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The Risk-taking Channel of Monetary Policy

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1 Introduction

"Most economists would agree that, at least in the short run, monetary policy can significantly influence the course of the real economy. [...] There is far less agreement, however, about exactly how monetary policy exerts its influence [...]. To a great extent, empirical analysis of the effects of monetary policy has treated the monetary transmission mechanism itself as a black box." (B. S. Bernanke & Gertler, 1995, p. 28)

Economists have experienced hard times trying to establish a clear-cut relationship between central banks' actions and their effects. The complexity and the changing nature of our economy have made it impossible to thoroughly accomplish this task. Yet, by exploiting the advancements in economic theory and by studying the specific transformations of the financial system greater understanding can be achieved.

This is the rationale behind the risk-taking channel of monetary policy, which tries to complement the literature by focusing on the relationship between low interest rates and risk-taking. According to it, changes in the official interest rates can influence economic agents' risk perceptions. The idea that perceptions of risk play a crucial role in determining agents' behaviour is indeed quite old and obvious to anyone without a background in economics. In the world of finance, traders are perfectly conscious of the importance of changes in perceptions (market sentiment) and most of their abilities reside precisely into anticipating such movements. Nonetheless, risk perceptions and non-perfectly rational behaviours are hard to measure and have always been put aside.

Economists are now trying to fill this gap in consequence of the following facts. First, the vast literature in Behavioral Finance has shown the importance of understanding agents' behaviour and it has provided consistent findings that can be used to build new models (e.g. representative heuristic). Second, advancements in Dynamic Stochastic General Equilibrium models (DSGE) and research in complex economics are supplying the required tools to deal with these complexities. Third, the recent global financial crisis has highlighted the changing nature of our financial system and the dangers of ignoring this fact.

The purpose of this thesis is precisely to give the reader a glimpse into this fascinating world. The risk-taking channel is the perfect topic to do so. At the time of writing (2018)

official interest rates are still at an historical low (the ECB main refinancing rate is at 0%), the stock markets close to their all-time high and the VIX, the index of implied volatility which measures risk perceptions, has never been this low for such a prolonged period of time. All ingredients of the risk-taking channel.

The thesis is organized as follows. In Section 2 I provide the context behind the risk-taking channel. Starting with an analysis of the recent financial developments I then present the traditional channels of monetary policy and how they have evolved through time. Both the credit channels and models of the credit cycle will be discussed. The main thread is the increasing importance of financial intermediaries and of the monetary nature of our economic system.

In Section 3 I specifically discuss the theoretical literature of the risk-taking channel. I first discuss a more radical approach following the paper of Borio and Zhu (2008) who are the two economists who have coined the name of the risk-taking channel. I then present a more rigorous approach by Adrian and Shin (2010) who try to model these mechanisms. Finally, I discuss the impact of regulations on the risk-taking channel and the financial system in general.

In the last Section (4) I review the literature that has empirically tested the risk-taking channel. Most of the work has concentrated on the behaviour of commercial banks, mainly because the huge amount of data these institutions provide in contrast to other kind of financial intermediaries. The empirical literature confirms the existence of the risk-taking channel, yet the magnitude of the effects is smaller than one would expect.

2 The Financial System and the Monetary Policy Transmission Channels

2.1 Financial Development

In the year 2005 the economist Raghuram Rajan wrote: *"In the last thirty years, financial systems around the world have undergone revolutionary change. People can borrow greater amounts at cheaper rates than ever before, invest in a multitude of instruments catering to every possible profile of risk and return, and share risks with strangers from across the globe"* (2005, p. 1). More than ten years later this quote still perfectly depicts the current transformations of our financial system. If there exist one difference, it is that these structural changes have become even more pronounced.

According to Rajan (2005), three are the main forces that have contributed to the development of the financial system, namely technical change, deregulation and institutional change. Technological developments have lowered transaction costs and exponentially increased the amount of information available to the public. The result has been more arm's length finance and an overall broader access to credit. At the same time, during the last quarter of the twentieth century most of advanced industrial economies saw a shift in politics that brought deregulation in their financial systems[1]. Together with technological development, these two forces have spurred competition among both domestic and foreign financial intermediaries. The result has been institutional changes. Because excess returns in more traditional investments have been competed away, in order to remain on the edge, financial intermediaries have reached out to non-traditional customers, or to traditional customers with innovative financial instruments.

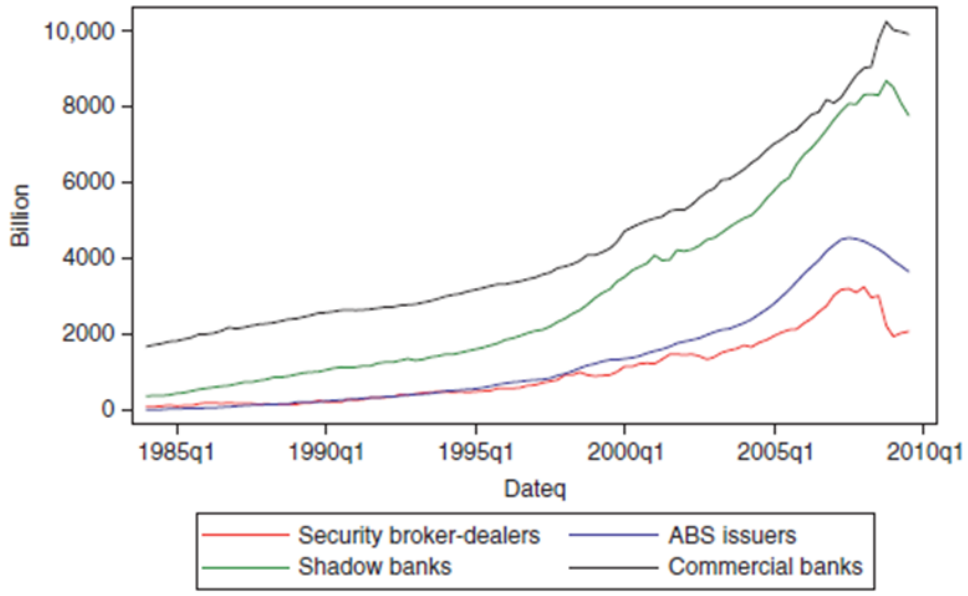
Specifically, the standardization of contractual terms has enabled financial intermediaries to package loans into bundles and then trench them into distinct securities that are

[1]Deregulation, which is the repeal of government regulations on the economy, became common as a result of new trends in economic thinking about the inefficiencies of government regulation. Rajan (2005) argues that technology is one of the causes of deregulation. It enabled financial intermediaries to extend their markets outside their state or country, thus forcing foreign politicians to deregulate in order to keep their domestic financial sector competitive.

then sold to different clients[2]. Such process, called securitization, allows banks and other financial institutions to specialize in particular products and at the same time to off-load much of the risk from their balance sheets. The most patent example of these products are the mortgage-backed securities, which played a central role in the U.S. housing bubble that burst in 2007, leading to a collapse of the global financial system. Moreover, financial liberalization and innovation have increased the possibility and the incentive to obtain external finance, making the financial system more efficient but also more connected.

At the same time, the increasing complexity and velocity of these innovative financial instruments has increased intermediation, as it reduces the costs of investing for clients. As a result, traditional banks evolved in more complex institutions, focused on financial innovation and risk-management and new financial institutions, specialized in searching returns in more exotic areas, have thrived (see Figure 1).

Figure 1: Total assets of commercial banks, shadow banks, and broker-dealers



Source: Adrian and Shin (2010)

On top, and also thanks to all these transformations, the nature of financial markets gradually shifted toward one based on capital markets, rather than one based on the traditional role of banks. Indeed, while in the 1980s traditional banks were the dominant

[2]The U.S. financial system was the main actor involved in this process.

financial intermediaries, making profits by receiving deposits and granting loans, during the subsequent years they have increasingly shared their position with marked-based financial institutions.

2.2 Monetary Policy Transmission Channels

Before delving into the specific mechanisms at work behind the risk-taking channel, we must first analyse its collocation among the other transmission channels of monetary policy. In doing so, we should first consider a development in the economic literature that is of critical importance in explaining how this concept emerged.

Spurred by the revolutionary transformations of the financial system over the last decades, research in economics has increasingly recognised the influence of financial intermediaries and more in general financial markets on the workings of the real economy. It is important to stress that this realization, clearly facilitated by the transformations cited above, goes beyond them and reflects our increasing awareness of the monetary nature of our economic system. In an ideal world where it is possible to imagine all future outcomes and assign a precise probability to their occurrence, money would just be a means to transfer resources without in any way interfere with such transfers. This is the scenario of the general equilibrium theory pioneered by Leon Walras. To the contrary, the future is simply unknowable[3]. In our world, money, banking and financial markets evolved to provide a way of coping with radical uncertainty. *"A capitalist economy is inherently a monetary economy. [...] Provided that there is sufficient trust that [money's] value will be maintained from one period to the next, it offers a means by which one can park generalised purchasing power to be used in the future when unimaginable events occur"* (King, 2016, p. 155). As Borio (2012) argues, financial contracts are set in nominal, not real, terms and the banking system, rather than just smoothly transferring resources among sectors, de facto generates purchasing power. The monetary nature of our system implies

[3]See Keynes (1937). *"By uncertain knowledge I do not mean merely to distinguish what is known for certain from what is only probable. [...] The sense in which I am using the term is that in which the prospect of a European war is uncertain, or the price of copper and the rate of interest twenty years hence, [...]. About these matters there is no scientific basis on which to form any calculable probability whatever. We simply do not know."* (Keynes, 1937, p. 213-14).

that the holders of our purchasing power (financial institutions) can have a profound distortionary impact on the real economy. The 2008 crisis is the most patent example of these facts.

Specifically for what concerns the transmission mechanisms of monetary policy, both theoretical and empirical works have concentrated on the role specifically played by financial markets and intermediaries, yielding interesting results. For instance, Adrian and Shin (2010) consider the effect that balance sheet aggregates of financial intermediaries have on the real economy and highlight the importance of tracking the institutional underpinnings of the financial system itself.

