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* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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# A descriptive model of banking and aggregate demand*


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**Abstract**

We integrate a banking sector into an accessible macroeconomic framework, which then provides new explanations for developments around the Global Financial Crisis. The analysis shows that growth of banking sector money supply may explain the secular decline in long-term interest rates before the crisis. A new bank funding channel of monetary transmission clarifies why even large increases in central bank policy rates could not reverse this trend. Our analysis challenges the view that monetary policy becomes ineffective in a liquidity trap, and shows that bank recapitalizations are more effective than fiscal expansions in restoring aggregate demand after a banking crisis.



**Keywords**: banking, aggregate demand, monetary transmission, global financial crisis.
**JEL classifications**: E32, E50, E63, G01, G21, G28.



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# 1 Introduction

In the wake of the 2007 Global Financial Crisis, academics and policy makers acknowledged the need to better understand the role of banks in the macro-economy. Since then, a large literature has emerged shedding new light on this topic. What has not yet emerged, however, is a descriptive analytical framework that is intelligible to a broader audience of academics, informed policy makers, and economics students alike. By developing such a framework we aim to fill this gap. Our framework contributes to economic policy making, as the debate on, for instance, bank regulation and banking crisis management is not uniquely the domain of macroeconomic theorists, but requires achieving an understanding between the wide audience of policy makers, politicians, public opinion leaders, and the electorate.[1] In addition, we contribute to economic research, as our analysis provides new explanations for some key developments observed around the Global Financial Crisis and the ensuing Great Recession.

A key building block of our framework is the banking sector, which intermediates funds between savers and investors and is based on Van den Heuvel (2008). Our model not only incorporates banks' role as suppliers of credit, as most macroeconomic models with banks, but also accounts for their role as suppliers of money (i.e., liquidity). In particular, banks provide money to savers by issuing short-term deposits, while they provide credit to investors by making long-term loans. To do so requires banks to engage in maturity transformation as they use short-term liabilities to finance long-term assets, but they are constrained by a regulatory equity requirement. This requirement imposes banks to fund a minimum percentage of loans with equity, thereby limiting their leverage. As bank equity is fixed in the short run (Adrian and Shin, 2011), it constrains the supply of money (e.g., Diamond and Rajan (2000), Van den Heuvel (2008)) as well as the supply of credit (e.g., Van den Heuvel (2002), Woodford (2010)).

To integrate the banking sector into an accessible macroeconomic framework we turn to the aggregate demand set-up initiated by Keynes (1936) and Hicks (1937), which was recently provided with a microfoundation by Michaillat and Saez (2014). This choice is not a coincidence: its ease of use leads Krugman (2000) to consider this framework as "superior for many practical applications." At the outset of the crisis, Mankiw (2006) describes this set-up as "the basic framework that modern students learn to make sense of the business cycle," while

[1] Rochet (2015) argues that "although many economists have tried to introduce banks and financial frictions into DSGE models, these models are too complicated with so many interacting 'blocks' (to reproduce data in the short term), that by adding another layer of complexity they lose transparency and the possibility to interpret the results. This is not a secondary issue, because this lack of transparency affects the accountability of policy decisions." While this complexity is to some extent inevitable when going beyond the descriptive level, it may also explain the observation by De Grauwe (2010) that, once the crisis broke out, policy makers "did not ask the advice of [those] who knew how to solve complex DSGE models," but "went straight back to the things that were taught in macroeconomic textbooks of 40 years ago before the Real Business Cycle (RBC) theory and the Rational Expectations (RE) revolution started captivating the macroeconomic profession. They applied the Keynesian principles found in these textbooks and massively increased budget deficits and flooded the money markets with hundreds of billions of dollars of liquidity."

Woodford (2010) uses it to convey the implications of the crisis for macroeconomic analysis. For our purpose, a particular advantage of the aggregate demand model is that it allows us to straightforwardly distinguish between money and capital market interest rates and between banks' roles as suppliers of money and credit. Coincidentally, these modifications also address some of the main caveats of the model raised by Blinder (1997) and Romer (2000), with the latter's IS-MP model being a special case of our approach.[2]

In short, our model can be described as follows. Money is supplied by banks rather than by the central bank, and is determined by the amount of bank equity in combination with a binding equity requirement. Demand for money is driven by a transaction motive that depends on aggregate demand and a speculative motive that depends on the spread between the long-term and the short-term interest rate. With the short-term interest rate being set by the central bank to conduct monetary policy, the money market equilibrium is described by all combinations of aggregate demand and the long-term interest that equate the supply and demand for money – the LM-curve. On the capital market (i.e., the market for bank loans), a weighted average of short-term and long-term interest rates determines the return on savings and investments. The capital market is in equilibrium for all combinations of aggregate demand and the long-term interest rate that equate the supply and demand for capital – the IS-curve. The demand-side equilibrium is then described by the simultaneous equilibrium of the money and capital market. Hence, in equilibrium, aggregate demand and the long-term interest rate are endogenously determined by, amongst others, the central bank's short-term interest rate and the supply of money by the banking sector.

Our model offers new insights on the 2007 Global Financial Crisis and the ensuing Great Recession. Four findings stand out in particular. First, the model suggests that the secular decline in the long-term interest rate prior to the crisis may be due to an increase in private bank money supply (comparable to how an increase in central bank money supply lowers the interest rate in the textbook aggregate demand setup). Usually, this decline is attributed to a global 'savings glut' stemming from an increase in savings or a decline in investment (e.g., Bernanke (2005), Greenspan (2010), IMF (2014)). Our analysis instead points at the role of an increase of bank money supply, such as through the production of liquid asset backed securities, made possible by rising bank equity values. These equity values outperformed the stock market by as much as 50 percentage points between 2000 and mid-2007. While the low interest rate environment is typically seen as a cause of excessive bank risk taking (Rajan, 2006), banking sector developments may thus be at the root of it as well.

[2]Blinder (1997) points out that the aggregate demand framework does not distinguish between the short-term and the long-term interest rate. Romer (2000) highlights that the model does not distinguish between the nominal interest rate determining the money market equilibrium and the real interest rate determining the capital market equilibrium. In addition, he points out that the central bank is assumed to conduct monetary policy by changing the money supply, whereas in practice it adjusts the short-term nominal interest rate. Our modifications of the model provide a straightforward manner to address each of these caveats.

