you do… Yeah, that would not be a compliment. It would mean, I'm not doing my job properly.

While some would argue that the yield curve's predictive power is broken due to the fact that central banks are now so influential of the yield curve, it is possible following our previous chapter to argue that the yield curve might become even more predictive than it used to. For if the yield curve's predictive power is a result of the social process by which market actors believe that others believe that the central bank stands behind the yield curve, then stronger central bank action on the yield curve will strengthen this very reading of the yield curve. Central banks stand behind yield curves, as in Christopher's (2017) argument, in an unprecedented way, and if it is the action of central banks that makes yield curves predictive (Estrella and Mishkin, 1997), then the yield curve's signalling of the future is not necessarily weakened. Indeed, it may grant it with stronger predictive abilities. "[I]n the last 10 years, the only driver you need to look at is the central bank. So it is in the meetings every month that you get a sense of where the curve's gonna go." (Interview QI).

7.3 Crises, model failure and (counter)performing the policy infrastructure

In a previous section we have seen how central banks needed to recraft their models of financial markets – of complete and efficient markets, and the expectations hypothesis of the yield curve – in their practice of QE. This model of financial markets, developed in the 1980s and 1990s (as we have seen in chapter 5), is a representation of the broad and liquid financial markets in part honed over several decades by the Bank itself. As we have seen, the model was adopted in the sociomaterial agencement in the 1990s (e.g. as part of DSGE models) and in the way the Bank conceived of its own policy implementation. Central banks such as the Bank of England thus learned to love financialisation (Walter and Wansleben, 2019) and embraced these new forms of markets in their epistemic, material and technical framework of monetary policy and its implementation.

In this section, we will see how this model became evidently less true as an approximation of reality during crises. However, while it is seemingly ‘abandoned’ by central banks, the model is still very much operative as it has turned from a ‘real-world approximation’ and ‘technical artefact’ into a ‘performative objective’ to be *achieved*. In deploying the balance sheet, central banks attempt to a) support arbitrageurs and b) perform complete and efficient markets, and thus counter-performatively establish a world in which quantitative easing is less effective. I argue that unconventional monetary policy, particularly QE, is as such deployed not purely as a matter of price stability (i.e. the *stance* of policy) but also as a matter of restoring the infrastructure through which central banks govern (i.e. the *transmission mechanism* of policy). In other words, I claim that we need to look at quantitative easing in terms of how central banks deploy it as they act as architects of the financial structures through which they channel their policy. Central banks, through unconventional monetary policy enabled by the yield curve, seek to restore the transmission mechanism, and thus financial markets as the infrastructure of policy, in an attempt to return to a pre-crisis assemblage of monetary policy and ‘interactional alignment’ with markets.

7.3.1 Constrained arbitrageurs, inefficient markets and central bank's market-making

The central bank's model of monetary policy in general and financial markets in specific relies on leveraged arbitrageurs to render markets complete and efficient, as we have seen in chapter 6. Because price deviations are typically small, the arbitrageur needs to deploy several magnitudes of leverage to extract reasonable profit. Leverage is crucial for arbitrage trading; leverage-constrained market participants would not exploit arbitrage opportunities because the profits generated from such trades are so low that it is only leverage which makes these trades worth exploiting. Indeed, central bankers tie the notion of complete and efficient markets directly to leverage. It is leveraged arbitrage which renders complete and efficient markets a reasonable approximation of reality[79]. As one central banker (Interview PY) told me when discussing what arbitrage means in the context of central banks:

> It's the efficient market hypothesis. So one way of characterising that would be well, financial market prices are such that … there are no arbitrage opportunities left. But one of the ways that that would happen in reality would be there's no constraints for someone in financial markets taking an infinitely large or arbitrarily large position in order to take advantage of those arbitrage opportunities. In reality… even the largest financial institutions have got leverage constraints, [but] then it comes down to the debate about how big they can be. Some people will say, look, there are massive hedge funds out there. Sure, they can't take infinite positions, but they can take really, really big ones. And so it's only going to be a few basis points that anything can be away from where it should be. It's an approximation.

According to Hauser (2020), common leverage rates in 2020 ran in the multiples of 40-60, and he suggests that in some cases leverage was much higher. In practice, leverage is also dependent on particular infrastructures. Hedge funds of the type we are dealing with fund their positions via repurchase agreements (repo) and posting collateral usually in the form of government bonds. While hedge funds of this sort and central banks do not interact directly, hedge funds' entire existence depends on

[79] Central bankers know that the model of complete and efficient markets is never perfectly true in the world of finance and economics, given that they are operating in social sciences rather than the natural sciences. Hence they settle for it being a 'reasonable approximation' and not as a perfect reflection of reality.

infrastructures such as repo and collateral financing (Adrian and Shin, 2010) which central banks themselves have over the years fostered (Gabor, 2014, 2016, Wansleben, 2020). Central banks, therefore, have contributed to the enacting of liquid, complete and efficient markets through which they govern.

By actively contributing to this process, central bankers could then easily adopt this conception of markets as an acceptable ‘real-world approximation’ and ‘technical artefact’ underlying their policy arrangement. This model is inscribed in the material devices through which central banks make policy. It is precisely for this reason that macroeconomic models of dynamic stochastic general equilibrium (DSGE) widely used in the central banking community do not incorporate the financial and banking systems within them (Interviews PY, NF, MB). In this model world, the absence of financial markets is both a result *and* cause of the conceptualisation of financial markets themselves as complete and frictionless and of a representative agent who has no constraint on trading across markets (Bailey et al., 2020, Dale, 2010). In this model, markets are frictionless and the market price of any asset (consistent with the no-arbitrage principles elaborated on in earlier chapters) “should be determined by the present value of the random returns to which it is a claim, where the present value is calculated using an asset pricing kernel (stochastic discount factor) derived from the representative household’s marginal utility of income in different future states of the world.” (Curdia and Woodford, 2010, p. 4).