Before these developments, monetary policy was believed to impact the real economy through the traditional monetary transmission channels. This view, also labelled as the conventional view or money view, is built on the idea that policymakers use short-term interest rates to influence the cost of capital, which in turn determines the level of investment and consumption in the economy and thus of real output. The mechanism rests on two key assumptions. The first assumption is that policymakers use their leverage over short term interest rates (via open market operations) to affect real short-term and, less markedly, also real long-term interest rates. This is possible because of price stickiness and expectations theory [4]. Secondly, the cost of capital must closely follow the movements in real interest rates. If these two assumptions hold, financial markets smoothly transfer changes in the policy rate to changes in the cost of capital. In turn, through consumption and investment, the cost of capital impacts both aggregate demand and the level of production. Specifically, spending on durable goods, such as fixed investment, housing, inventories and consumer durable is believed to be quite interest-rate elastic.

Important for my analysis are also two other transmission channels that evolved under the traditional view, namely the Tobin's q channel and the wealth mechanism. Starting from the assumption that monetary policy affects stock prices, they analyse how companies (Tobin's q) and households (wealth mechanism) react to such changes. For what concerns companies, the necessary concept is Tobin's q ratio, which is defined as the mar-

[4]See APPENDIX for theoretical explanation.

ket value of an enterprise divided by the replacement value of the enterprise's capital[5]. If $q > 1$ then it is convenient for a company to issue new equity to finance investment, and as q rises it becomes even more convenient. An expansionary monetary policy that leads to higher stock prices will raise the Tobin's q of companies and increase investment (see Tobin (1969)). For what concerns households, the necessary concept is that private individuals desire to smooth their periodic consumption over time depending on their lifecycle resources. Then, because stocks represent a significant portion of private wealth, changes in stock market prices will be reflected in the consumption paths of private individuals (see Modigliani (1971)).

Although the traditional channels apparently explain how central banks' policies are transmitted to the real economy, empirical studies during the 80s and 90s found several anomalies these mechanisms could not account for[6]. As Bernanke and Gentler put it, *"the textbook story is incomplete in several important ways"* (1995, p. 27).

The crucial issues are the magnitude, the timing and the composition of the effects of changes in the policy rate. Some of these puzzles are observable in Figure 2, which shows the dynamic responses of important economic variables to an unanticipated tightening in monetary policy, calculated with the method of vector autoregression (VAR)[7]. For those who are unfamiliar with such models, a vector autoregression is a stochastic process model used to capture the linear interdependencies among multiple time series. Each variable of interest has its own equation, which comprises lagged values of the variable itself, the lagged value of the other model variables and an error term.

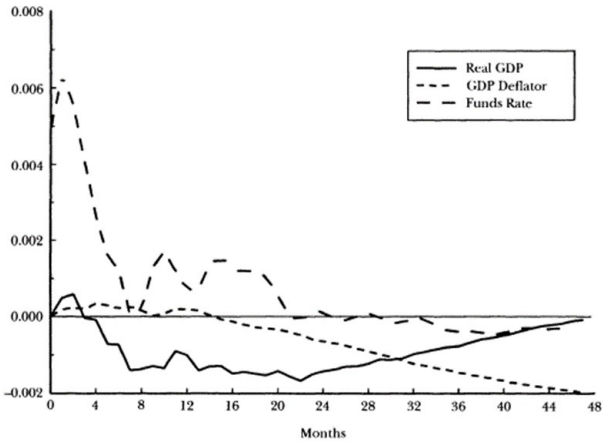
As shown by Panel a of Figure 2, following a monetary contraction the federal funds rate is back to trend 8 to 9 months after the shock. Yet, some important components of spending tend to react much later in time. For instance, as shown in Panel b, business fixed investment starts decreasing only after 6 months have passed from the shock. Similarly

[5] $q = \frac{\text{Market value of installed capital}}{\text{Replacement cost of capital}}$

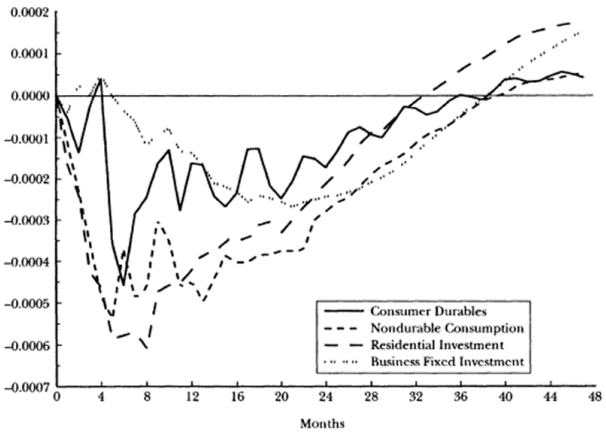
[6] See B. S. Bernanke and Gertler (1995, p. 28) for an exhaustive list of the literature of interest. In order not to further complicate the analysis, I will just refer to the empirical results of this literature.

[7] The sample period on which Figure 2 is based is January 1965 through December 1993. Monthly data is employed.

Figure 2: Responses to a Monetary Policy Shock



(a) Responses of Output, Prices and the Federal Funds Rate



(b) Responses of Spending Components

Source: B. S. Bernanke and Gertler (1995)

interesting is the composition of the spending effects. Panel b shows the dynamics of residential investment, which among the variables is the one which has the quickest and strongest reaction to the monetary policy shock. Yet, the change in the federal funds rate is expected to have a bigger impact on components of spending that depend on short-term interest rates rather than long-term. Clearly this is not the case, as residential investment is typically very long-lived and should be most sensitive to long-term real interest rates.

These gaps in the traditional view suggest there is something missing to the picture, namely financial markets. Indeed, under the neoclassical approach financial markets were assumed to function perfectly, without creating distortions, and therefore there was no need to include them. By contrast, a number of economists started exploring whether imperfect information and other "frictions" in these markets could enhance our understanding of the transmission of monetary policy. The result was the theorization of different mechanisms that in the economic literature are known loosely as the credit channel. Rather than being an alternative, the credit channel should be interpreted as a *"set of factors that amplify and propagate conventional interest rate effects"* (B. S. Bernanke & Gertler, 1995, p. 28).

The credit channel rests on the conception that frictions in financial markets (such as imperfect information) hinder the smooth functioning of these markets, increasing the deadweight costs attached to the traditional agency problem between a lender and a borrower. The result is a wedge, termed the external finance premium, between the cost of funds raised externally (for instance, through the issuance of new debt) and the opportunity cost of internal funds (such as retained earnings). According to B. S. Bernanke and Gertler (1995) the external finance premium reflects three main types of costs. First, the lender's expected costs of evaluation, monitoring and collection. Second, the costs of the typical "lemon's premium" arising from the fact that borrowers inevitably possess better information than the lender. Third, the costs of distortions in the borrower's behaviour that stem from moral hazard. In order to include these observations in the transmission channels, economists have identified two mechanisms that seem to explain the link between monetary policy and the external finance premium, namely the balance sheet channel and the bank lending channel. As we will soon see, the risk-taking channel is built upon these two mechanisms, as it borrows more than one feature from them.

The balance sheet channel hinges on the presumption that the external finance premium is dependent on the borrower's financial position. Specifically, there is a negative relationship between the external finance premium and the borrower's net worth, measured as the sum of her liquid assets and marketable collateral. Clearly, a greater net worth of the borrower reduces her conflicts with the lender, by providing her with more collateral and additional resilience to possible losses. The balance sheet channel of monetary policy arises because the central bank is able to influence the financial position of borrowers. Indeed, changes in interest rates directly impact interest rate expenses and asset prices, thus expanding or contracting borrowers' balance sheets. In addition, monetary policy affects the net cash flows and the value of collateral indirectly. For instance, higher interest rates tighten spending by customers that in turn diminishes firms' revenues and profits (as fixed costs will not adjust in the short run).

In contrast to the balance sheet channel, which focuses on the borrower's side, the bank lending channel analyses the effects of monetary policy on the external finance premium on the lender's side. Banks are a vital component in the supply of credit in most countries and are specialized in overcoming informational asymmetries in credit markets. The bank lending channel was initially built on the key assumption that bank reserves strictly constrain the supply of credit by banks. Yet, it may still be valid today, even if over the recent decades banks have been able to raise funds on the margin more freely. In fact, if banks do not face a perfectly elastic demand for their liabilities, open market operations pursued by the central bank will directly impact banks' costs of funding (managed liabilities are more expensive than core deposits) that in turn will influence the supply of loans. As a result, a hypothetical disruption in the supply of bank loans will cause borrowers to incur extra costs when raising funds externally, therefore increasing the external finance premium.

2.3 The Credit Cycle and the Financial Accelerator

Important for my analysis of the risk-taking channel is the concept of credit cycle and its relationship with the transmission channels of monetary policy. The credit cycle can be broadly interpreted as fluctuations in the leverage of the different agents that make up the economic system. The concept is often associated with credit booms and busts, and

it has been widely researched in economics.

The focus on of financial intermediaries in the literature of the transmission channels of monetary policy has gradually blurred the distinction between the modelling of these channels and of the credit cycle itself. In fact, models of the latter have been built using the mechanisms behind the external finance premium, becoming known as the financial accelerator. Defined by Borio and Zhu (2008, p. 38) as the "most widely used rationalization of the credit channel in the literature", the financial accelerator is also, according to the same authors, the set of mechanisms more similar to the risk-taking channel (as they first conceived it). The basic idea behind it is that endogenous procyclical changes in market conditions (such as movements in borrower balance sheets) can amplify and propagate initial real or monetary shocks. In accordance with the credit channel, a hypothetical decrease in interest rates by the central bank increases borrowers' net worth and reduces their expected default probability, thus stimulating investment. In turn, the increase in investment further pushes up asset prices, creating a feedback process with a multiplier effect. This set of mechanisms, which is usually developed using the principal-agent framework, can be considered as a possible solution to the puzzle of "small shocks, large cycles" that could not be explained by the traditional view of monetary policy (B. Bernanke, Gertler, & Gilchrist, 1996), (B. S. Bernanke, Gertler, & Gilchrist, 1999), (Borio & Zhu, 2008).