Second, our model suggests a new monetary transmission channel which may explain the 'interest rate conundrum' first pointed out by Greenspan (2005). This conundrum describes the apparent unresponsiveness of the long-term interest rate to changes in the short-term interest rate. As a result, central banks' pre-crisis attempts to raise long-term interest rates through monetary tightening proved largely ineffective. Our model accounts for this inability by showing that monetary policy directly affects both the money market and the capital market (i.e., it also shifts the IS-curve). Consider, for instance, a monetary tightening through an increase in the short-term interest rate. It is well known that this stimulates money demand and thereby causes the long-term interest rate to rise. However, in our model also the capital market is directly affected because banks pass on their higher short-term funding costs to their borrowers, who react by lowering investment spending. This second mechanism renders the overall impact of monetary policy on the long-term interest rate ambiguous. We refer to this mechanism as the *bank funding channel* of monetary transmission, and note that it complements the interest rate, bank lending (Bernanke and Blinder, 1988), and bank capital channel of monetary policy transmission (Van den Heuvel, 2002).

Third, our model highlights that a bank recapitalization can be a particularly powerful policy instrument to restore aggregate demand in the wake of a banking crisis. In fact, it allows us to derive a bank-equity multiplier that is reminiscent of the government spending multiplier. Comparing the two reveals that the former is generally larger than the latter. Comparatively small changes in bank equity can therefore have large effects on aggregate demand, in line with the large decline in economic activity observed after the Global Financial Crisis. While part of this decline has been attributed to fiscal consolidation policies adopted after the crisis, the fact that bank equity values in 2015 were still 46 percent below their pre-crisis level thus probably played a role as well. Moreover, the crisis increased risk premiums in financial markets while inflation expectations declined, both of which depress aggregate demand in our model by the same extent as a rise in the short-term interest rate.

Fourth, by taking into account that the short-term interest rate is controlled by the central bank while the banking sector supplies the quantity of money, the model highlights the difference between the zero lower bound and a liquidity trap. While the two are often seen as part and parcel (e.g., Krugman, 1998, Eggertsson, 2008), we show that both have substantially different implications for policy effectiveness. The zero lower bound involves the case where a conventional monetary expansion is no longer feasible because the short-term policy interest rate cannot decline below zero. The liquidity trap, by contrast, can also occur when interest rates are higher than zero. It involves the case where an increase in banking sector money supply can no longer reduce the long-term interest rate because this rate would then have to decline below the short-term one. While being in a liquidity trap limits the impact of bank money supply on aggregate demand, it increases the effectiveness of fiscal and monetary policy. The classic result that monetary policy is ineffective in a liquidity trap thus disappears once taking into account that central banks do not control the supply of money, but instead target the short-term interest rate.

The results from our descriptive analysis may benefit the literature on banking and the macro-economy. Recent examples of such studies include Gerali *et al.* (2010), Gertler and Karadi (2011), Gertler *et al.* (2012), Clerc *et al.* (2014), and Boissay *et al.* (2015). These studies focus on the role of banks in supplying credit to the real economy, but do not account for their role as suppliers of money. This omission may stem from the belief discussed by Woodford (2010) that central banks can easily offset a decline in bank money supply by increasing the provision of reserves to the banking sector. But as the model by Van den Heuvel (2008) and our own framework illustrate, a decline in bank equity reduces money supply even if banks are not required to hold reserves in the first place. Belongia and Ireland (2006) and Goodfriend and McCallum (2007) incorporate a role for bank money supply, but their models do not contain bank equity. Moreira and Savov (2014) and Brunnermeier and Sannikov (2015) recently highlight the key role of financial intermediaries as suppliers of money to the real economy. Inspired by these contributions, our paper integrates a banking sector into a descriptive macroeconomic framework, thereby providing new insights that may inform future research and economic policy making.

The remainder of the paper is set up as follows. In the next section we incorporate a banking sector in an easy to use model of aggregate demand and describe its equilibrium. In Section 3 we illustrate the model's properties by analysing the efficacy of economic policy, focusing especially on the role of banks in the transmission of monetary policy, the role of bank equity regulation, and the equilibrium impact of fluctuations in financial market risk premiums and in the value of bank equity. Section 4 then applies the model to the 2007 Global Financial Crisis and the Great Recession, while the final section concludes.

## 2 A Descriptive Model

Taking the textbook aggregate demand model as a starting point we use this section to extend the model with a banking sector based on Van den Heuvel (2008). To this end, we commence by outlining the balance sheet of the aggregate banking sector. Having done so, we integrate this banking sector into the aggregate demand framework. To keep things analytically tractable we focus on linear functional forms.

### 2.1 The Banking Sector

We display the balance sheet of the aggregate banking sector, in stylized form, in Figure 1. The asset side of the balance sheet is composed of long-term loans $L$ while the liability side is equally stylized and consists of short-term debt liabilities $D$, from now on referred to as 'deposits', and shareholder equity $E$.

| Assets | Liabilities |
|---|---|
| L | D |
| | E |

Figure 1: Aggregate bank balance sheet

For the purpose of our analysis the three items in Figure 1 cover the key characteristics of real-world banking sector balance sheets.[3] On the asset side, loans are risky and illiquid and yield the bank lending rate $r_b$, to be defined below. On the liability side, what we refer to as deposits can compose any form of liquid financing. This includes immediately redeemable retail deposit funding, but also, for instance, mortgage backed debt securities which are issued by banks and are traded in financial markets. Furthermore, the market value of bank equity entails the buffer with which banks can absorb losses on their asset portfolio.[4] For future reference the balance sheet can be written as the following identity:

$$L \equiv D + E. \tag{1}$$

In structuring their balance sheets, banks are constrained by an equity requirement set by the central bank.[5] This requirement obliges banks to fund at least a share $0 \leq \lambda \leq 1$ of total assets with equity so that losses on their assets are absorbed by bank shareholders rather than by bank depositors.[6] As in the absence of such a requirement banks would finance all their assets with relatively cheaper deposits, the constraint will bind and total equity equals:

$$E = \lambda L. \tag{2}$$

Hence, by increasing the equity requirement, the central bank effectively reduces the amount of leverage in the banking sector.