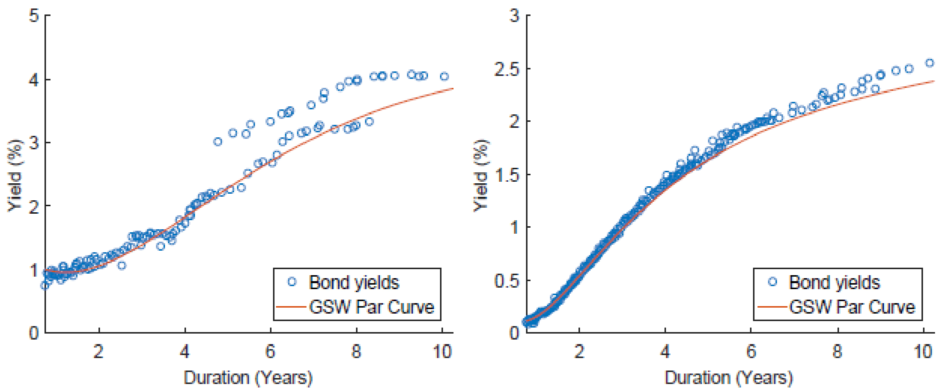
The Great Financial Crisis of 2007/08 and the Covid-19 market disruption in 2020 both led to severe constraints on arbitrage. Similar to LTCM in 1998, as spreads along points on the curve and across curves widened[80], this led to higher margin calls which forced hedge funds to liquidate their positions (even if they might have proven successful in the long-run). In trading on mean-reverting relationships along the curve

[80] A clear example of this is the cash-futures basis in March 2020’s dash for cash. Arbitrageurs would traditionally buy government bonds funded by repo, and simultaneously sell futures of the same issuer. Prior to the crisis, there was therefore a close relationship (an arbitrage relationship) between government bonds and government bonds’ futures, a relationship maintained by arbitrageurs themselves, as we have seen in the previous chapter. During the crisis, however, the relationship broke down, and arbitrageurs were constrained to the extent that they could not trade the broken relationship even if it was very clear that there were large profits to be made on it. See FSB (2020) and Duffie (2020) for a more detailed analysis of arbitrage relationships during the dash for cash in March 2020.

(e.g off-the-run vs on-the-run[81]) and across curves (e.g. cash-future basis[82]), arbitrageurs find themselves exposed as points move further out of line. Arbitrageurs have thus no choice but to liquidate their positions, which during the crisis created a second round of price volatility as spreads went further out of line in a feedback loop, similar to a bank run or margin spiral (Pederson and Brunnermeier, 2007, Schrimpf et al., 2020). As a result, market-makers were flooded with requests to intermediate, many of whom stopped making markets altogether (Interview ZQ). The yield curve thus experienced severe dislocations that normally would be arbitraged away. Figure 3 shows the effects of constrained arbitrageurs in 2008 at the peak of the crisis against 2014 where leveraged arbitrage was largely restored. Individual bonds move closer to the yield curve in the presence of arbitrageurs, and away from the curve in a world with severe limits-to-arbitrage, an empirical observation that would lend support to the argument that arbitrage renders yield curves smoother.

Figure 3: Yield to maturity dispersion of US Treasuries by maturity

Yields to maturity for US Treasury securities from the CRSP database plotted against each security's duration. The Grkaynak et al. (2007) parametric par curve (GSW) is plotted for comparison.



(A) 24 November 2008 (B) 24 November 2014

Source: Fontaine and Nolin (2019)

Before dealing with the question about the kind of monetary policy to implement, central banks had a more urgent matter. The crises, and the effects on market-makers who refused to quote, threatened financial markets' functioning as a whole. Central banks had to intervene in order to restore some normal functioning of markets. They

[81] On-the-run bonds are bonds that are more recently issued and thus actively being traded, while off-the-runs are those that have been issued before the most recent ones and thus are generally less actively traded.

[82] Cash-future basis refers to the price difference between reference bonds and its futures contract.

did so in their role as market-maker of last resort and for financial stability purposes (Cunliffe, 2020), reminiscent of the Bank's operations in the second half of the 20th century where they made markets in government bonds through emergency measures. The very act of having a large actor capable of and willing to make markets on a wide scale was enough of an incentive for financial market participants to enter the market once again and to restore some normality in financial markets (Gabor, 2016, Garbade, 2021, Mehrling, 2011).

Because central banks operate *through* financial markets, they have an interest in shaping and maintaining financial markets, and especially fixed income markets. In times of crises, therefore, when markets seem to be breaking down, central banks step in to prevent it not just for the sake of financial stability but also for the sake of monetary policy purposes (i.e. the transmission mechanism) and the central bank's own relevance. Because their operative procedures are entangled via the channel of financial markets which they have historically shaped and co-constructed, central banks have an interest in maintaining those markets. They become repo dealers of last resort to prevent run on repos (Wansleben, 2020), and to restore the arbitrageurs' work. Central bankers themselves perceive an ambiguity over whether such measures are of a monetary policy or financial stability nature:

> And so, if you go back to March [2020], you could reasonably argue that if the MPC hadn't done any QE at all, there would have been a very significant tightening in financial conditions in certain parts of the financial markets. And that would almost certainly have passed through into the wider economy. And so that would have weakened the outlook and probably jeopardise the ability to bring inflation back to target. So it's monetary policy. But the way that the actual transaction operates has a flavour of a cash flow alleviation type of instrument. And so there's a bit of ambiguity there about whether you should classify [QE] as a market policy or as a monetary policy. But at least from our perspective, we view it through the MPC that does this… it's not the Bank's Executive or the Markets area. So it's a monetary policy tool very clearly, but there are some complexities. (Interview PY)

7.3.2 The model of complete and efficient markets as a performative objective and the performativity of quantitative easing

Disruptions in financial markets during crises were therefore glaringly evident for most economists[83]. Bank economists who held a model of complete and efficient markets, and the expectations hypothesis of the yield curve, in the pre-crisis period could point to the crisis as the catalyst of market disruption and thus embrace (different forms of) quantitative easing. As one central bank economist (Interview VF) told me referring to another on the Bank of England's MPC, "it wasn't hard for [him] to find an escape in 2009, because obviously, the markets aren't perfectly arbitraged. In fact they're barely arbitraged at all. So of course there are supply effects. And so [he] doesn't have to abandon the position that he's taken in the past, because the conditions under which his past position hold no longer hold."