Yet, financial accelerator models fall short of explaining what triggers the fluctuations in the credit cycle. Interestingly, there is another strand of literature on credit cycles which I believe possesses some similarities with the risk-taking channel of monetary policy. Broadly known as behavioural theories, they try to explain these oscillations in leverage without recurring to external shocks. They have become popular in the aftermath of the 2008 financial crisis. As their name heralds, these behavioural theories of the credit cycle are built on the large literature of behavioural finance[8]. Still, the first pioneer of these theories was Hyman P. Minsky with *The Financial Instability Hypothesis* which argued that *"over periods of prolonged prosperity, the economy transits from financial relations that make for a stable system to financial relations that make for an unstable system"*

[8]See for instance Bordalo, Gennaioli, and Shleifer (2018), which will be discussed below.

(Minsky, 1992, p. 8). The basic concept is that periods of financial stability alter agents' perceptions and lure them in taking on excessive leverage, thus planting the seeds for a period of instability. This idea of altered perceptions is very similar to the first set of effects of the risk-taking channel[9].

[9]The reason the risk-taking channel has been compared to the financial accelerator and not to the behavioural theories of the credit cycle is that the former possesses a more rigorous and coherent framework, thus making it easier to use for the construction of new economic models.

3 The Risk-taking Channel in the Literature

3.1 An Overview

The idea of a risk-taking channel of monetary policy was first introduced by Borio and Zhu with the paper "Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism?" published in 2008. Taking into considerations the changing characteristics of the financial system and the literature on the transmission mechanism of monetary policy, the authors argue that insufficient attention appears to have been paid to the link between monetary policy and the perception and pricing of risk by economic agents. Both directly and indirectly, changes in the official interest rates and the characteristics of the central bank reaction function can have an impact on risk-taking, by impinging on the perceptions of risk and risk tolerance. Indeed, the definition is intentionally broad, as it encompasses all the different kinds of agents operating in financial markets and speculates on issues of economic modelling that go well beyond the transmission channels of monetary policy. Not surprisingly, subsequent papers on the topic have interpreted the relationship between monetary policy and risk-taking in diverse ways, exploring more in depth distinct aspects of it.

Nevertheless, there are two common factors shared by the literature on the risk-taking channel. The first one is the focus on investors and financial intermediaries. In line with the credit channel, the risk-taking channel focuses specifically on the behaviour of agents who operate in financial markets. Yet, contrarily to the credit channel it does not focus on problems of asymmetric information, but it rather analyses how agents perceive and price risk. Moreover, it focuses more broadly on financial markets rather than specifically analysing banks[10]. In this respect, it could be argued that it presents some similarities with the traditional transmission channels of monetary policy. Clealry, it is not argued that this channel is the most important one. Rather, it is maintained that it exists a set of mechanisms whose exploration would provide a fuller understanding of how monetary policy is transmitted to the real economy.

[10]The empirical analysis focuses specifically on banks behaviour, as it is much simpler to test. (See Section 3)

The second factor is the central role played by short-term interest rates on the behaviour of these agents and the subsequent impact on the real economy. Following the global financial crisis, many argued that the low interest rate environment antecedent to the crisis helped fuelling the asset prices boom, spurring financial intermediaries to increase leverage and take on excessive risks (Taylor, 2009). This focus on short-term interest rates, which are believed to be important in their own right, is in contrast with the current models in economics that emphasize the importance of managing market expectations. According to such models, commonly used for policy purposes, short-term interest rates have an impact on the real economy only by influencing long-term rates (Adrian & Shin, 2010).

Specifically, the risk-taking channel operates mainly during periods characterized by low short-term interest rates [11]. Still, its effects could be apparently hidden for a long time and manifest themselves only in response to a monetary or economic shock. This idea, called the Paradox of Credibility, states that under the regime of a credible central bank, which has kept inflation low and stable for a prolonged period of time, it is likely that the effects of monetary policy expansions will be reflected earlier in changes in financial markets variables (e.g. leverage or credit spreads) than in inflation. The effect should be even stronger for the risk-taking channel, which directly influences the behaviour of financial intermediaries and traders. Thus, the paradox entails the risk that policymakers, when analysing the effects of monetary policy, could be looking at the wrong signals (Borio & Lowe, 2002).

3.2 A First Approach

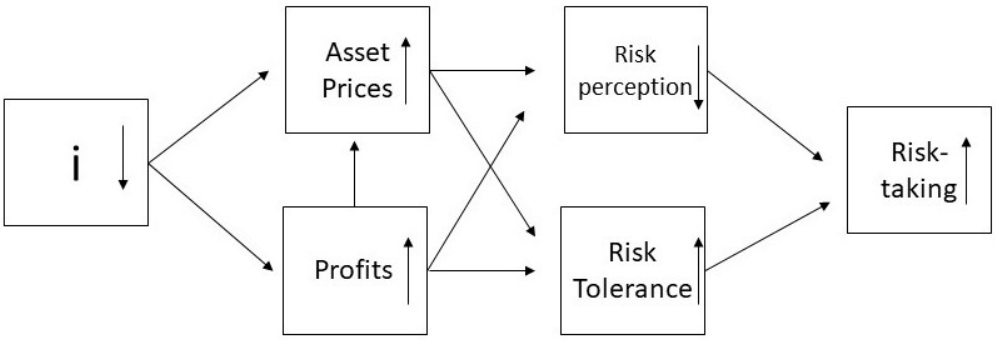
According to the framework proposed by Borio and Zhu (2008), there are at least three ways in which changes in policy rates may influence risk perceptions and risk tolerance of economic agents.

One set of effects operates through the impact of interest rates on valuations, incomes and cash flows. A decrease in interest rates boosts asset prices and collateral values as well as income and profits, which further push up asset valuations. In turn, these positive

[11] I do not quantitatively define low, it is more a relative than an absolute value.

changes directly decrease risk perceptions and increase risk tolerance of economic agents (see Figure 3). A concrete manifestation of this effect is the procyclical behaviour of estimates of probabilities of default, volatilities and correlations. All this can encourage risk-taking. For instance, low interest rates and high stock prices can reduce risk perception by diminishing asset price volatility. This because higher stock prices increase the value of equity relative to corporate debt, thus decreasing corporate leverage and possibly the risk of holding stocks (leverage effect) (Gambacorta, 2009).

Figure 3: A simple illustration of the first set of effects of the risk-taking channel



The widespread use of Value-at-Risk methodologies for economic and regulatory capital purposes is a good, yet mechanical example of these mechanisms. This kind of risk management techniques is used to estimate how much a portfolio could lose in any specific day. If such amount rises above a certain threshold, the VaR signals the traders they should sell. The main limit to Value-at-Risk methodologies is that they rely on backward looking measures of risk (calculated using actual historical data), which by construction treat risk as exogenous. In this way, VaR techniques rule out the possibility of feedback loops, thus underestimating system wide risks [12]. Danielsson, Shin, and Zigrand (2004) show that, even assuming constant preferences, the VaR method constraints traders' behaviour as if their degree of risk aversion is fluctuating with the market outcome. Thus,

[12] A feedback loop is a specific structure of the system that causes output from one node to eventually influence input in the same node. In the above case, a possible feedback loop could be the following: a price decrease in one security influences traders' sentiment in the market that eventually causes the price of the security to decrease further.

when volatility tends to decline in rising markets, it releases risk-budgets of financial firms and encourages position taking, as if the risk perceptions of traders were diminishing and risk tolerance increasing.

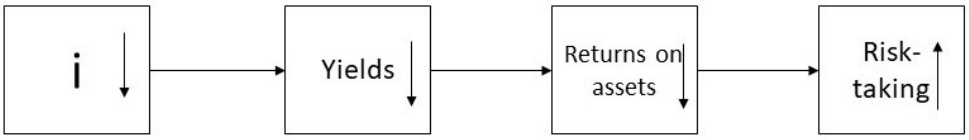
By contrast, a more behavioural approach to modelling shifts in risk perception is the inclusion of biases in how agents form their expectations. A noticeable example is the work of Bordalo et al. (2018). They develop a model of credit cycles in which agents possess a belief formation mechanism called diagnostic expectations. Even if their approach does not concern monetary policy transmission channels, I believe the model could be easily adapted to analyse such framework. In particular, diagnostic expectations are based on Kahneman and Tversky (1972)'s representativeness heuristic, which says that a certain attribute is judged to be excessively common in a population when such attribute occurs more frequently in the given population than in a relevant reference population. A clear example is provided by the situation in which one individual must assess the distribution of hair colour among Irish people. Because it is more common for an Irish to be red headed than for a member of another reference population, the individual will tend to overestimate the probability that an Irish is read headed. This happens because of the limited working memory of the individual. While red headed Irish are only 10 per cent of the population, the individual will easily guess a much higher number.

Thus, agents overreact to paths of improving good news by focusing on good future outcomes and overestimating the probability of such outcomes. As a result, they become excessively optimist and are prone to neglect bad news and tail risks. In the framework of the risk-taking channel of monetary policy, expansionary monetary policies (especially if unexpected) that improve both the current and the future states of the economy would easily lead to an overreaction of financial markets. The more such policies improve the economic outlook the more risk perceptions will shift, causing agents to become overly optimist and to take on additional risk.

A second, but equally relevant, set of effects operates through the relationship between market rates and target rates of return (see Figure 4). These mechanisms are narrowly defined the "search for yield" (Rajan, 2005). Because targets rate of return may be sticky for contractual, behavioural or institutional reason, their interaction with low interest rates increases risk tolerance and pressures asset managers to take on more risk. For

what concerns contractual or institutional constraints, a good example is an insurance company or a pension fund that has entered into fixed rate commitments. Indeed, this kind of institutional investors has typically nominal liabilities at predefined long-term fixed rates. When interest rates fall, riskier but higher return investment may be the only strategy to have some chance of survival. This phenomenon, known as risk shifting, tends to induce participants to ignore collective downside risks, since their attention is focused on the upside. In a similar way, hedge fund managers may have incentive to take on risk when the risk-free rate is low. This happens for two reasons. First, their compensation is strictly tied to performance relative to a fixed nominal return. Second, private investors are likely to use short-term returns to judge managers competence and withdraw funds after poor performance. As a result, taking higher risks is the only way to exceed the target, make profits and remain competitive.