Combining (1) and (2) provides a straightforward expression linking deposits to bank equity:

$$D = mE, \text{ with } m \equiv \frac{1-\lambda}{\lambda}, \tag{3}$$

[3] As we consider the whole banking sector as a single unit, any interbank lending can be disregarded.

[4] Bank equity could also be interpreted in terms of book values rather than market values. We focus on market values as this is also what banks' financiers do when determining the liquidity of their deposits. In fact, as shown by Flannery (2015), book value measures of bank equity are least informative during a crisis, with their stability during the past decade suggesting that there never was a crisis to begin with.

[5] For sake of clarity we refer to the bank regulator and monetary policy maker generically as the *central bank*. In practice these tasks need not be handled by be the same entity.

[6] In bank regulatory practice as well as in much of the popular press, the equity requirement is referred to as a bank capital requirement. We refrain from doing so in order to avoid confusion with the broader capital market contained in the IS-curve below.

where $m$ can be interpreted as the deposit multiplier of bank equity, which for the typical bank balance sheet is equal to 30.[7] For a given value of $E$, the amount of deposits decreases if the equity requirement $\lambda$ tightens. The intuition behind this comparative static effect is that higher equity requirements allow banks to hold fewer assets for a given amount of equity, which through the balance sheet identity implies they can also have fewer deposits. Hence, as bank equity behaves as a predetermined variable (Adrian and Shin, 2011), and in line with Diamond and Rajan (2000) and Van den Heuvel (2008), the total amount of deposits is constrained by the amount of equity in the banking sector.

Viewing the operations of the banking sector in an abstract fashion we see that the main objective of the sector is to finance long-term loans with short-term deposits in such a way as to maximize profits. In particular, banks are price-takers and maximize profits according to:

$$\begin{aligned} \Pi &= \max_{L,D,E} \left(Lr_b - Dr_s - Er - L\sigma\right) \\ & \quad \text{s.t. } L \equiv D + E,\ E = \lambda L, \end{aligned} \tag{4}$$

where $\Pi$ indicates aggregate profits, $r_b$ is the bank lending rate, $r_s$ is the risk-free short-term interest rate, and $r$ denotes the risk-free long-term interest rate. In addition, $\sigma$ denotes a risk-premium banks pay to their financiers as a compensation for the risk on the asset portfolio. If the equity requirement is sufficiently high for deposits to remain risk free, $L\sigma$ goes to bank shareholders so that the return on equity equals $r + \frac{L}{E}\sigma$ and the return on deposits equals $r_s$.

Solving the optimization problem in (4) yields the following expression for the bank lending rate:

$$r_b = \lambda r + (1 - \lambda) r_s + \sigma, \tag{5}$$

with economic profits being equal to zero: $\Pi = 0$. This lending rate is equal to the one in Van den Heuvel (2008) except that he sets the risk-premium equal to zero.[8] As can easily be verified, $r_b$ is equal to the weighted average bank funding cost. The ability of banks to fund themselves with deposits thus limits the impact of the long-term interest rate on their lending rate and funding costs. Indeed, as $\lambda$ is reduced, $r_b$ converges toward $r_s + \sigma$, which for a positive interest rate spread, i.e. $r > r_s$, implies that $r_b$ declines.

[7] Under the Basel III Accord banks are required to meet an equity (leverage) requirement of $\lambda = 0.03$, leading to a multiplier $m$ of roughly 30. While in practice banks may hold some equity in excess of the minimum requirement we abstract from such considerations for purpose of exposition.

[8] The remaining difference with Van den Heuvel (2008) is that his model includes a real resource cost associated with servicing deposits and loans, which we omit for clarity of exposition.

## 2.2 The Money Market

We first consider the role of the banking sector in the money market. In particular, we take into account that bank deposits constitute the supply of money to the real economy:

$$M^S = D = mE, \tag{6}$$

where $M^S$ is money supply and we have used (3) to highlight the fact that the amount of money supplied is determined by the economy-wide level of bank equity. This observation contrasts with the standard LM-curve in which money supply is determined by the central bank but is in line with the recent work of McLeay *et al.* (2014) who explain that "the majority of money in the modern economy is created by commercial banks." Using the discussion surrounding (3) we may also infer that money supply falls as $\lambda$ increases, which implies that central bank equity requirements reduce the supply of money to the economy.[9]

In practice, central banks change regulatory requirements very infrequently, and implement their monetary policy changes by altering the short-term interest rate. We incorporate this policy instrument in the model by introducing the spread between the long-term and short-term interest rate in the money demand equation:

$$M^D = dY - e\left(r - r_s\right), \tag{7}$$

where $Y$ is aggregate demand and $d \in (0,1)$ is the parameter reflecting the transaction motive of money demand. In (7) the dependence of money demand on the interest rate spread reflects that the opportunity cost from holding liquid short-term over illiquid long-term assets is equal to the difference between the long-term and short-term interest rate.[10]

Combining (6) and (7) provides the LM-curve:

$$Y = \frac{e}{d}r + \frac{m}{d}E - \frac{e}{d}r_s. \tag{8}$$

Viewing the LM-curve in a $(Y, r)$ space, reveals that changes to either bank equity, the short-term interest rate or the equity requirement $\lambda$ contained in $m$ can cause the curve to shift.

[9] Earlier literature has focused on the case where central bank reserves rather than bank equity are the binding constraint on bank money supply, so that the central bank can steer the money supply in the economy by changing the supply of reserves. In practice, however, the reserve requirement has become obsolete as central banks supply any amount of reserves demanded by the banking sector at a given price (Kydland and Prescott, 1990). Consequently, this policy deems the reserve based 'money multiplier' redundant, as is discussed in more detail by Benes and Kumhof (2012). By 2010, some countries had abolished reserve requirements altogether, including the United Kingdom, Canada, Denmark, and Sweden (Gray, 2011).

[10] The spread between nominal interest rates is the same as the spread between real interest rates, as the difference between inflation expectations drops out in equilibrium. Formulating money demand in terms of the interest rate spread thus allows us to focus on real interest rates, thereby achieving consistency with the analysis of the capital market below.