Endorsing the narrative of the 'crisis acting as a catalyst of market frictions' therefore allowed central bankers to abandon, at least temporarily, the model of complete and efficient markets. But the problem of which model to resort to once the worst of the crisis was over remained. The Bank of England has over the years emphasised different channels of QE, but poring over publications by the Bank over the course of the past decade, together with what my interviewees tell me, the Bank has established an empirical *progression* of transmission mechanism channels that mirrored changes in financial markets and their modelling. While the liquidity channel is most relevant in times of severe market disruption, such as the financial crisis of 2007/08 and dash-for-cash of March 2020 when the Bank took the role of market-maker of last resort (Bailey et al., 2020, Buiter and Sibert, 2007, Mehrling, 2011), it is less relevant during times of less significant market disruption. The portfolio rebalancing channel is stronger when markets are less arbitraged (including but not limited to times of severe market disruption) but less so during times when markets are well-arbitraged. Finally, the expectational channel is relevant in all market conditions, but especially so in 'stable' times. Indeed the broad progression of the Bank's literature shifts from emphasis of liquidity at the end of 2008 (when the Bank acted as market-maker of last resort in corporate bond markets) to portfolio rebalancing over the following few years,

[83] Despite this, there were a few Bank economists who did not abandon the main model and pushed a policy design that reflected that model even during the crisis.

and then to the signalling/expectational channel up to the start of the Covid pandemic (when the liquidity channel became prominent once again) (Broadbent, 2018, Haldane et al., 2016, Joyce et al., 2012, Miles, 2009).

What this entails, therefore, is a view by the Bank that quantitative easing is *state-contingent*[84]. There is increasing evidence and consensus build-up within the Bank that the underlying model of financial markets at the Bank is not static. Rather, the model changes to reflect 'states of the world' (Interview PY). The idea of QE being state contingent is reflected in the documents and speeches published by the Bank of England – see Miles (2014a), Haldane et al. (2016), Broadbent (2018), Vlieghe (2018), Bailey et al. (2020), Vlieghe (2020), and Ramsden (2021). From this viewpoint, QE is most effective when financial markets are severely disrupted (via liquidity channel), somewhat less strong when markets are not severely disrupted but which involve frictions and limits-to-arbitrage (via the portfolio rebalancing channel), and even less strong when markets are fully-arbitraged (via the expectational channel)[85]. This is not to say that the channels are mutually exclusive, but that QE's effectiveness and channels rely much on the conditions (or states) of financial markets. Argue Bailey et al. (2020, p. 18):

> Both the portfolio balance and the market liquidity channels of QE transmission may depend intimately on the state of financial markets and so vary with the degree of market dysfunction. For example, as markets become more dysfunctional, arbitrageurs become more constrained, strengthening the role of portfolio rebalancing effects. Similarly, impaired market functioning may give rise to an increased role for a liquidity channel of QE, if liquidity premia are larger and more sensitive to intervention. Relatedly, increased risk aversion may strengthen the portfolio rebalancing channels of transmission, as it may lead assets with different risk profiles to be seen as less perfect substitutes (the 'local supply' channel) and increase the sensitivity of investors to changes in interest rate risk (the 'duration' channel).

And yet there is a *performative* element underneath the process of unconventional monetary policy. Because to the extent that quantitative easing *is* state-contingent, then the very act of purchasing assets in financial markets will necessarily have an effect on financial markets conditions, i.e. on the states of the world. Quantitative easing, therefore, alters the states of the world within which it functions and which

[84] 'State' here refers to the state of financial markets, in the form of a spectrum from severely disrupted and poorly-arbitraged to approximating the efficient market hypothesis.
[85] The latter implies that QE turns into an extension of conventional policy.

render it more or less effective (Interview PY). This is the case when the Bank purposely pushes liquidity into severely dysfunctional financial markets (these being the 'state of the world'), with the consequence that markets become stable once again. But it is also the case when there is no shortage of liquidity in markets. For instance, one plausible reason why the Bank's empirical work stressed the portfolio rebalancing channel in the first few years after QE was implemented (Joyce and Tong, 2012) and later on the expectational channel[86] (Vlieghe, 2018) is that QE may have had an effect on 'the states of the world' of financial markets and thus on its own transmission mechanism. Echoing a performativity argument in discussing how the 'states of the world' and channels change, Broadbent (2018, p. 10, emphasis mine) argues: "[t]he point I want to make here is that all three can change. *One might even say this is intrinsic to the effects involved."*

But doesn't QE distort markets, with the consequence that QE can never achieve complete and efficient markets? In other words, is it not a contradiction in terms to say that QE can bring about efficient markets (i.e. markets that discover prices by themselves)? The first part of the answer is that, as we have seen, arbitrageurs are typically not concerned with central bank action and its involvement (Interview EZ). Arbitrage relations can be restored even in the presence of the central bank, a non-market actor. Indeed, the liquidity provision by central banks can assist market-making and arbitrage operations (Logan and Bindseil, 2019). The second part of the answer lies in the way MPC members have spoken about the winding down of QE. By the time that MPC members are looking to return to the management of expectations (as arbitrage relations are restored), and evidence shows that this is still an end-goal for central banks (Bailey et al., 2020, pp. 27-28), the state of the world would have altered in such a way as to approximate complete and efficient markets. The wind down itself, therefore, may not have significant effects because the state of the world under which it will be wound down will be different from that in which QE was first implemented. In this 'state of the world', the wind down of QE should precede the raising of Bank rate[87] (in order to restore pre-crisis normalcy):

[86] See also the Bank's Independent Evaluation Office review on the Bank's approach towards QE.