Figure 4: A simple illustration of the second set of effects of the risk-taking channel



Hanson and Stein (2015) provide a simple model that features yield-oriented investors (for institutional reasons) and use it to explain the effects of monetary policy changes on long-term real interest rates. They divide investors in expected return-oriented and yield-oriented. They then show that, because the latter kind of investors is mainly interested in current returns, a decrease in the official interest rate is associated with an increase in price, and a decline in the term premium, of long-term bonds. A fall in sort-term interest rates forces yield-oriented investors to increase their risk-tolerance, pushing them to demand more of long term assets in order to keep the same level of income. By expanding the proportion of long-term assets, investors increase the duration risk of their portfolios. At the same time, the higher demand bids up bond prices and down the

term premium. Indeed, yield-oriented investors may also increase their current returns by taking on more credit risk (or any other kind of risk). Still, even if very simple, the model of Stein (2014) is important to show the broad implications of the risk-taking channel on the real economy. As the authors comment, through the risk-taking channel conventional monetary policy has the same effects on long-term rates as unconventional ones (such as QE).

Otherwise, sticky rate of return targets may reflect deeper behavioural features. Particularly powerful is the money illusion, which causes investors to confound nominal with real interest rates (Shafir, Diamond, & Tversky, 1997). Suppose today future inflation expectations are revised downward and therefore the central bank decides to lower the official interest rate. The reaction of perfectly rational investors, who only care about real rates of return, would be to accept lower nominal return on their assets [13]. By contrast, investors affected by the money illusion, who care only about nominal returns, are likely to reallocate their portfolio on more risky assets in order to maintain the same nominal rate of return on their assets as before the action of the central bank. The latter kind of investors are indeed contributing to the search for yield because they do not grasp the real value of their returns. In addition, economic agents may have difficulties in adjusting expectations following periods of exuberance in markets. In conclusion, these second set of effects suggests that the impact of the risk-taking channel may be more pronounced when the gap between market and target rates is wider.

A third set of effects operates through aspects and characteristics of the communication policies and the reaction function of the central bank. Specifically, there are two kind of mechanisms that are relevant in this context. The first one is the transparency effect: by increasing the degree of transparency or commitment accompanying specific moves, and hence removing uncertainty about the future, the central banks compresses risk premia. Clearly, lower risk premia mean investors will take more risks. The second mechanism is the insurance effect: by influencing market perception about its ability in cutting off large downside risks and by showing its commitment to avert such risks by pumping in

[13]For low levels of the variables the following equality is a good approximation of the relationship between real and nominal rates $r = i - \pi^e$. Where r is the real interest rate, i the nominal and π^e are inflation expectations. Thus if π^e decrease, i must also decrease to keep constant r.

liquidity, the central bank distorts investors behaviours by inducing moral hazard. As a result, changes in rates have an asymmetric impact, with reductions encouraging risk-taking by more than equivalent increases would curtail it.

This last set of effects is much more complex and harder to identify than the previous ones. It is in fact difficult to establish a clear relationship between investors' perception of the central bank behaviour and its actual behaviour (degree of transparency, commitment to specific policies). Especially because these kinds of behaviour are harder to quantify than simpler changes in official interest rates. Unsurprisingly, the transparency and the insurance effect have received much less attention by the literature on the risk-taking channel and will play a secondary role as well in the following parts of this paper.

As already mentioned, the most noticeable feature of the risk-taking channel proposed by Borio and Zhu (2008) is the stark similarity of the first set of effects with the financial accelerator of B. Bernanke et al. (1996). Both mechanisms operate through the indirect impact that changes in interest rates have on the pricing of risk by affecting asset values, cash flows and profits, and hence also financing constraints. The first set of effects of the risk-taking channel builds upon the idea of a financial accelerator and in some sense enhances its complexity and strengthens its impact. A fundamental merit of the financial accelerator is that the pricing of risks is endogenously determined, as the external finance premium just depends on the borrower's financial structure and the default probability, which are two variables endogenous to the model. Such feature is the starting point of the risk-taking channel, which tries to capture how interest rates influence the pricing of risk by limiting as much as possible exogenous or artificial constraints to this mechanism.

Although B. S. Bernanke et al. (1999) certainly made huge progresses by introducing the credit channel into a general equilibrium framework (which means that most of the variables are endogenously determined), their approach presents some relevant differences with the risk-taking channel. First, according to Dell'Ariccia, Laeven, and Suarez (2017, p. 614) financial accelerator models are concerned only with the quantity and not the quality of bank credit, and thus "have little to say about the overall credit risk in the system". On the contrary, the risk-taking channel focuses precisely on the quality of such credit.

Second, according to Borio and Zhu (2008), B. S. Bernanke et al. (1999) had to

make two strong assumptions that differentiate financial accelerator models from the risk-taking channel. First, B. S. Bernanke et al. (1999) assume risk-neutrality and thus rule out the possibility that the risk tolerance of the agents changes over time. Second, they enforce rational expectations, which prevent the possibility of systematic errors or biases. By contrast, time varying pricing of risk and possible behavioural biases are two core elements of the risk-taking channel. For what concerns the second assumption, the diagnostic expectations of Bordalo et al. (2018) are certainly a useful tool to relax rational expectations without losing too much in rigour [14]. Indeed, they would enable economists to include behavioural biases in the modelling of the risk-taking channel, a feat that has been hard to accomplish.

In conclusion, the risk-taking channel seems to go one step further than the financial accelerator, relaxing more assumptions and trying to better capture the irrationalities of our financial system. Yet, the framework proposed by Borio and Zhu (2008) is a speculative and explorative one. As such, it lacks a rigorous model that would allow to really capture the complexities and the potentialities of the risk-taking mechanisms.

3.3 A More Rigorous Approach

Adrian and Shin (2010) develop a simple model of a narrower definition of the risk-taking channel of monetary policy. Specifically focusing on the behaviour of financial intermediaries (shadow banks, broker dealers and commercial banks), the authors highlight the importance of short term interest rates in affecting real activity. By changing the risk-bearing capacity of financial intermediaries, interest rate shift market risk premiums and the supply of credit, which in turn affects the real economy. In such framework, financial intermediaries drive the financial cycle through their influence on the determination of the price of risk. We now analyse this model in more detail[15].

Broker dealers, shadow banks, and commercial banks fund themselves with short-term debt and invest the proceeds in longer-term, less liquid securities, a practice called maturity transformation. The interest income earned on long term assets is higher than

[14] See APPENDIX for a theoretical comparison of rational and diagnostic expectations.

[15] The empirical analysis of the model is included in section 4.

the interest expenses of short-term liabilities. The average difference between these two values is called the net interest margin (NIM) and reflects all the risks associated with such practice. For instance, it reflects the liquidity premium of long-term assets, which are usually harder to sell in a short time at a fair value. This is especially true in those situations in which liquidity dries up, forcing financial intermediaries to sell assets at a discount in order to repay their debt (fire sales [16]). The NIM also reflects the interest rate premium, compensation for the sensitivity of the return of long-term assets to changes in interest rates.

Financial intermediaries profit by bearing such risks in their balance sheets. Indeed, higher leverage (more liabilities with respect to equity) means higher returns, thus to maximise profits financial intermediaries should increase the amount of liabilities as much as possible. Yet, risk and regulations constraint the amount of leverage. Similarly to Danielsson et al. (2004), Adrian and Shin (2010) use Value-at-Risk methodologies to determine the balance sheet size, risk premia and credit supply of financial intermediaries. In their model active investors [17] can take up debt, which maximises their return, subject to the condition that equity is large enough to cover the Value-at-Risk. It follows that an improvement in the fundamentals of the risky securities, which can be interpreted as an increase in the value of bank assets, produces an amplified response from the active investors. The increase in equity relaxes the VaR constraint and the leveraged sector can increase its holding of risky securities by taking on additional debt (See Fig. 5).

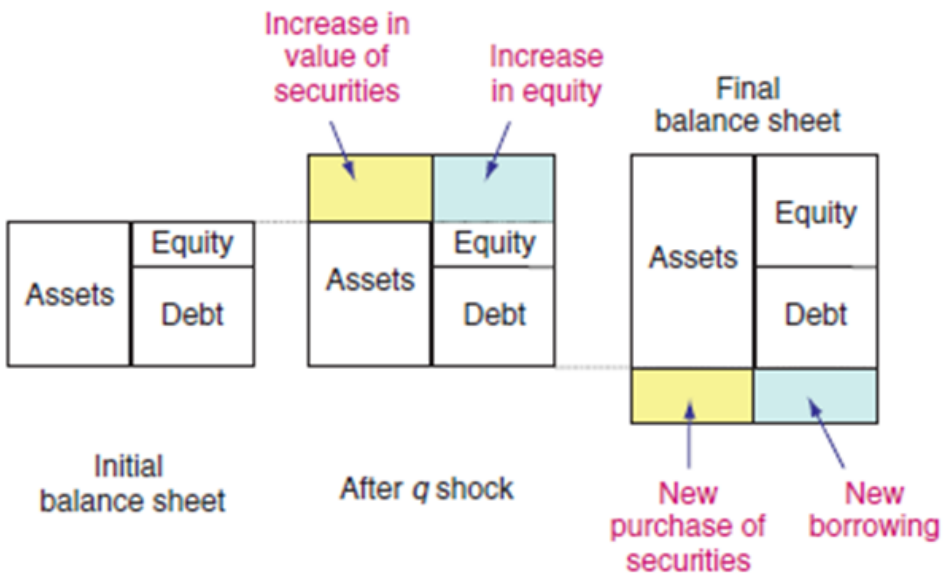
The result of the expansion of the balance sheets of the active investors is an increase in the risk-taking capacity of the banking system that has two main consequences. First, it leads to a fall in the risk premiums. Second, it increases the supply of credit by decreasing the required interest rate for financing projects. The capacity of the banks to lend increases because the marginal loan that was not made before the boost in capital now becomes feasible, under the greater risk-bearing capacity of the bank.

Thanks to its leverage on short-term interest rates, the central bank influences the

[16] See the APPENDIX for a theoretical definition.

[17] They differentiate between active investors, which are proxies for banks or broker dealers that have received the funds from households, and passive investors, households investing directly into securities.