## 2.3 The Capital Market

Demand for capital (i.e., investments) is given by:

$$I = \bar{I} - br_b, \tag{9}$$

where $\bar{I}$ is baseline investment and $b$ measures the sensitivity of firms' investment demand to changes in the marginal cost of capital, which is the bank lending rate derived in (5). While the structure of the investment demand curve is the same as in the textbook specification, the difference lies in the interest rate on which the investment decision depends. That is, we take into account that firms do not borrow against the long-term rate $r$, but obtain loans from banks whose funding costs partially depend on the short-term interest rate.

The supply of capital (i.e., savings) is equal to:

$$S = sY + fr_b, \tag{10}$$

where $s \in (0, 1)$ is the marginal savings rate and the parameter $f$ measures the sensitivity of savings to the banking sector's weighted average funding cost. As with the capital demand function, the structure of the capital supply function is similar to its textbook equivalent with the difference lying in the interest rate on which the function depends. In particular, our set-up takes into account that savings can also be held in the form of bank deposits, in addition to being held in the form of bank equity, in which case they earn the short-term rather than the long-term interest rate.

We allow for government deficit spending $G$ in order to compare any consequences of central bank policy or changes in bank equity with those of fiscal policy. As $G$ represents the part of government spending not covered by taxes it can be seen as the net-financing need of the government. Therefore aggregate capital demand in the economy is given by: $I^A = I + G$.

Imposing $I^A = S$, substituting (5) and some rewriting yields the IS-curve:

$$Y = \frac{1}{s}\left(\bar{I} + G - (b + f)\left(\lambda r + (1 - \lambda)\, r_s + \sigma\right)\right), \tag{11}$$

where we notice immediately that in contrast to the textbook IS-curve conventional monetary policy (see below) can shift the curve as well. Hence, by letting banks fund long-term loans with short-term deposits and by allowing the central bank to alter the short-term interest rate, monetary policy directly affects both the IS and the LM-curve.

## 2.4 Equilibrium

The equilibrium of the model is given by the intersection between the IS-curve in (11) and the LM-curve in (8). At that point both the money and capital market are in equilibrium.

Equating the IS and LM-curve and solving for $Y$ and $r$, respectively, provides:

$$Y = \frac{e}{d(b+f)\lambda + es}\left(\bar{I} + G - (b+f)(r_s+\sigma) - \frac{sm}{d}E\right) + \frac{m}{d}E, \quad (12a)$$

$$r = \frac{d}{d(b+f)\lambda + es}\left(\bar{I} + G - (b+f)(r_s+\sigma) - \frac{sm}{d}E\right) + r_s. \quad (12b)$$

Viewed through the lens of the expectations hypothesis of interest rates, we note that the equilibrium value for $r$ in (12b) can be interpreted as the sum of the short-term interest rate and the term-premium, with an expression for the latter being obtained after subtracting $r_s$ from both sides of the equation. We display the equilibrium graphically using a $(Y, r)$ space in Figure 2 below. As can be seen it consists of a downward sloping IS-curve and an upward sloping LM-curve.[11]

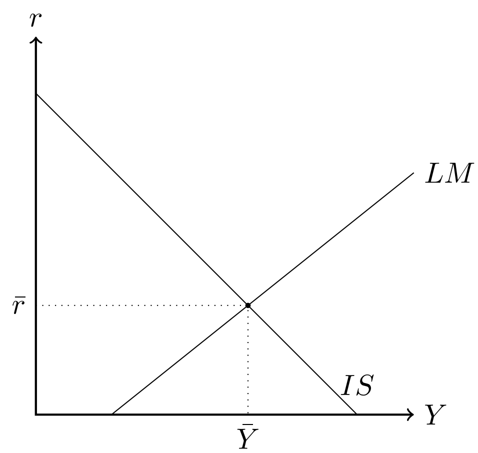


Figure 2: Equilibrium in the model

# 3 Comparative Statics

Before applying the model to the Global Financial Crisis in Section 4 below, we first analyze various policy and structural changes in isolation. In particular, we focus on the staple analysis of macroeconomics by considering the impact of fiscal and monetary policy on aggregate demand and on the long-term interest rate. Moreover, we consider the consequences of changes in bank equity requirements, financial market risk premiums, and the level of bank equity.

[11] Our model yields Romer's (2000) IS-MP model for the special case where $\sigma = 0$ and $E = \frac{d}{sm}\left(\bar{I} + G - (b+f)(r_s+\sigma)\right)$. The equilibrium is then described by the IS-curve in (11) and the expression $r = r_s$. Assuming that the central bank sets $r_s$ using a monetary policy rule like the one by Taylor (1993) then yields the IS-MP model. In this environment, bank equity and bank equity requirements no longer affect aggregate demand, the implications of which are discussed in Section 3.5.1 on the liquidity trap.

## 3.1 Fiscal Policy

The impact on aggregate demand of a change in debt-financed government spending (i.e., the government spending multiplier), can be assessed by taking the first order derivative of (12a) with respect to $G$:

$$\frac{\partial Y}{\partial G} = \frac{e}{d\,(b+f)\,\lambda + es} = Y_G > 0, \tag{13}$$

which reveals that the efficacy of government spending in changing aggregate demand is determined by the typical parameters – such as the savings rate $s$ – as well as the bank equity requirement $\lambda$. Since the government spending multiplier is positive, an increase in deficit-financed government spending drives up aggregate demand. Similarly, to derive the impact of government spending on the long-term interest rate we can take the first order derivative of (12b) with respect to $G$:

$$\frac{\partial r}{\partial G} = \frac{d}{e} Y_G > 0, \tag{14}$$

which shows that an increase in government spending increases the long-term interest rate. Hence, the impact of fiscal policy on equilibrium levels of $Y$ and $r$ is qualitatively the same as in the textbook model. Moreover, as (13) and (14) are larger for smaller values of $\lambda$, the impact of fiscal policy is reduced by tighter equity requirements.