[87] The Bank of England's MPC has adopted a stance where Bank Rate will be pushed up to the 1.5% threshold before unwinding QE. The idea being that if QE is wound down when Bank Rate is still at the zero-lower bound, a potential tightening of the monetary policy stance via the winddown might boomerang onto monetary policy and keep Bank Rate (or push it back) at the zero-lower bound. The MPC intends to create some leeway between Bank Rate and the zero-lower bound so that the former

> These ideas suggest that the impact on monetary conditions of gilt sales by the Bank of England could be very different from the effect of its purchases. This is because sales would be conducted in a very different environment. The bulk of the Bank of England's asset purchases were made in 2009 and in 2011 – both occasions when financial markets were seriously disrupted because many financial intermediaries, in particular banks, were reluctant to take any risks because they found themselves short of capital and liquid assets. In contrast, the unwinding of such asset purchases is likely to occur when financial markets are operating more normally. (Miles, 2014a, p. 16)

Similarly, Vlieghe (2018, p. 17) argues: "in the slow moving capital view, large quantity effects are mostly temporary, and larger when intermediaries are constrained, as in the financial crisis. But they have much smaller or no long run effects once intermediaries are unconstrained".

But suppose we remain unconvinced that the strong claim of performativity just argued – in which QE has actual effects on financial markets (i.e. not simply on a model thereof) - is accurate and we dismiss it as a flaw of empirics. There is yet another sense in which this process is performative. To the extent that the Bank and the MPC are rallying around this interpretation, then the underlying model through which they conduct policy will have a performative effect on the policy itself. How might this be so?

I have argued that the model of complete and efficient markets, and the expectations hypothesis of the yield curve, was temporarily abandoned as an epistemic tool on which unconventional monetary policy hinged. In other words, the model no longer approximated the world which central bankers were observing. And yet, despite the temporary abandonment of the model in the sense just outlined, it was (and is at the time of writing) still labouring in the background of monetary policy. Not only is it still the underlying model of the main workhorse DSGE model, it has also turned into a performative outcome to be *achieved*. A clue can be found when central bankers speak of 'returning to normality' or a variation thereof. While this can be easily interpreted as a return to pre-crisis economic growth, stable inflation rates and the like,

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is not bound to the latter. Nevertheless, the Governor Andrew Bailey has raised the point that, given QE's state contingency, unwinding QE first would provide more space for future QE in the event of a crisis (where QE has a stronger effect than Bank Rate via the liquidity channel).

it also refers to the pre-crisis monetary policy arrangement of expectation management.

Central bankers *aim* to return to a form of monetary policy which relies on the governing mechanism of expectations management. While it is not strictly necessary for the expectations management arrangement to operate in a world of efficient and complete markets (indeed expectations can still be governed in imperfect markets), there are two reasons why the model is a desirable outcome to be *achieved*. Firstly, as we have seen in the previous chapter, the more markets are arbitraged, the easier it is for the central banker to govern a *consistent* path of market expectations and thus to read the yield curve in terms of the expectations hypothesis. Limits-to-arbitrage present the central banker with a set of inconsistent expectations that, while not impossible, are harder to govern as a totality. Secondly, central bankers wish to return to a world in which they understand the transmission mechanism of monetary policy and around which there exists a consensus in the international central banking community. Disagreements over the way central bankers govern undermine the 'epistemic authority' (Rosenhek, 2013) of the central banking community in general.

The model of complete and efficient markets and the expectations hypothesis has therefore turned from one which explains the conditions under which central bankers govern, to a performative objective to be achieved. The vast amount of asset purchases carried out over the past decade were intended not simply as a monetary policy tool in the strictest sense – i.e. to bring back inflation to target – but also to 'repair' the transmission mechanism, or in other words, to restore market completeness and efficiency. In one sense, then, we can say that in altering the states of the world, quantitative easing contributes to the enacting of a state of the world within which it itself is rendered less effective. Quantitative easing is performative over complete and efficient markets and counter-performative on itself. The closer the approximation of the state of the world to the model of complete and efficient markets, the weaker the effects of QE would be. But in another sense, we might conclude that, irrespective of whether the Bank's model is truly accurate or not, to the extent that QE is one of the main tools that central bankers deploy to restore that model and the underlying financial market through which it governs, then policy-making will revolve around this conceptualisation. QE will be used especially in times of crisis and less so in 'normal' times when the model of complete and efficient markets is *taken* to be an acceptable real-world approximation, and in which the management of expectations via Bank Rate will prevail once again.

Chapter 8

Conclusion

This project has sought to delineate the central mediating role played by the yield curve as it came to form a core part of secondary bond markets and central banks and their interactions. I have laid out the historical processes by which the yield curve became embedded in multiple sociomaterial agencements and how it reconfigured them and their practices. I also explored the contemporary practices through which order is rendered in and around financial markets, and the reconfigurations required of the sociomaterial agencements to restore order once again. This conclusion will provide a summary of the main points advanced in the analysis together with a revisiting of its contributions to knowledge. To conclude, it will lay out potential avenues for future research.

8.1 Recapitulating the thesis

The thesis has been driven by the theoretical approach of actor-network theory in which nothing exists outside of the sets of relations making up 'the social' (Latour, 2005, Law, 2009b). Amongst the various concepts offered by ANT, this thesis has adopted the notion of sociomaterial agencements which, to recapitulate, refer to sets of networks or associations, particular formulations, configurations and arrangements between humans and nonhumans. ANT is especially strong in following the assembling of these agencements. Hence it was appropriate to open the empirical section of this thesis (Part 1) by looking into the (re)configurations and (re-)assembling of a number of agencements: stockbroking firms in the City of London, bond trading desks in the US, arb desks and hedge funds, and finally central banks. I speak of *re*-assembling, rather than assembling, because in classic ANT fashion, no network is formed out of thin air but is invariably and necessarily a reconfiguration of older ones.