Figure 5: Balance sheet expansion after an improvement in fundamentals



Source: Adrian and Shin (2010)

risk-bearing capacity of financial intermediaries in two ways. First, lower short-term interest rates directly impact asset valuations, by improving the fundamentals, and as such boost their net worth. Depending on the accounting conventions used by the specific institution, the gains will be reflected either into the income statement (if securities are marked to market) or will bypass it entirely and go straight into equity (if they are treated as available for sale). Second, because the majority of the liability side of financial intermediaries comes from short term borrowing arrangements (repos agreement for broker dealers, commercial paper for shadow banks and deposits for commercial banks), their cost of borrowing is tightly linked to short-term interest rates. If a decrease in the official rate is translated into an increase in the slope of the yield curve, financial intermediaries will benefit from a higher net interest margin, which will boost the present value of their income and thus of equity. In conclusion, with its leverage on short-term interest rates the central bank is able to influence the equity of financial intermediaries and thus the supply of credit. Such mechanism is the risk-taking channel of monetary policy.

However, for what concerns the interest income of commercial banks, the mechanisms

at work are more complex. Traditionally banks' profitability has been regarded as positively related with not only the slope of the yield curve but also with the level of interest rates. In fact, while the interest charged on loans is quite sensitive to changes in official rates, the contrary is true for deposit rates, which are less sensitive and cannot fall significantly below zero. As a result, when interest rates are particularly low the margin is more compressed and banks profitability is eroded. The overall effect of interest rates on banks profitability thus depends on which of the two effects prevails (slope of the yield curve or level of interest rates). It is plausible to assume that following an expansionary monetary policy banks' profitability will first increase benefitting from an immediate steeper yield curve. Yet, as the curve flattens the second effect will prevail and banks will be hurt. This is precisely what happened after the recent financial crisis according to Borio, Gambacorta, and Hofmann (2015). Using data from G10 countries, the authors show that during the first two years post-crisis (2009 - 10) the Return on Asset (ROA) of commercial banks was boosted by the actions of the central banks, while it was hampered in the subsequent four years (2011 – 14).

The approach of Adrian and Shin (2010) presents more than one similarity with the previous literature on monetary policy transmission channels as well as some important differences. In contrast to the balance sheet channel, which emphasizes the demand for credit, the risk-taking channel emphasizes the supply of credit, being in this respect much more similar to the bank lending channel. Indeed, in both channels the actions of the central bank are transmitted to the real economy by relaxing or constraining lenders' supply of credit (reserve requirements for the bank lending, VaR for the risk-taking). On the other hand, similarly to Borio and Zhu (2008), the risk-taking channel gives a prominent role to the price of risk and the market-determined risk premium, features that are absent in the other monetary policy transmission channels. I believe Adrian and Shin (2010) approach can be seen as a bridge between Borio and Zhu (2008) and the previous literature on monetary transmission channels.

3.4 Capital Regulation, Bank Capital and the Risk-taking Channel

One crucial factor is still missing from our discussion of the risk-taking channel, namely the effects that capital regulations have on bank behaviour. Clearly, when talking about risk-taking we cannot ignore the efforts made by the global authorities in promoting world-wide financial stability. Already in 1988, the Basel Committee on Bank Supervision had issued its first set of international banking regulations, named Basel I. Although Basel I and the subsequent regulations, Basel II, [18] were not successful in ensuring global financial stability (they did not prevent the global financial crisis), they certainly have an effect on the behaviour of financial intermediaries. As a result, in the late 1990s and the early 2000s an increasing number of papers started exploring the effects that such regulations had on the transmission of monetary policy. Such strand of literature has become known as the bank capital channel (For an in-depth analysis see den Heuvel, 2006).

At a first glance, the bank capital channel may appear similar to the bank lending channel. The main difference is that the bank capital channel does not consider the role that reserves play in the supply of credit by banks, but on the contrary it focuses on the implications of different costs of equity funding. Yet, the two channels overlap in many aspects and possess also more than one similarity with the risk-taking channel. Nevertheless, the bank capital channel explores two effects that is worth considering.

The first one is associated with the presence of a minimum threshold, whose breach can be extremely costly for a bank. When capital decreases below such threshold, banks need to raise external funding or alternatively liquidate some of their assets. Both actions imply additional costs, especially in situations of general financial distress. Moreover, there is the possibility of triggering restrictive supervisory actions and incurring in reputational costs. Because of the risk of materialization of such costs, the effect of the capital threshold is operating even when banks are distant from such possibility. Such effect can be interpreted as a cost that changes in value depending on the size of the cushion above the minimum and its potential volatility. In this sense, it is very similar to an option, which changes in value depending on the volatility of the underlying asset and on the difference between

[18] At the time of writing the Basel III regulations are being implemented.

the market price and the exercise price. The result is that, because increasing capital is costly, the size of the cushion will affect banks' supply and price of credit (Borio & Zhu, 2008). In so far as the central bank policies have an impact on the value of equity and its volatility, the bank capital channel will be at work.

The second effect considers the influence of the regulations capital framework on how bank actually perceive, manage and price risks. Indeed, one rationale behind implementing Basel II, was to make the minimum capital standard more risk-sensitive. Such regulations encourage banks to more actively measure risk, thus making them more prudent when granting credit. Yet, prudential tools may also have negative effects. Some economists argue that, as we have already shown, risk measures such as the Value-at-Risk methodology tend to be procyclical, thus spurring rather than restraining risk-taking. In addition, I believe prudential regulations may create a moral hazard problem. Indeed, moral hazard has been often associated with the concept of *"too big to fail"*, but there is scope for applying it also in this context[19]. In the presence of minimum capital standards, bank managers who comply may feel that part of their responsibility in ensuring good risk management is shifted away from them and may thus underestimate the risks of a downturn. Alternatively, they may have the incentive to take excessive risks in new and exotic ways, which are by nature less predictable and transparent, thus circumventing the requirements and worsening the position of their banks.

Clearly, this last set of effects is intimately connected to the risk-taking channel. Indeed, a recent paper by the ECB Beyer et al. (2017), which explores in detail the interactions between micro, macro-prudential and monetary policies, argues that prudential policies can have an impact on the risk-taking channel. First, capital-based constraints encourage banks in investing in less risky assets, thus dampening the search for yield effect. According to Dell'Ariccia et al. (2017) capital-based constraints have asymmetric effects, depending on how much a bank is capitalised. More capitalised banks should be less sensitive to changes in monetary policy. Second, asset-based prudential policies will impose restrictions on the supply of credit. Finally, liquidity constraints will tend to reduce the maturity mismatch between assets and liabilities, thus diminishing interest

[19]According to the idea of "too big to fail" banks must be bailed out in case of bankruptcy because are the holder of the citizens' wealth and enable the financial system to work.

rate risk and how banks react to changes in short-term interest rates.

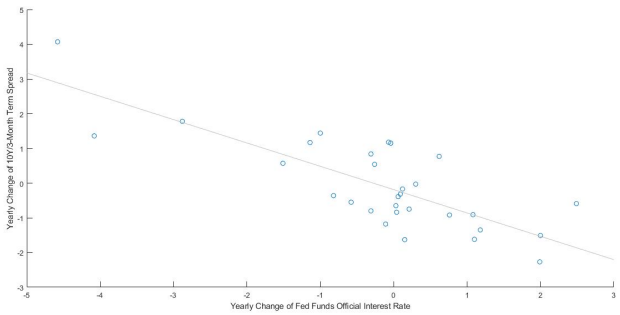
4 Empirical Analysis of the Risk-taking Channel

We now turn to an empirical exploration of the risk-taking channel whose theory I analysed in section 3. Indeed, because it is still a vague and vast concept, the empirical studies are different from each other not only in the tools used but also in the specific features and characteristics they test. Further, the risk-taking channel overlaps with and combines many other strands of economic literature. Thus, in this section I will also explore papers that do not explicitly mention the risk-taking channel but nevertheless are intimately related to it. I begin with the empirical analysis of the risk-taking channel proposed by Adrian and Shin (2010).

4.1 The Balance Sheet of Financial Intermediaries

As we have seen, according to Adrian and Shin (2010) changes in the central bank official rate directly impact the net interest margin and thus the profitability of financial intermediaries [20]. As a result, financial intermediaries change their risk appetite. In the case of a decrease in the official rate, banks would expand their balance sheets, increasing the supply of credit and decreasing the market price of risk.

Figure 6: The Term Spread and the Fed Funds Official Interest Rate



For the argument to be valid, all the rings of chain must be empirically proved. The first key assumption is that changes in the official short-term interest rate shift the slope of the yield curve. Figure 6 shows the relationship between the yearly change of the Fed

[20]The NIM is the difference between the total interest income on the assets side and the interest expenses on the liabilities side.

Funds official interest rate and changes in the term spread, measured as the difference between the 10 years treasury yield and the 3-month treasury yield (the plot uses yearly data from January 1988 to January 2018; the line plotted is found using a least-squares estimation).

Clearly, there is a strong negative relationship between the Fed Funds official interest rate and the term spread. By running a simple linear regression, I find the following result:

$$\Delta TS_t = -0.19 \quad - \quad 0.67\Delta FFR_t \ ^{21}$$

Thus, a 100 basis point decrease in the Fed Funds official rate from one year to the next predicts a 67 basis point increase in the term spread of the same year. This means that variations in the official rate have an impact on the slope of the yield curve. Because the term spread leads the net interest margin, changes in the Fed Funds official rate affect the profitability of financial intermediaries.

Next, the relationship between balance sheet conditions and the market risk premium must be examined. Adrian and Shin (2010) label the looseness of balance sheet constraints as risk appetite. The looser is the VaR constraint, the higher is the risk appetite of financial intermediaries and presumably the more they will expand their balance sheets. Under such definition, risk appetite is inversely related to the additional profit that the banking sector may earn by having one extra dollar of bank capital. Clearly, this is only true in the case in which financial intermediaries have expanded their balance sheet to the maximum, subject to the capital constraints. Thus, when the VaR is loose, risk appetite is high and the profit from one extra dollar of bank capital are low (capital is subject to diminishing marginal returns). As it was the case for Danielsson et al. (2004), to an outside observer the fluctuations in risk appetite appear as fluctuations in the financial intermediary's risk preferences [22].

[21] The FFR coefficient is statistically significant at the 1% level. R-squared= 0.625.