## 3.2 Monetary Policy

The impact of a change in the short-term interest rate on aggregate demand can be obtained by considering the first order derivative of (12a) with respect to $r_s$:

$$\frac{\partial Y}{\partial r_s} = -(b+f) Y_G < 0, \tag{15}$$

which is unambiguously negative. As in the textbook model, an increase in the short-term interest rate (i.e., a monetary tightening) lowers aggregate demand. The impact of a change in the short-term interest rate on the long-term interest rate can be obtained by taking the first order derivative of (12b) with respect to $r_s$:

$$\frac{\partial r}{\partial r_s} = 1 - (b+f)\frac{d}{e} Y_G \gtreqless 0, \tag{16}$$

which can either be positive or negative. Indeed, it can be shown that the impact of $r_s$ on $r$ depends crucially on the relative sensitivities of the IS and LM-curve to changes in $r_s$. If the former is more sensitive than the latter, implying $\frac{e}{d} > \frac{1}{s}\,(b+f)\,(1-\lambda)$, both interest rates will move in concert.[12] If both have the same sensitivity, $r$ is independent of $r_s$. Finally, if the

[12] This condition holds for $\lambda = 1$ as it then simplifies to $\frac{e}{d} > 0$, which replicates the textbook result that a monetary contraction increases the long-term interest rate. However, for $\lambda = 0$, the condition becomes $\frac{e}{d} > \frac{b+f}{s}$, which need not hold in practice.

LM-curve is more sensitive than the IS-curve, there will be a negative relationship between $r_s$ and $r$. Figure 3 displays two alternative IS-curves to illustrate the possible ways in which an increase in the short-term interest rate can affect aggregate demand and the long-term interest rate. In both cases the LM-curve and IS-curve shift inward. However, depending on the magnitude of the shift of the IS-curve, the new long-term interest rate may be either higher or lower than before.

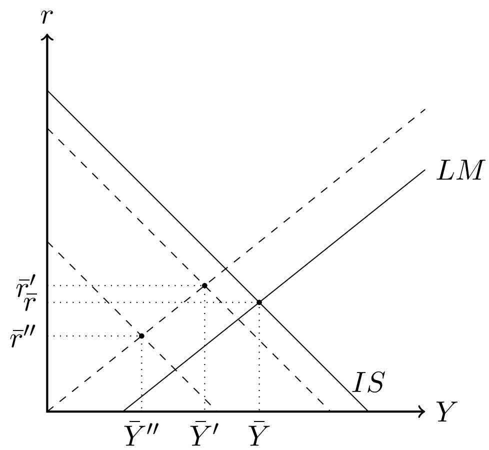


Figure 3: Monetary contraction

The limited impact of monetary policy on the long-term interest rate does not imply that monetary policy is ineffective in changing aggregate demand. On the contrary, the shift of the IS-curve in Figure 3 dampens the conventional impact of monetary policy on the long-term interest rate, but amplifies its impact on aggregate demand. The fact that monetary policy also shifts the IS-curve may help explain the 'interest rate conundrum' pointed out by Greenspan (2005) and analyzed by Adrian, *et al.* (2010). These authors describe how the Federal Reserve raised its policy rate from 1 to 5.25 percent between June 2004 and June 2006, while the 10-year US Treasury yield only increased from 4.73 to 5.11 percent over that same time period. This limited impact of monetary policy on the long-term interest rate is hard to account for in the absence of a shift in the IS-curve, but follows naturally from our model in which monetary policy affects the money market as well as the capital market.

#### 3.2.1 Monetary Policy Transmission

The impact of monetary policy on the LM-curve in our model is in line with the well-known interest rate channel of monetary transmission. An increase in the short-term interest rate increases households' demand for short-term assets (bank deposits) and reduces their demand for long-term assets (bank equity), which causes the long-term interest rate to rise and aggregate demand to fall. However, the empirical literature reviewed by Peek and Rosengren (2014) indicates that this mechanism creates an empirical puzzle, as monetary policy shocks that had relatively small effects on the long-term interest rate appear to have had substantial effects on aggregate demand.[13]

In order to address this puzzle Bernanke and Blinder (1988) and Kashyap and Stein (1994) suggest the so-called bank lending channel of monetary policy while Van den Heuvel (2002) suggests the bank capital (i.e., equity) channel. Under the former, the central bank tightens monetary policy by reducing the supply of reserves to the banking sector which causes banks to limit their supply of loans to the economy. Under the latter, a monetary tightening is effectuated through an increase in the short-term interest rate, which in turn reduces bank profits and, thereby, the value of their equity. By means of the equity requirement, banks then need to reduce the amount of loans provided to the economy. Hence, in both cases, rather than through the money market, the transmission of a monetary policy contraction is achieved through a reduction in loans supplied to the economy, which leads to a reduction in aggregate demand.

Supplementing these channels, our model highlights an additional mechanism through which banking interacts with the transmission of monetary policy. This mechanism differs from the aforementioned channels, in that it neither relies on a change in the supply of central bank reserves (which are absent in the model) nor on a change in the value of bank equity. In fact, the impact of monetary policy on the IS-curve in (9) is largest if $\lambda = 0$. That is, when banks are not required to hold equity. As a monetary contraction in our model increases banks' short-term funding costs, which banks then pass on to the real economy by increasing their lending rates, we refer to this transmission mechanism as the *bank funding channel* of monetary policy. As the shift in the IS-curve is larger for lower values of $\lambda$, we conclude that the ability of banks to finance long-term loans with short-term deposits amplifies the impact of monetary policy on aggregate demand while dampening - and possibly even reversing - its conventional impact on the long-term interest rate.[14] Hence, while the bank-funding channel complements the transmission channels mentioned before, the mechanism behind it is quite different.

### 3.2.2 The Zero Lower Bound

A common theme in current monetary policy making is the so-called zero lower bound which deals with the problem that once the *nominal* short-term interest rate has hit zero it is no

[13] See also Beck *et al.* (2014) for a recent overview of various monetary transmission channels involving banks. In addition, Borio and Zhu (2012) highlight how monetary policy can also affect risk-taking in the economy.