Chapter 3 took us back to 1950s London, in which stockbroking firms experienced a process I termed 'quantification'. Rather than relying on social forces such as networks in the manner of Granovetter for their business, stockbroking firms set up and amped up their research departments, which became a core part of their business. Slowly and incrementally, the research departments switched from one device to another, until the yield curve became strictly embedded within these agencements. This gave rise to new evaluation practices, such as different forms of ‘switching’, which in turn performed the market by consolidating it. In chapter 4, we saw how a parallel process was experienced later in the US during the 1960s and 1970s, as investment banks like Salomon brothers set up research departments and adopted the yield curve as a core part of their arrangements. As a result, by providing a novel pricing tool, the yield curve assisted in the development and spreading of new derivatives, from swaps to forward rate agreements and other exotic derivatives.

We then observed the transformation of the yield curve from a tool of valuation to one of risk, as it migrated from the traditional bond trading desk to the arbitrage desk. Novel modelling practices were developed around the yield curve, such as Krasker’s 2+ model, that assisted in hedging and in identifying arbitrage opportunities. As it was employed in multiple agencements, the yield curve took on different ontologies. In the manner of ANT, an object can only be defined in and through the networks in which it is located and operative (Mol, 2002). Indeed, such an approach is helpful to the extent that it problematises objects, devices, nonhumans and opens them up to further scrutiny. Rather than mundane black boxes, an ANT sensibility reveals their (multiple) nature, and therefore what they do. In one instance, the yield curve is a tool of valuation that tames assets by providing a standardised metric for comparison purposes. In another, it is a representation of ‘the market’, of a collectivity of humans and their expectations.

Similarly, the yield curve became an entirely different object in Chapter 5. The chapter recounts a history of the assembling of another sociomaterial agencement, that of central banking. The history reveals a long and complex process in which the Bank of England became entangled with the gilt-edged market, as the two developed structural and infrastructural alignments. The Bank supported and nurtured the gilt market, and then embraced it in the context of financialisation as an architecture through which it would govern. But the Bank also developed new tools and procedures, largely adopted from New Keynesian economics, that would establish a set of stable practices in the interaction between central banks and the gilt market – as an interactional alignment. As such, this chapter follows Wansleben (2018) and Walter and Wansleben (2019) in emphasising not just the role of science and knowledge within central banks as technocratic entities, but also the infrastructural (and interactional) alignments they developed with markets within wider processes of financialisation. I suggest that the assembling of the Bank of England into a 'modern' central bank, as a sociomaterial agencement, was both the result of infrastructural and institutional alignments developed over a number of decades between central banks and markets, as well the adoption of novel tools and devices. Within this agencement, the yield curve took centre stage as a policy device that represented the market and rendered expectations measurable, calculable, and governable.

Part 2 then turned to the contemporary patterning of sociomaterial agencements. The multiplicity of agencements observed in Part 1 flow into each other (Law, 2009a) by way of a set of routinised practices. Although these multiplicities present different modes of ordering, the interaction between and among them renders order, though this is necessarily and invariably a temporary form of order. At the heart of this perpetual process of (or attempt at) rendering order is the yield curve. Despite exhibiting multiple ontologies within the different sets of associations and networks, the yield curve retains an element of universality as an immutable mobile that turns it into a central mediating object as a coordinating device. There is a sense in which, therefore, the modes of ordering flow into each other through the yield curve as a sociomaterial device.

Chapter 6 delved into the practices of fixed income trading and central banks' monetary policy. I adopted Beckert's (2016) notion of fictional expectations to refer firstly to the practices employed by sets of market agencements in their attempt to read the future. Because their disposition is principally 'to have a view', their daily practices revolve around (re)building this view. Cutting across these practices are organizational rules, such as needing to build 'a house view'. But this is not only about reading the future, or purely about knowledge production (Svetlova, 2018). The entire process surrounding the building of fictional expectations involves another step: *expressing* a view and making money. The yield curve is therefore less of an input to expectations and more of a tool through and against which those expectations are expressed. Agencements express their view against the market's view as implied in the yield curve. The yield curve thus acts as a representation of the 'market view', as it collectivises multiple fictional expectations deriving from multiple agencements onto a single 2-D plane. The yield curve makes expectations graspable, and transforms a dispersed set of actors and expectations into a singular entity.

This final transformative process is also crucial for central bankers. Central banks can now interact with the market as a whole, as a singular entity. They speak of the market as if it had a mind of its own (Hutchins, 1995), and by providing a high-frequency read, the yield curve becomes an object around which policy revolves. But in order to govern market expectations, the central bank requires a set of practices through which it can control or steer those same expectations. I showed how central banks construct an interpretive filter through which information absorbed by market participants is passed. As they read data and news on unemployment, inflation, economic growth, liquidity and so on, market participants treat it as relevant and consequential only to the extent that it is relevant and consequential on central bank policy. In other words, it is not purely about building fictional expectations of future economic conditions, but about building fictional expectations in terms of how central bank policy will react to those same conditions. Central banks, therefore, are often at pains to maintain this anchoring of expectations and the (re)construction of this interpretive filter via discursive, linguistic and symbolic signalling.

Furthermore, a different type of agencement's – the arbitrageurs – activities flow into the central banks' and other market participants' activities. Their mathematical take to yield curves ensures a particular structure of the yield curve that is smooth and internally consistent. By engaging in arbitrage work across asset markets and instruments, they also connect different yield curves – futures, swaps, and money market yield curves so that multiple markets are connected via discount rates. In effect, the work of central banks implicitly relies on arbitrageurs to carry the effects of monetary policy to different markets, and ultimately to the economy. Indeed, the transmission mechanism of monetary policy requires a smooth functioning of money markets and fixed income markets, a function that is often carried out by arbitrageurs. Additionally, the work of arbitrageurs ensures that the efficient market hypothesis and the expectations hypothesis of the yield curve become a plausible approximation of reality, such that the model implicit in New Keynesian monetary policy is actualized.