[22] Because it is a mechanical approach, the actual risk preference of the managers of the financial intermediary do not change. Yet, the looseness of the Value-at-Risk constraint is not constant. As the Net Interest Margin changes, the VaR constraint becomes looser or stricter and the risk appetite of

Figure 7: The calculation of the market risk premium.

$$\text{GDP growth} = \alpha + \sum_{i=1}^{n} \beta_{1i} * TS_i + \sum_{k=1}^{m} \beta_{2k} * CS_k + \epsilon$$

$$Z = \sum_{i=1}^{n} \beta_{1i} + \sum_{k=1}^{m} \beta_{2k}$$

$$\text{Market Risk Premium} = \frac{\sum_{i=1}^{n} \beta_{1i}}{Z} * TS_i + \frac{\sum_{k=1}^{m} \beta_{2k}}{Z} * CS_k$$

For what concerns the market risk premium, it measures the minimum rate of return for new projects that are financed in the economy, hence it reflects the ease of the credit conditions. Adrian and Shin (2010) refer to it as a macro risk premium and calculate it as a weighted average of spreads from fixed income securities. The authors include both credit spreads and spreads of the Treasury yield curve, as "both term spreads and credit spreads are measures of hurdle rates (minimum rates) — the additional yields on longer dated or riskier bonds that induce market investors to fund additional investment or consumption" (Adrian & Shin, 2010, p. 625-626). The term spreads are calculated by subtracting from the yields of Treasuries of different maturities the Fed Funds Target. The credit spreads are calculated by subtracting from corporate bonds with different ratings (with maturity 10 years) the 10-year constant maturity Treasury yield. Because the macro risk premium is not a simple arithmetic average of all these spreads but rather a weighted average, the weights must be determined. They are given by the regression coefficients that are obtained by regressing GDP growth on these spreads. This means that those spreads that influence more GDP growth will also have a greater impact on the market risk premium. An intuitive formula for the market risk premium is provided by Figure 7[23].

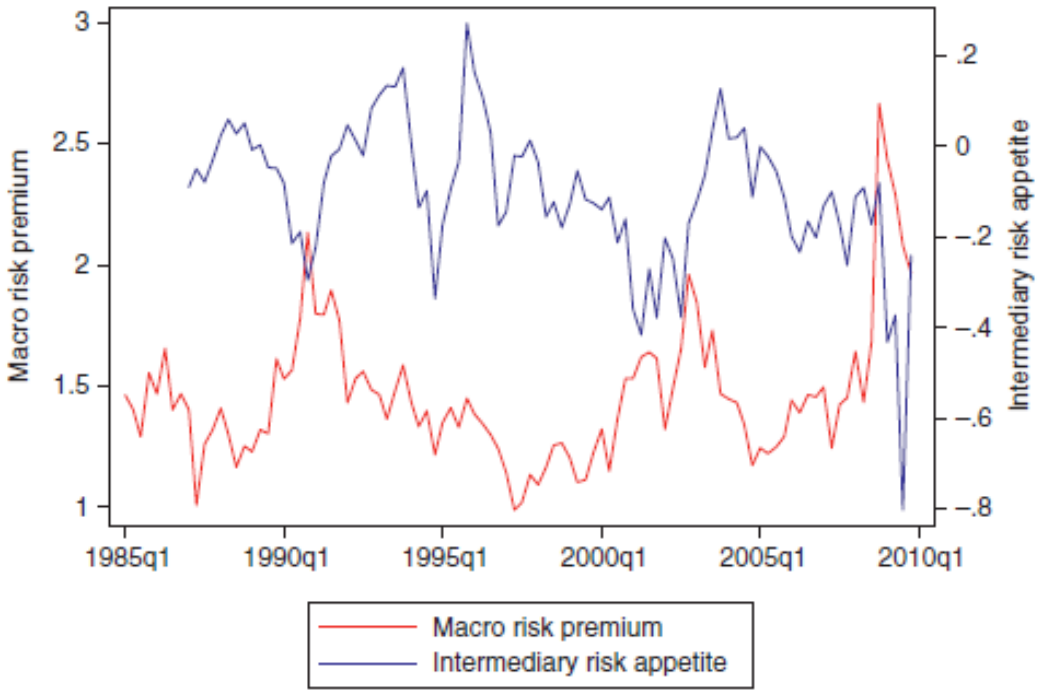
The method used to calculate the market risk premium is applied in an analogous way to calculate the risk appetite of financial intermediaries. Because looser capital constraints mean expanded balance sheets and higher risk appetite, a good approximation of a measure of risk appetite can be constructed precisely with balance sheet variables

financial intermediaries does the same.

[23]In Figure 7, TS_i is the term spread i, CS_k is the credit spread k, n is the total number of term spreads and k of credit spreads.

of financial intermediaries (variables from broker dealers, shadow banks and commercial banks are all included). In particular, risk appetite is the linear combination of one-year lagged balance sheet variables that best predicts negative one-year changes in the market risk premium[24]. The authors do so because, in an approximated way, these negative changes capture the returns to risk premia. An expansion in balance sheets means an increase in asset prices and as a result future lower spreads. Thus, risk appetite can be interpreted as a weighted average of balance sheet variables whose weights depend on their ability to influence returns in credit markets.

Figure 8: The risk appetite measure and the market risk premium



Source: Adrian and Shin (2010)

As it can be observed in Figure 8, risk appetite is highly negatively correlated with changes to the market risk premium (Macro risk premium in Figure 8). The reasoning behind such result is the following. Financial intermediaries want to maximise profits and

[24]One-year lagged independent variables means that they are measured one year before the dependent variable is measured. In this way it is possible to analyse effects that require time to take place (not just instant effects).

always increase their leverage up to the limit set by the VaR constraint. When the VaR constraint becomes looser, which is equivalent to an increase in risk appetite, financial intermediaries exploit the ample balance sheet capacity by taking on additional leverage, expanding their balance sheets and increasing their supply of credit. Such expansions are associated with higher asset prices and subsequently more compressed risk premia and spreads. The effects on the real economy are higher credit supply, lower financing rates and higher GDP. In addition, as Figure 6 shows, there is a close relationship between the Federal Funds rate and the NIM, which is one of the main determinants of balance sheet capacity and consequently of risk appetite[25]. In conclusion, already with this simple analysis, it is possible to establish a clear empirical relationship between the official interest rate and real activity through the mechanisms of the risk-taking channel.

Alternatively, Adrian, Estrella, and Shin (2010) use a vector autoregressive model to examine the connection between financial intermediary balance sheet management, the slope of the yield curve, and real economic activity in the United States. Their model and results are summarised in Figure 9.

Figure 9: The VAR model (data from 1990Q3 to 2008Q3)

	GDP Growth	Term Spread	Net Interest Margin	Asset Growth	Short Rate	VIX Change
GDP Growth (lag)	0.106	-0.329***	-0.026	0.911*	0.411***	1.933*
Term Spread (lag)	0.041	0.958***	0.038*	-0.729**	0.029	-1.173
Net Interest Margin (lag)	0.241	-0.302	0.804***	1.822*	0.241	1.451
Asset growth (lag)	0.112***	0.012	0.002	-0.066	0.058**	-0.742**
Short Rate (lag)	-0.032	-0.019	0.015	-0.093	0.965***	0.199
VIX Change (lag)	-0.002	0.004	0.002	0.037	-0.015*	-0.442***
Constant	0.024	1.620*	0.598**	-3.028	-1.540**	-4.197
Observations	73	73	73	73	73	73

*** p<0.01, ** p<0.05, * p<0.1

Source: Adrian, Estrella, and Shin (2010)

The results reported by Adrian et al. (2010) are empirically consistent with the ex-

[25]A higher Net Interest Margin means a higher value of the financial intermediary's assets and thus a looser VaR constraint.

istence of a risk-taking channel. The Vector Autoregressive model is able to explain the mechanisms that relate a decrease in the official interest rate with an increase in GDP growth. First, an increase in the term spread tends to increase the net interest margin. This happens because the profitability of the new loans funded with short-term liabilities, which directly impact the net interest margin, is strongly dependent on the term spread. Combined with our previous result, it proves the existence of a direct negative link between the Fed Fund rate and banks interest margin. Second, an increase in the net interest margin leads to an increase in total assets. As lending becomes more profitable, risk appetite increases, and balance sheets and credit supply expand. Finally, higher asset prices predict higher GDP growth.

4.2 Banks Risk-taking and Monetary Policy

When empirically testing the existence of a risk-taking channel, the inclusion of other financial institutions in addition to commercial banks is certainly of vital importance. Broker dealers and shadow banks have been found to provide a better gauge of current financial conditions than traditional banks (Adrian & Shin, 2010). Indeed, capital markets are increasingly at the centre of our financial system. Yet, there are many kinds of financial intermediaries and their activities are usually less subject to strict supervision by regulatory authorities (making it harder to obtain reliable data). Not surprisingly, the more detailed and rigorous empirical analysis of the risk-taking channel have concentrated exclusively on commercial banks. This is the case of Dell'Ariccia et al. (2017), who explore the relationship between commercial banks' issuance of new loans, leverage and short-term interest rates, using a confidential dataset on U.S. individual banks [26]. I will now report the main findings of their work.

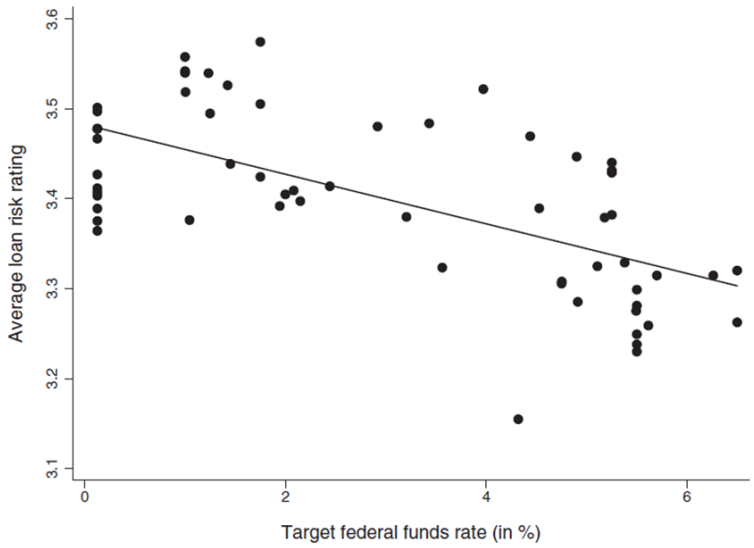
The strength of Dell'Ariccia et al. (2017) is their attention to issues of endogeneity between the Fed Funds official interest rate and banks risk-taking. To overcome the problem, they conduct many robustness tests in order to establish a causal relationship between their variables of interest. Their main findings, which survive all the robustness tests, are a statistically significant negative relationship between short-term interest rates

[26]The data is from the Federal Reserve's Survey of Terms of Business Lending (STBL).

and bank-risk taking and the fact that such relationship is increasing in bank capital.