[14] To explain the limited impact of monetary policy on the long-term rate, Adrian *et al.* (2010) suggest that a monetary contraction reduces aggregate demand by flattening the spread between the long-term and short-term interest rate. This decline in the spread then reduces the profitability of bank lending to the real economy, which leads them to restrict their supply of credit and thereby reduces aggregate demand. Under the bank funding channel, by contrast, a monetary contraction reduces investment by increasing the bank lending rate. The fact that the monetary contraction also flattens the interest rate spread actually dampens its negative impact on aggregate demand, which follows from writing the lending rate as $r_b = r_s + \lambda(r - r_s) + \sigma$ and observing that it declines as the interest rate spread flattens.

longer feasible to decrease it any further. After all, once the nominal short-term rate arrives at zero, a further decline would cause savers to withdraw their deposits and hoard cash instead. As the nominal short-term rate equals $i_s \equiv r_s + \pi^e$, where $\pi^e$ denotes expected inflation (which we consider as exogenous), the zero lower bound can be defined as the constraint that $r_s \geq -\pi^e$. Note that this constraint implies that lower inflation (or even deflation) expectations limit the room for expansionary monetary policy, which may pose a problem for central banks. Although a conventional monetary expansion is infeasible at the zero lower bound, the other properties of the model remain unaffected. That is, setting $r_s = -\pi^e$ in (12a) and (12b) does not change how aggregate demand and the long-term interest rate are determined. In this way the zero lower bound differs markedly from a liquidity trap, as we discuss in detail in Section 3.5.1 below.

### 3.3 Bank Regulation Policy

In light of the Global Financial Crisis of 2007, policy makers around the world are reforming the bank regulatory framework. Indeed, inadequate bank equity requirements have been seen as amplifying factors of the financial crisis and currently proposals are being implemented for such requirements to be tightened (see BIS, 2010). Within our model such policy proposals can be evaluated by considering changes in $\lambda$. While bank regulation policy is generally not implemented to affect aggregate demand or the long-term interest rate, our model illustrates that it does have such side effects.

The impact of changes in equity requirements $\lambda$ can be calculated as:

$$\frac{\partial Y}{\partial \lambda} = Y_\lambda < 0, \tag{17a}$$

$$\frac{\partial r}{\partial \lambda} = r_\lambda \gtreqless 0, \tag{17b}$$

where we relegate the full derivation of the result to the Appendix. Inspection of (17a) reveals that stricter equity requirements lead to lower aggregate demand. The impact of a change in equity requirements on the long term interest rate is analytically ambiguous and depends on the specific parameter constellations.

In terms of the IS and LM-curve underlying the model equilibrium, Figure 4 shows that an increase in $\lambda$ causes bank money supply to fall so that the LM-curve shifts inward (the curves are drawn for $r_s = 0$ so that the interest rate spread is positive for all values of $r$). At the same time, the IS-curve flattens because banks finance a larger share of their balance sheet with equity, so that a change in the long-term interest rate now has a larger impact on their funding costs and lending rates. Combined with the inward shift in the LM-curve this leads to a decline in aggregate demand and an ambiguous change in the long-term interest rate.

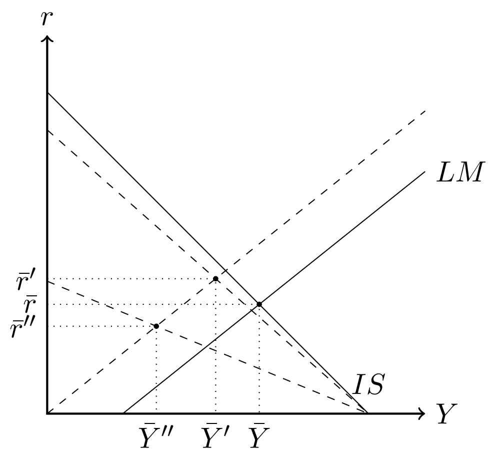


Figure 4: Equity requirement increase (drawn for $r_s = 0$)

### 3.4 Risk Premium Changes

The risk premium $\sigma$ changes when bank loans become riskier or when the market price of risk increases as investors become more risk averse. The impact of a change in the risk premium on aggregate demand equals:

$$\frac{\partial Y}{\partial \sigma} = -(b+f)Y_G < 0, \tag{18}$$

which is unambiguously negative. Furthermore, the impact on the long-term interest rate equals:

$$\frac{\partial r}{\partial \sigma} = -(b+f)\frac{d}{e}Y_G < 0, \tag{19}$$

which is negative as well. An increase in the risk premium thus depresses both aggregate demand and the long-term interest rate, as is illustrated in Figure 5.[15] Notably, the impact on aggregate demand is the same as the impact of a change in the short-term interest rate $r_s$, which implies that an increase in the risk premium has the same effect as a monetary contraction. This result is in line with Woodford's (2010) finding that monetary policy should respond to changes in financial market credit spreads.

### 3.5 Bank Equity Changes

To close this section, we examine the impact of changes in banks' money supply due to changes in the value of their equity. Taking the first order derivative of (12a) with respect to $E$ yields the impact of a change in bank equity on aggregate demand:

$$\frac{\partial Y}{\partial E} = (1 - sY_G)\frac{m}{d} > 0, \tag{20}$$

[15] Although it lowers the long-term interest rate, a rise of the risk-premium increases the bank lending rate. This result follows from observing that $\frac{\partial r_b}{\partial \sigma} = \lambda\frac{\partial r}{\partial \sigma} + 1 = sY_G$, which is larger than zero.

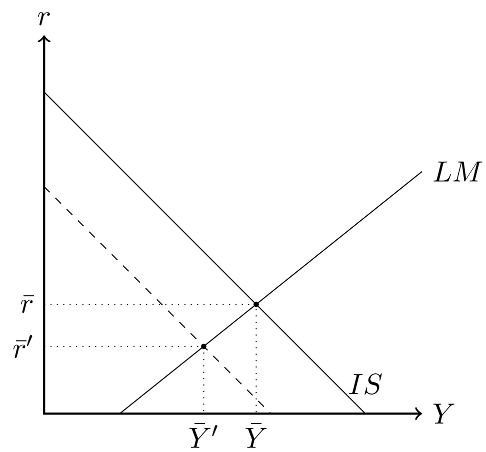


Figure 5: Risk premium increase

which is unambiguously greater than zero.[16] Moreover, if:

$$\frac{m}{d + sm} > Y_G,$$

the bank equity multiplier, $Y_E$ will be larger than the government spending multiplier $Y_G$. For example, if $s = 0.25$, $d = 0.5$ and $Y_G = 1$, the bank equity multiplier equals $1.5 * m$, with $m$ typically equaling about 30 (see, fn.7). As we outline in fn. 17 for all practical purposes, this inequality holds so that the bank equity multiplier is larger than the government spending multiplier.[17] This implies that for an equivalent increase of government spending and bank equity, the latter will have a larger impact on aggregate demand than the former.