The yield curve's universal element, by virtue of Bloomberg's standardised yield curve, therefore transcends the multiplicity of arrangements and establishes a sense of shared temporalities, intersubjective meaning, and communication across agencements. But there is also a sense in which the yield curve can be performative over economic futures. The yield curve is seen to be predictive over macroeconomic growth and recessions. I attribute this performative element of yield curves not to the fact that central banks stand behind the yield curve in producing it materially, as Christophers (2017) argues, but rather to fact that market participants are aware that other market actors will read the yield curve in terms of central bank policy, i.e. via the interpretive filter established by central banks. As a slight nuance to Christophers' argument, the yield curve is performative because central banks stand behind the practices of fictional expectations and the way they are expressed through and against the yield curve. Nevertheless, while the performative power of the yield curve is recognized by market actors themselves, it also hinges on the central bank's ability to safeguard the interpretive filter.

In chapter 7 I show how fragile this interactional alignment (and mode of ordering) is as it is hit by crises. As a result, central banks engaged in a reworking of their arrangements as they developed new monetary policy tools which made the yield curve even more central to policy. The yield curve moved downstairs in the engine rooms of central banks, as it started to be dissected into various components as an epistemic object, and simultaneously moved to the Markets section as it became a tool of policy implementation. More recently, some central banks developed a new policy of Yield Curve Control which turned the yield curve into an explicit target of central banks. I argue that, surrounding these new practices and reworkings of agencements internal to central banks, the driving logic behind the maintenance work involved in restoring markets' functioning lays primarily in the infrastructural alignments built over several decades between fixed income markets and central banks.

Indeed, as argued in chapter 5 and 6, central banks have an interest in seeing that financial markets function and work smoothly precisely because it is through them that they govern. As such, quantitative easing involves a clear element of liquidity provision as the central banks act in a market-maker of last resort. But I also show that, in the case of the Bank of England, quantitative easing is treated as state-contingent and that it performs a world within which quantitative easing ceases to be effective. In doing so, quantitative easing restores the very architecture of financial markets such that the efficient market hypothesis and the expectations hypothesis are re-actualised, or more precisely, become a reasonable approximation of reality once again. In this attempt, I argue that central banks have an interest in returning to a pre-crisis monetary policy (by restoring pre-crisis social order) in order to start governing once again purely through fictional expectations.

8.2 Revisiting the thesis's contributions

8.2.1 Evaluation practices in the social studies of finance

The first substantive contribution this thesis makes is directed towards the recent literature in the social studies of finance on evaluation practices (MacKenzie and Spears, 2014a, b, Spears, 2014, Van der Heide, 2019, Van der Heide, 2020). It gives attention to another context beyond derivatives pricing and life insurance – that of fixed income valuation. Firstly, it presents a historical analysis of the ways in which evaluation practices in the gilt market developed since the 1950s. I show how evaluation practices emerged in a number of stockbroking firms who moved away from networks a la Granovetter to the setting up of research departments as a way to gain and maintain their business. In a process of quantification, stockbroking firms recruited mathematically-oriented individuals with various professional backgrounds (actuaries, accountants and economists). A similar process occurred in the US sometime later during the 1960s and especially the 1970s. In both contexts, the yield curve became embedded in these agencements as a core component of the practices of bond valuation. I show that, as a result of this, these evaluation practices shaped markets by consolidating the gilt market in the UK, and by supporting the development of derivatives in the US.

Similar to Spears (2014), I argue that the ontology of a particular agencement (i.e. the *local* patterning and organization of the sociomaterial relations making it up, together with the evaluation practices that sustain it) can shape material devices such as models. Spears show how interest rate models are moulded as they move from academia to investment banks' derivatives quant community. Similarly, Van der Heide (2020) lays out the migratory process of no-arbitrage models into the British insurance industry and the political compromises involved that shaped not only the practices around these models, but also the models themselves.

My own thesis provides another example of this process by looking at how the yield curve was moulded as it moved from research departments to bond trading desks to arbitrage desks and hedge funds, and later to central banks. This goes beyond the boundaries of the organisation, as a firm or central bank. A bank, a central bank and an investment management firms may be composed of multiple agencements. For instance, I show how the yield curve was shaped as it moved from the Monetary Policy Committee of the Bank of England (in which it was a device that materializes expectations) to the engine room of central banks: from research and analysis department (where the yield curve became a body to be autopsied, dissected, decomposed, and broken apart into several components, i.e. expected future inflation, expected interest rates, inflation risk premia and interest rates risk premia) to the Markets division tasked with the implementation of quantitative easing (in which the yield curve became a tool with which to valuate bonds and carry out asset purchases). Multiple ontologies within and across organisations give rise to and are sustained by multiple evaluation practices that grant a device such as the yield curve a multiplicity of ontologies.

Finally, I contribute to the evaluation practices literature by extending their remit from markets to the policy world. The notion of 'evaluation' is broad enough to allow an analysis not just of how traders and quants go about their valuation and pricing of assets and instruments, but also of how they evaluate policy, its effectiveness, what goes into it, and how to go about it, particularly one which is oriented to markets. Because of the historical central bank and market entanglements, central banks repurposed a 'market device' and transformed it into a 'policy device' (Hirschman and Berman, 2014). I contribute to this literature by showing how the yield curve became a crucial component in reading market expectations for policy purposes, and later as an epistemic device and material target of intervention with which to craft and implement policy in a post-crisis world. More importantly, I extend Hirschman and Berman (2014)'s discussion on policy devices by laying emphasis on the way the yield curve is operative in the *interaction and coordination* between central banks and markets as a coordinating device. Following the long and complex process by which the yield curve, a market device, came to be repurposed and reworked into a policy device, the yield curve came to sit at the centre of the interaction between central banks and markets as these became increasingly susceptible to each other.