The attention of the authors is restricted to a specific form of risk-taking: the extension of new loans. In contrast to the overall riskiness of the portfolio of loans, which is subject to cyclical changes in market conditions and thus it is not under the full control of the bank, newly issued loans depend only on the bank management. Further, new loans are less likely to influence the decision of the Federal Open Market Committee (FOMC, the body which sets official interest rates). Thanks to the detailed datasets, Dell'Ariccia et al. (2017) had access to the banks measure of the riskiness of the loans extended, which is a discrete index that ranges from 1 to 5 (1=minimal risk, 4=acceptable risk). [27]The average loan risk rating in the sample is 3.35 with a standard deviation of 0.85, meaning new loans on average have a risk that is slightly more than moderate. In Figure 10 the quarterly average loan risk rating is plotted against the target Federal Funds rate. The fitted line (computed with an OLS estimation) confirms the idea of a negative relationship between official rate and risk-taking.

Figure 10: Interest rates and bank risk-taking



Source: Dell'Ariccia, Laeven, and Suarez (2017)

The main regression analysis has as dependent variable the riskiness of the new loans

[27]The index of riskiness takes into account both characteristics of the borrower and the protection provided in the loan contract.

granted and as explanatory variables the Fed Funds Target plus a large set of other control variables. The latter are added precisely to not confound the analysis and limit problems of endogeneity. Loan characteristics such as the spread, maturity, collateral and loan size are included. Similarly, bank specific features such as capitalization or profitability and socioeconomic characteristics such as GDP growth, inflation and unemployment are all included. By running the regression, the authors find a significant negative relationship between short-term interest rates and ex-ante [28] bank risk-taking. According to the results, a one standard deviation decrease in the interest rate would suggest an increase in loan risk ratings of 0.11. Although significant at the 1% level of confidence, such effect is modest if we consider that the standard deviation of the loan ratings is 0.85.

Next, they include in the regression analysis an interaction term between the Fed Funds rate and bank capital, measured as the ratio of Tier 1 regulatory capital to total risk-weighted assets. The interaction term is used in econometric regressions when there are precisely interactions between two or more explanatory variables and thus their influence on the dependent variable is not additive. In this particular case Dell'Ariccia et al. (2017) wants to study how bank capital influences the effect of short-term interest rates on bank risk-taking. They obtain a statistical significant and negative coefficient on the interaction term that is consistent with the assumption that better capitalized banks are more sensitive to changes in short-term interest rates. This implies that a decrease in interest rates increases the riskiness of the loans issued more in the case of highly capitalised banks than for banks with low level of Tier 1 capital. This result is supported by other regression analysis (made by Dell'Ariccia et al. (2017)), which show that highly capitalized banks disproportionally expand the amount of commercial and industrial loans (C & I) and hold of risky securities when interest rates are low.

The results on the effect of the level of capital on bank risk-taking are justified by the authors with two contrasting theoretical mechanisms, traditional portfolio allocation and risk-shifting. According to the former, lower interest rates should increase risk-taking, as banks reallocate from safer securities to riskier ones. By contrast, risk-shifting models are based on the assumption that higher interest rates exacerbate agency problems and thus

[28] Obviously, the riskiness of the loan is measured at the moment of granting it.

inefficiently increases bank risk-taking. The latter effect should be more pronounced for least capitalised banks, which are more exposed to agency problems. The overall result is that portfolio allocation and risk-shifting cancel out each other. Nevertheless, portfolio allocation mechanisms prevail more for better capitalised banks than for low capitalized ones.

Clearly, the authors' explanation excludes from the picture the theoretical literature that I illustrated in section 2. This is because it is inadequate in explaining the effects of capital on risk-taking. Even the model proposed by Adrian and Shin (2010) is too simplistic, as it includes only one type of risky security, which makes it impossible to analyse the mechanisms illustrated above.

Finally, Dell'Ariccia et al. (2017) conduct some robustness tests. Because they are many, I will report only the two more interesting in my opinion. The first one concerns the role of securitization. The authors argue that the results may be biased due to the fact that highly capitalized banks have better access to securitized funding, and thus can more easily unload risks from their balance sheets. However, by adding the level of loan securitization into the regression analysis the results remain unchanged. The other test further explores the problem of endogeneity. In this case Dell'Ariccia et al. (2017) run a series of additional regressions that dismisses such concerns. Interestingly they exclude periods of financial distress, in which it is more likely that stability considerations are taken into account by monetary authorities. Alternatively, they include only banks that operate mainly locally (which will influence less the overall economy) or banks from states that are less in sync with the overall U.S. business cycle (which should be less affected by financial stability considerations).

Similarly to Dell'Ariccia et al. (2017), Jiménez, Ongena, Peydró, and Saurina (2014) empirically study the impact of monetary policy on the composition of the supply of credit, in particular testing the existence of the risk-taking channel. The authors have access to detailed monthly data from the credit register of Spain, a country which is an ideal setting for the identification. Indeed, its economic system is dominated by banks and it has a fairly exogenous monetary policy [29]. The strength of Jiménez et al. (2014)

[29]They authors use data from 2002 to 2009. During such period monetary policy was set by the ECB.

approach is the extensive use of complex econometric techniques (well beyond the scope of my paper) which make the results significantly robust. The use of such techniques, enabled by loan applications data contained in the Spain credit register, differentiates their work from all the other papers on this topic.

Consistent with the risk-taking channel of monetary policy, the authors find that a lower monetary policy rates spurs bank risk-taking, as it increases the probability of extending loans to borrowers with a poor credit history. Moreover, they also test for the effect of capital on banks behaviour. In contrast to Dell'Ariccia et al. (2017), they find that the least capitalized banks are the ones that most react to changes in the official interest rate. A decrease in the policy rates implies that poorly capitalised banks grant more risky loans relatively to better capitalized banks. Such result is consistent with the search for yield effect, as a compressed interest margin has more pronounced effects on least capitalized institutions (The profitability of highly leveraged institutions is more sensitive to changes in the interest margin). The contrast in the results suggests that the link between interest rate, leverage and risk-taking is likely to depend on country circumstances (Dell'Ariccia et al., 2017).

As we have seen, one of the main concerns of economists when empirically studying the risk-taking channel is the issue of endogeneity between monetary policy and banks behaviour. Such problem is very common in econometrics and stems from the impossibility of running experiments on the topics studied[30]. Yet, there exist some peculiar circumstances in which real situations can be used as experiments, usually called quasi-natural experiments. This is precisely the case of Ioannidou, Ongena, and Peydro (2015), who study the risk-taking channel in Bolivia during the period 1999-2003. During those years, Bolivia's banking system was almost fully dollarized, its currency was fixed to the US dollar (specifically it followed a crawling peg) and there were no restrictions on its capital account. But its small economy was not synchronized with the US economy and thus changes in the Fed official rate provided exogenous variations in the relevant mon-

[30]This is not to say that macroeconomic experiments would resolve the issue, as new problems such as external and internal validity are likely to arise. Nevertheless, experiments enable scientists to control for all other factors and thus help isolate the relationship of interest.

etary rate [31]. Further, according to the authors the richness of Bolivia's credit register enables them to cope with other two important identification issues. First, changes in the demand for loans must be disentangle from changes in the supply of loans (the risk-taking channel concerns banks and thus changes in the supply of loans). Second, banks could be adjusting other loan terms to compensate for the extra risk incurred.

The first step of Ioannidou et al. (2015) is to study the relationship between ex-ante measures of risk (directly available to the banks when making the loan decisions) and short-term rates. They find supportive evidence for the risk-taking channel, as a lower federal fund rate prior to origination implies that banks give more loans to borrowers associated with worse measures of risk (such as past nonperforming borrowers)[32]. Next, they estimate the ex-post default probability of the loans granted, assessed within the framework of a simple probit model, and use it to calculate the Net Expected Return[33]. This is done for the following reasons. First, because the banks loan officers use information on firms not available to the authors, such calculations complement the ex-ante measures of risk and enable them to better gauge the riskiness of the loans issued. But more importantly, banks could be altering the loan terms to off-set the higher expected default rate, thus not really increasing their risk-taking. Only if the increase in riskier loans is supply-driven the loans expected returns will drop and the risk-taking channel is at work. They define the Net Expected Return of a 1 dollar loan as:

$$NER = [(1–P) * (1 + InterestRate) + (P * CollateralValue)]–(1 + InterbankRate)$$

P is the estimated probability of default of the loan. The Interest Rate is the annual contractual interest rate at origination and the Collateral Value is the value of collateral to

[31]Such conditions imply that the Fed official rate influences Bolivia's money markets as if it was set by the domestic central bank. The natural experiment lies in the fact that Bolivia's economy does not influence in any way the setting of the rate by the OMC.

[32]See Altunbas, Gambacorta, and Marques-Ibanez (2010) and Paligorova and Santos (2012) for two further studies empirically supporting the existence of a risk-taking channel.

[33]A probit model is a type of regression where the dependent variable can take only two values. It is used to estimate the probability that an observation with particular characteristics will fall into a specific one of the two categories.

the loan amount. The Interbank Rate is the interest rate the bank pays on an interbank loan one month prior to origination. The first two terms are the revenues in case the borrower does not default and defaults, weighted by the respective probabilities. The third term are the costs of granting such loan (If the bank borrows the money in the interbank market they are actual costs, otherwise opportunity costs). When the costs are set equal to 0 the Expected Return is calculated. The results are summarized in Figure 11[34].