We obtain the impact of a change in bank equity on the long-term interest rate by taking the first order derivative of (12b) with respect to $E$:

$$\frac{\partial r}{\partial E} = -\frac{sm}{e} Y_G < 0, \tag{21}$$

which is unambiguously negative. An increase in bank equity thus lowers the long-term interest rate. Comparing (21) and (14) and acknowledging that in practice $sm > d$ shows that, in absolute value, changes in bank equity $E$ have a larger impact on the long-term interest rate than equally large changes in deficit-financed government spending $G$. Indeed, for the parameter values used above, their impact differs by a factor $2 * m$.

[16] To see this, use (13) to observe that $sY_G \in (0, 1)$.

[17] To see this, consider that for $\lambda$ in the policy relevant range of 0.03 to 0.10, $m$ ranges from 32.3 to 9. Equating the marginal savings rate $s$ with the average savings rate implies that $s$ lies between 0.15 and 0.30 and has a worldwide average of 0.21 (World Bank, 2015). Viewing $d$ as the ratio of broad money (M3) to GDP suggests that $d$ lies between 0.5 and 0.65 for the U.S. (FRED, 2015). Setting $\lambda$, $s$ and $d$ to the maximum of their ranges implies that the inequality in the main text holds for any $Y_G \leq 2.7$, which is well above the upper bound suggested by Blanchard and Leigh (2013) who put the government spending multiplier between 0.9 and 1.7 worldwide. For any less extreme values for $\lambda$, $s$ and $d$, the cut-off value for $Y_G$ is even higher.

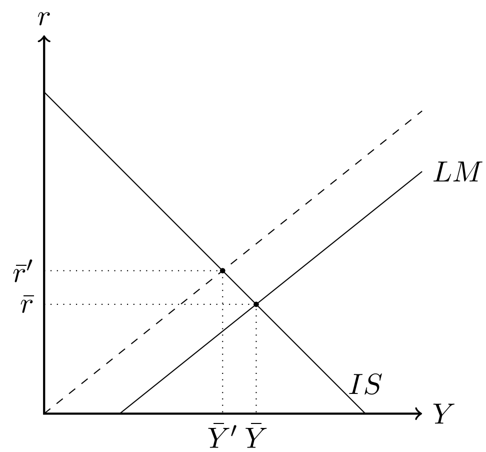


Figure 6: Bank equity decline

Figure 6 illustrates the impact of a decline in bank equity on the model equilibrium. The comparative statics of changes in bank equity highlight that bank equity is a prominent determinant of equilibrium outcomes. The intuition behind this effect is that a decline in bank equity reduces bank money supply to the real economy, which has a similar equilibrium impact as a reduction in central bank money supply in the textbook model. When compared to fiscal policy, changes in bank equity have a much more pronounced impact on aggregate demand and on the long-term interest rate than a deficit-financed increase in government expenditures.

### 3.5.1 The Liquidity Trap

Our analysis sheds new light on the liquidity trap and its impact on the efficacy of monetary and fiscal policy. In a liquidity trap an expansion of the money supply, which in our model results from an increase in $E$, is fully absorbed by an increase in money demand without lowering the interest rate on savings and investment, so that aggregate demand remains unchanged. Typically, e.g., Eggertsson (2008), this situation is associated with monetary policy being at the zero lower bound (see Section 3.2.2), as illustrated by Krugman's (1998) observation that "a liquidity trap may be defined as a situation in which conventional monetary policies have become impotent, because nominal interest rates are at or near zero." However, our model shows that both concepts differ markedly from each other. In particular, the economy is in a liquidity trap when $r = r_s$, as a further decline of $r$ then is infeasible as savers would start selling bank equity and hoard bank deposits (which also implies that the equilibrium term-spread implicit in (12b) cannot become negative).

The above implies that the liquidity trap causes the LM-curve to be horizontal at $r = r_s$. In our context, this can be modeled by letting $e = \infty$ in (8) if $r = r_s$. A change in the money supply through a change in $E$ then no longer affects aggregate demand or the long-term interest rate. Furthermore, viewing the government spending multiplier in (13), a fiscal expansion now becomes particularly potent – having an impact on aggregate demand equal to $1/s$. However, with the LM-curve being flat there is no impact of fiscal policy on the long-term interest rate. Surprisingly, the impact of monetary policy on aggregate demand is enhanced in tandem with the impact of fiscal policy, which follows from observing that (15) is a fixed multiple of the government spending multiplier. In addition, as $r = r_s$ implies that $r_b = r_s + \sigma$, a change in the monetary policy rate translates into a one-for-one adjustment of all other interest rates.

Compared to the zero lower bound in Section 3.2.2, which hinders monetary policy by imposing a constraint $r_s \geq -\pi^e$ on the short-term interest rate, the liquidity trap imposes a constraint $r \geq r_s$ on the long-term interest rate and causes the efficacy of both fiscal and monetary policy to be enhanced. Hence, while similar in spirit, the zero lower bound and the liquidity trap are distinct concepts with both their own consequences. Notably, the common view that a liquidity trap renders monetary policy powerless hinges crucially on the assumption that this policy is implemented through changing the money supply, and vanishes when taking into account that monetary policy involves changing the short-term interest rate.

# 4 The Global Financial Crisis

Using the insights collected above we now apply our model to the 2007 Global Financial Crisis (GFC) and the ensuing Great Recession. We structure the analysis by distinguishing between i) the run-up to the crisis, ii) the outbreak of the crisis, iii) the policy response to the crisis, and iv) the aftermath of the crisis. For future reference, Figure 7 depicts the main developments in bank equity, GDP growth, and the risk-free long-term interest rate during these periods, with the shaded area indicating the two years following the crisis outbreak in mid-2007. We adopt this stylized distinction between crisis phases for narrative purposes and acknowledge that the actual chain of events is of course less clear-cut.