8.2.2 Amalgamating the social studies of finance and Beckertian sociology

The second substantive contribution of this thesis relates to the attempt to bridge between the literature in the social studies of finance which emphasizes performative processes and knowledge practices and a Beckertian literature on fictional expectations and imagination in the economy. I have argued in the literature review that the two are not necessarily incompatible, and in fact could be a powerful combination to explain the sociality of the economy. My study lays out how evaluation practices and multiple ontologies involve both economic calculation and knowledge but also belief, faith, and imagination. For instance, the crafting of fictional expectations ('view') is both a function of calculation and economic knowledge as well as imagination in scenario-building, faith in *which* future will unfold, and watching central banks for signals, narratives and stories about their policy.

The shifting balance on the weighing scale from one to the other is determined by the specific ontology of the agencement: for instance, the quant agencements (arbitrageur and derivatives quant) will rely more on calculative models. However, this is not to imply that they are model dopes (MacKenzie and Spears, 2014a). As we have seen, even within such an agencement there is an element of judgements. For example, in chapter 4 I have shown how the quants and nobel-prize winners at LTCM (some of whom later moved to JWM) debated and made judgements on how best to parametrize their 2+ model. As Callon (2007) argues, a calculative actor is never a perfect framing insofar as there will always be overflows. On the other hand, other agencements (speculative traders, bond funds, economists strategists) rely less on calculative models and more on stories, narratives, and central banks watching as they seek to detect, identify and infer from specific language, symbols and signs. They make judgements on which data and news is more relevant, may form beliefs about particular futures, and build faith around particular scenarios materializing. For instance, some traders have abandoned the *calculation* of term premia because they do not believe in the output of models that dissect the yield curve, and so they rely on a more heuristic reading of it. On the other hand, central bank economists have persisted in decomposing the yield curve into term premia, which knowledge is then crucial in policy-making, but they have also enacted an interpretive filter by which they could anchor markets' fictional expectations.

Inevitably, then, the yield curve will take on multiple ontologies: from a mathematical universe to be solved via calculation and a degree of judgement, to an object that allows the grasping of expectations, sometimes heuristically and at other times mathematically. But it is precisely the existence of such multiple ontologies that enable the SSF literature and Beckertian analyses to form a powerful analytical amalgam in the interrogation of social life in and around markets, and it is for this reason that I have chosen to rely on both approaches and bodies of literature.

8.2.3 Sociology of central banking

A third substantive contribution I seek to make is to the sociology of central banking. This body of knowledge has been crucial in opening up the black box of central banks, which had hitherto not been given the necessary scrutiny. What I seek to add to this literature, beyond the focus on the yield curve, is a historical narrative which investigates the processes by which a so-called 'modern' central bank was assembled. I have traced the historical process by which the Bank of England was constructed between the 1950s and 1990s. I have then shown how the yield curve became embedded in the arrangement as a core component of it. As the central bank turned towards the management of market expectations as a form of governance, the yield curve became crucial in allowing the central bank to grasp and measure market expectations. It therefore turned market expectations into durable material, firstly spatially – as it represented a set of geographically-dispersed actors and their expectations and put them onto a singular 2-dimensional space -, and secondly temporally – as it allowed the compilation of historical series of data on market expectations. Further to this, it constructed 'the market' as a singular collective that took shape and form through the yield curve itself. In doing so, it allowed central banks to conceptualise and interact with the market as a singular entity. This thesis therefore builds on the body of literature in the sociology of central banking (Braun, 2018a, b, 2016, 2014, Coombs, 2020, Holmes, 2013, Wansleben, 2018) by laying attention on the sociomaterial practices through which central bank monetary policy is crafted and implemented.

Furthermore, I sought to lay out how central banks needed to rework their internal arrangement *following* the crisis of 2007/08, a period which has been less studied by scholars in the social studies of central banking, with some exceptions (Braun, 2018a). I show how central banks went about developing new policy tools, such as quantitative easing and forward guidance, but also how they reconstructed their internal practices to support these new tools of governance. As I have explained in some detail, this recrafting of the internal arrangements and practices of central banks did not come without challenges and pitfalls, and they therefore needed to navigate a treacherous path to restore order.

8.2.4 Sociology and political economy of central banks and bond markets in the context of financialisation

A final contribution I wish to make via this thesis is related to the argument offered by scholars like Walter and Wansleben (2019), Braun (2018b), and Wansleben (2020). This literature has put emphasis on the infrastructural relations between central banks and markets, and has shown how over the years they have developed particular entanglements which has made them susceptible to each other. Political economy has long been concerned with such questions, particularly on the ways in which financial markets have grown to constrain states in their policy-making (Hardie, 2011, Maxfield, 1998, Mosley, 2001). Other more recent political economy scholarship has sought to counter the argument in which processes of financialization have led financial markets to capture states as the latter become servants to market forces (Dutta, 2018, Lagna, 2016). Instead, this literature has shown how such processes have provided opportunities for states, and in some instances even enhanced state power. For instance, Dutta's work (2018) argues that the Big Bang expanded the size and liquidity of the gilt market, which process allowed for a more effective monetary policy and government financing. Rather than a complete win for finance (Braun, 2018b), financialization was repurposed by states (and central banks by extension) for their own (joint) win.

I build on this literature by tracing the historical process through which the gilt market and the Bank of England supported and shaped each other, and became susceptible to each other. The Bank of England defended the interest of the gilt market, particularly through its tight relationship with Government Broker which played an intermediating role between gilt market participants and the Bank. It also backstopped and saved multiple times the gilt market, and made sure to nurture it so that as a result, the gilt market later became a core part of the Bank's governance. But the Bank also benefitted from this relationship. The processes of financialisation of the 'real economy' rendered financial markets a core engine of economic activity, and thus the Bank could capitalise on those very same markets which it had for decades cultivated. In doing so, it gained a stable architecture through which it could govern the economy.