Figure 11: The Net Expected Return of a one dollar loan

		Net expected return		Expected return	
Variables	Model	(1)	(2)	(3)	(4)
Federal Funds$_{t-1}$		0.925***	3.307**	1.491***	3.496**
		[0.238]	[1.528]	[0.238]	[1.530]
Set of Controls from Table II		Not included	Included	Not included	Included
R^2		0.00	0.04	0.00	0.04

Source: Ioannidou, Ongena, and Peydro (2015)

The results show that a decrease in the federal funds rate decreases the Net Expected Return of the loan. Ceteris paribus, a decrease of 100 basis point in the Fed fund rate lowers the NER by 350 basis points, quite a strong effect (Model 2). The results confirm the hypothesis that lower interest rates increase bank risk-taking, as they not only grant new loans to more risky borrowers but are also willing to accept lower returns.

Ioannidou et al. (2015) run further econometric tests that confirm their initial hypothesis and rule out the possibility that banks risk-taking is demand-driven. Moreover, one of their main findings is that monetary policy diminishes the default rate on outstanding bank loans. Following a decrease in the official rate the newly issued loans are riskier, but the overall quality of the loan portfolio improves. Such results were also found by Jiménez et al. (2014) and are consistent with the model of Adrian and Shin (2010). An expansionary monetary policy reduces banks' credit risk on existing loans, relaxing the

[34]The set of controls in Figure 11 includes Bank, Firm, Bank–Firm Relationship, Loan and Banking Market Characteristics, and Macroeconomic Conditions.

VaR constraint and allowing them to take higher risks. Finally, the authors estimate that banks with stronger balance sheets in terms of capital are more likely to grant loans with a higher credit risk, thus supporting the results of Dell'Ariccia et al. (2017).

In conclusion, the empirical literature on the risk-taking channel confirms the theory: a decrease in the official interest rate increases bank risk-taking. Strikingly, the articles of interest have used different data from different periods of time and from different countries, they have used different models, have tested different measures of risk-taking and have run different robustness tests, yet they have all confirmed this result. This is impressive, especially for Economics. On the other hand, the magnitude of the effects found is quite small on average.

5 Conclusion

In this thesis I have shown the reader how, through the mechanisms of the risk-taking channel, it is possible to better understand how monetary policy is transmitted to the real economy, shedding some light on the "black box" of Bernanke and Gertler.

One step in this direction was made thirty years ago with the introduction of the credit channel, which claimed that asymmetric information in financial markets played an important role in the transmission of the central bank's actions. Following this line, the risk-taking channel goes one step further and focuses directly on the behaviour of financial intermediaries. Two are the main sets of effects through which it operates. First, changes in the official interest rates can have an impact on risk-taking, by impinging on the perceptions of risk and risk tolerance of economic agents. Second, a decrease in interest rates may cause agents, for behavioural or institutional reasons, to take on additional risks in order to not decrease the returns on assets (search for yield).

However, the risk-taking channel presents two basic problems, namely the difficulty of modelling and empirically testing it. Concerning the former, the complexities and the nuances of the financial system that the risk-taking channel tries to capture make the modelling job very difficult. Unsurprisingly, in their paper Borio and Zhu (2008) did not present any mathematical formula but limited themselves to describe with words the mechanisms of interest. For what concerns the empirical tests, because risk-taking and risk perceptions are hard to measure and to precisely define, the analysis has been confined to a specific phenomenon, risk-taking in commercial banks. Although the results confirm the theory, it is plausible that only a small part of the overall effect has been captured.

Still, the presence of such limitations does not frustrate the gains that the risk-taking channel has brought to the discipline of Economics. Having been mostly developed in the aftermath of the global financial crisis, the work on the risk-taking channel is embedded with important insights that are of vital importance for the future development of Economics and of the world.

Already before the years 2007-2008 may economists had claimed that monetary policy should incorporate into its mandate a financial stability objective or at least financial stability considerations (the topic is excellently discussed in Stein (2014) and Woodford

(2012)). The existence of a risk-taking channel provides further support for this proposal. It establishes a direct relationship between the central bank actions and financial instability, as excessive risk-taking is a possible cause of the latter. Indeed, as Borio and Zhu (2008) argue, this relationship should not be of concern most of the time. Nevertheless, the changing characteristics of the financial system suggest that the prolonged build-up of imbalances, caused by excessive risk-taking, could on some occasions wreak havoc in financial markets. Whether a new monetary policy framework will be adopted or the current one modified it is impossible to predict. In both cases the risk-taking channel will play an important role in such decision.

Moreover, the difficulty of modelling and empirically testing the risk-taking channel stems from the fact that, as I have mentioned above, it tries to incorporate insights that are at the frontier of economic theory. Besides the focus on interest rate spreads and short-term interest rate, the aspect under which it is more revolutionary is the analysis of agents' risk perceptions and how they influence financial markets. It is precisely with the inclusion of these kinds of behavioural aspects that economists are trying to better capture how the financial system works, especially in times of financial distress.

In my opinion it is this last point the most important aspect of the risk-taking channel of monetary policy. Even if the channel per se may not be particularly relevant for the transmission of monetary policy, it nevertheless incorporates theoretical insights that will definitely shape how Economics will evolve in the years to come.

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6 APPENDIX

6.1 Price Stickiness and Expectations Theory

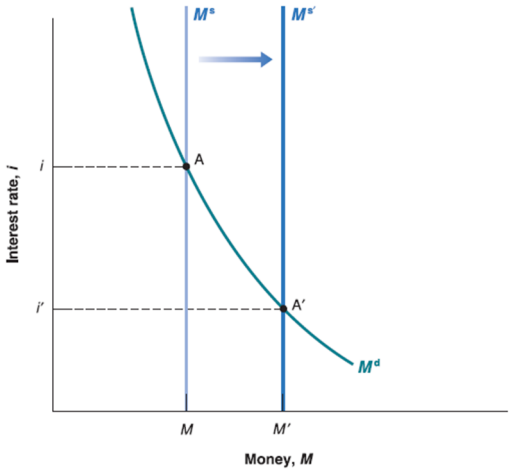
Price stickiness, or sticky prices, refers to the tendency of prices to remain constant or to adjust slowly despite changes in the cost of producing and selling the goods or services. There are many factors that cause nominal price rigidity, among which there are menu costs (the costs incurred when changing prices) and the money illusion (see Section 3.2).

We can define the real money supply as:

$$M^s = \frac{M_n^s}{P}$$

Where M_n^s stands for the nominal money stock and P for the price level. If the price level remains constant or does not change much, an expansionary monetary policy (an increase in the nominal money stock) will not only lower the nominal interest rate but also the short-term real interest rate. (A simple graph of the money market is presented in Figure 12).

Figure 12: The equilibrium in the money market



Source: Macroeconomics: a European Perspective (2010)

For what concerns the expectations theory, it argues that real long-term interest rates are simply the average of future short-term real interest rates. Because an expansionary monetary policy lowers present and future real short-term interest rates, it will directly

influence long-term real rates. The key assumption is that buyers of bonds do not prefer bonds of one maturity over another, so they will not hold any quantity of a bond if its expected return is less than that of another bond with a different maturity. Then, an n-periods bond's yield can be calculated as:

$$i_{nt} = \frac{i_t + i^e_{t+1} + i^e_{t+2} + ... + i^e_{t+(n-1)}}{n}$$

6.2 Rational and Diagnostic Expectations [35]

The Rational expectation hypothesis (REH) is one of the main features of the so-called New Classical Macroeconomics and assumes that economic agents do not make systematic errors when predicting the future. According to the REH, the expectation at time t of the realisation of x at time t + 1 can be written as follows:

$${}_t x^e_{t+1} = E_t\Big[x_{t+1}|\Omega_t\Big]$$

where the subjective expected level of a variable ${}_t x^e_{t+1}$ held by economic agents is equal to the mathematical expectation of the probability distribution conditional on the information set available at time t Ω_t . It is worth noticing that Ω_t includes all the information concerning the policies to be carried out by the government in the future. Under the REH, agents formulate unbiased forecasts of future values of an economic variable and their forecast error is on average equal to zero.

The REH assumes the best use of available information and that the agents' subjective distribution of expectations corresponds to the objective probability distribution of the true model describing the economy.

Diagnostic Expectations were introduced into the literature by Bordalo et al. (2018). In a simplified way they can be represented as a linear combination of the rational expectations of ω_{t+1} held at t and at $t-1$. Mathematically can be written as follows:

$$E^\theta_t(\omega_{t+1}) = E_t(\omega_{t+1}) + \theta\big[E_t(\omega_{t+1}) - E_{t-1}(\omega_{t+1})\big].$$

[35] Sources: RATIONAL EXPECTATION HYPOTHESIS (REH). [online] Bankpedia.org. and Bordalo et al. (2018).

Where $\theta \in [0, +\infty)$ measures the severity of judging by representativeness. When $\theta = 0$, the agent has no memory limits and appropriately uses all information, forming rational expectations (as in the case above).When $\theta > 0$, memory is limited. In the latter case agents overreact to the information received at t by the additional term $\theta\big[E_t(\omega_{t+1}) - E_{t-1}(\omega_{t+1})\big]$. For instance, if at time t the agent revises its expectations of ω_{t+1} upward $(E_t(\omega_{t+1}) > E_{t-1}(\omega_{t+1}))$, then he will overestimate ω_{t+1} by the additional term.

Interestingly, the average diagnostic forecast is rational. On average, diagnostic expectations revert to rational expectations because the diagnostic distortion is a linear function of news, and the average news is zero by definition.

6.3 Fire Sales [36]

A fire sale is essentially a forced sale of an asset at a dislocated price. The asset sale is forced in the sense that the seller cannot pay creditors without selling assets. The price is dislocated because the highest potential bidders are typically involved in a similar activity as the seller, and are therefore themselves indebted and cannot borrow more to buy the asset. Indeed, rather than bidding for the asset, they might be selling similar assets themselves.

Fire sales of securities have broader effects than fire sales of real assets because financial investors, such as hedge funds or banks, finance themselves with money that can be withdrawn quickly. The extreme vulnerability of financial investors to sudden stops in short-term financing can lead to cascades of liquidation. When financial investors are forced to liquidate their holdings, security prices decline. These declines, in turn, prompt further fund withdrawals and collateral calls for both these investors and their competitors. Such self-reinforcing fire sales were central in the 2008 financial crisis.

[36]Source: Shleifer, Andrei, and Robert Vishny. 2011. Fire Sales in Finance and Macroeconomics. Journal of Economic Perspectives, 25 (1): 29-48.