My thesis presents these structural and infrastructural alignments between central banks and financial markets as the foundation on which they then developed *interactional* alignments. While chapter 5 focuses on the foundations by which these sociomaterial agencements flowed into each other, chapter 6 looked into the practices and arrangements developed on an interactional level. I show how the yield curve stood at the heart of this interaction as a coordinating device that allowed order to be established. But we only need to look at the financial crises of 2007/08 to realise the implicit consequences which the structural alignments between central banks and markets play. Just like 1950s and 1960s Britain, the post-2007/08 crisis environment required central banks to intervene in financial markets quickly and firmly (as they did in March 2020) in an attempt to restore stability in those markets (see Rostagno et al., 2021).

One might argue that this would be the result of capture by financial interests, but I claim that this is more accurately explained by the fact that the central bank itself now governs principally through financial markets and thus requires a stable channel to do so – a form of infrastructural power (Braun, 2018b). This is increasingly clear when central bankers talk about the transmission mechanism. Monetary policy is not only about the *stance* of policy, but also about the *transmission mechanism* which is entirely operative via financial markets. Hence, as I explained in Chapter 7, the introduction of QE is not only about providing accommodation to the economy, but also a way by which they can restore efficient markets through which they can govern more smoothly. Equally interesting is the fact that central banks embarked on QE as their main policy tool that works via secondary bond markets. Some of my interviewees, as well as parts of the public, have raised questions on why central banks needs to go through secondary financial markets in order to implement their policies. Yet, this is also an effect of the entanglements between financial markets and central banks which have led the latter to rely on a tool that is necessarily operative through that channel. I therefore have sought to contribute to this body of knowledge by combining a science and technology studies perspective (and SSF) with an institutional and political economy perspective, similar to Coombs and Thiemann (2021), which looks at broader structures and interests between states and markets.

8.3 Potential avenues for future research

This thesis necessarily involved some defined parameters of focus driven by practical needs. As a result, there exist some related areas of study that could prove fruitful as new frontiers of investigation. In what comes, I lay out a couple of potential avenues for future research.

Because I limited my work to the *secondary* bond market, I have excluded from my analysis the practices and arrangements within the primary bond market. During the data collection process I had the opportunity to interview a head of research at the UK's Debt Management Office. While the data I collected in this interview was rich and detailed, I opted to not include it in this research. But it pointed me very clearly towards some issues arising in the primary market and the way by which government raises finance. This is ground which has been worked by political economists and political scientists (Fastenrath et al., 2017, Hardie, 2012, 2011, Lagna, 2016, Preunkert, 2017, Rommerskirchen, 2020, Trampusch, 2015), but it requires more scrutiny of the daily practices and tools employed in the market and debt management offices. For instance, the UK's DMO uses yield curve models through which it 'feeds' the recipients of government bonds. It has developed tacit knowledge on the various habitats of different players in the market, such as institutional investors at the longer end of the curve, hedge funds in the short-to-middle part, and banks in the shorter end. As a result it makes sure to maintain the required issuance according to the demand of each player on the curve (see Rommerskirchen, 2020). And it has also developed a risk management culture in the management of sovereign debt (Davies, 2005). This is an area which would most definitely produce some interesting research and findings.

On a related note, another potential research piece could look into the interactions between central bank monetary policy and government financing, and the intermediary role played by the so-called GEMMs (gilt-edged market makers). Questions on monetary financing have been raised ever since the first tranche of government bond purchases were made, but it is increasingly a question that is on the radar of expert debates and to an extent even the public. Beyond this issue, the structural advantages enjoyed by GEMMs deserve further attention. GEMMs enjoy a privileged position allowing them to participate in gilt auctions and to make markets on the secondary market. It is possible that this grants them some invaluable information through which they are able to, in Bourdieu's (2005) terms, distort the field in which they partake at the expense of their challengers, competitors and the rest of participants in the chain of finance (Arjaliès et al., 2019). I was fascinated during an interview with an investment banker (Interview QI) who admitted to me how morally wrong this structural advantage can be, particularly in the context of QE:

> So [QE has] actually been very profitable. I don't honestly feel terribly comfortable about that. It feels a bit wrong. But it's not the banks that have abused the system. Since the nineteen eighties, there's been this kind of formal split between monetary policy and fiscal policy. This is where it all comes from… So there's this high volume of transactions going on which is all about quantitative easing, which is pretty, pretty easy for banks to make money on… And we have to charge the gap between buying and selling on trades. We're not a charity. We are taking risk in doing this. It's a business expense. I'd say that the thing that I find pretty unpleasant about this really is the system. I don't understand why it needs to be this way. We're breaking the form of separation between monetary and fiscal policy. For a good reason it was needed. I don't understand why we can't just put one side that model and let the banks print to the government. It's paid my bonus so I'm not too worried about that.

The structural advantage enjoyed by investment banks (and GEMMs in particular) therefore goes beyond information. Such a study would involve looking into the mundane political economy and to 'follow the money', as suggested by Arjaliès et al. (2019) (see also, MacKenzie, 2019, MacKenzie, 2018b).

Finally, my recent return to a central bank has brought me into direct touch (and first-hand experience) with economic analysis, this time in the context of the European Central Bank. Despite claims that central banks are increasingly scientised, which is sometimes interpreted as an attempt by central banks as technocratic entities to de-politicise their decisions as a legitimacy tactic for audiences, I have come to realise that science and knowledge itself involve significant *politics* even within organisations. Pieces of research may be mobilised as armament and weaponry to push through one's own interest in the crafting of policy, and economics may lend itself nicely as a legitimate weapon with which to fight battles in technocratic contexts. It may be an impossible task for the researcher to penetrate the secretive world of central banks, particularly to uncover the internal battles which may at times unfold, but it is most certainly worth the effort.

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