## 4.1 Run-up to the Crisis

The years preceding the 2007 GFC were characterized by a steady decline in long-term interest rates and a marked increase in bank risk-taking (e.g., Brunnermeier, 2009). Indeed, banks managed to increase their risk profiles by engaging in off-balance sheet activities that remained largely unregulated. A notable example is the originate-to-distribute model in which banks transferred mortgage, car and student loans to the balance sheets of special purposes vehicles. These entities, which were not subject to banking regulation, held almost no equity buffers and financed themselves by issuing short-term debt. These debt instruments provided their buyers with an important source of money as they could be traded easily in financial markets. By boosting profitability, the originate-to-distribute model contributed to an exceptionally

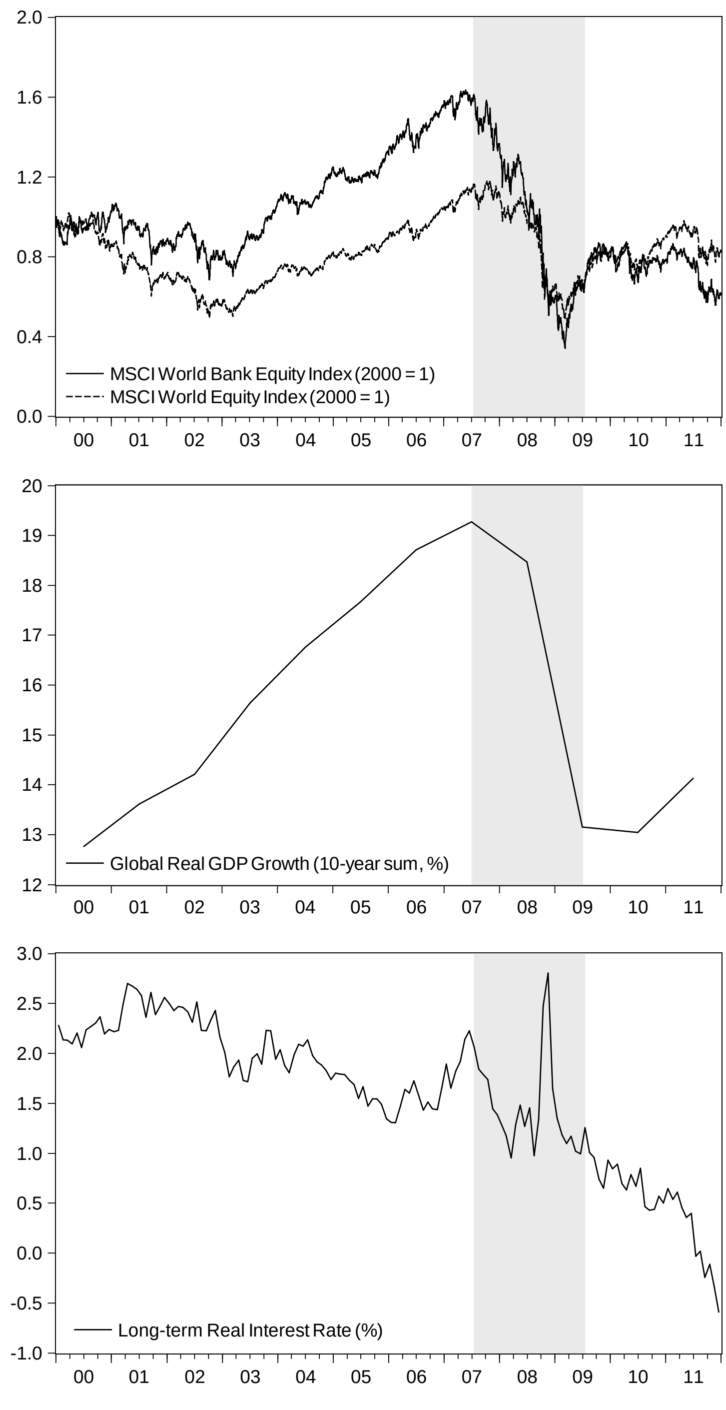


Figure 7: Macroeconomic Developments

The top panel displays the MSCI World Banking Equity Index and includes the MSCI World Equity Index for comparison. The middle panel displays growth per decade of global real GDP per capita, obtained from the World Bank's Global Development Indicators. The lower panel displays the long-term real interest rate, measured as the 10-year yield on inflation-indexed triple-A U.K. treasury bills (which is available for a longer time period than similar statistics for the U.S.). The shaded area comprises the two-year period starting mid-2007.

large increase in the total value of bank equity. The MSCI World Banking Index rose by 65% between 2000 and its in peak in May 2007, while the MSCI World Index as a whole only increased by 15% in the same period - a 50 percentage point difference.

Within our framework, higher bank risk taking can be modeled as a reduction in bank equity requirements $\lambda$. This reduction was not, however, due to regulatory reform, but was a consequence of banks' increasing ability to circumvent equity requirements through regulatory arbitrage. As we know from Section 3.3 lower equity requirements boost aggregate demand. The resulting increase in bank equity values can be interpreted as an increase in $E$ within our model. As is borne out by Section 3.5, this provides a strong (i.e., larger than an equivalent change in government expenditures) boost to aggregate demand and depresses the long-term interest rate.[18]

The above discussion suggests an alternative explanation for the secular decline in the long-term interest rate in the run up to the GFC. In their statements before the U.S. Financial Crisis Inquiry Commission, Bernanke (2010) and Greenspan (2010) attribute this decline to an increase in savings relative to investments – especially in emerging markets. In addition, the IMF (2014) considers increased demand for safe assets to have been an important factor, and also explores the potential contribution of fiscal and monetary policy. Supplementing these views, our model suggests that the decline in long-term rates can also be driven by an increase in bank money supply, e.g., through the supply of liquid asset backed securities, made possible by rising bank equity values. While various studies (e.g., Rajan, 2006) have argued that banks increased their risk-taking in response to low long-term interest rates, our model suggests that bank behavior may be at the root of these low rates as well. Moreover, the discussion of the interest rate conundrum in Section 3.2.1 highlights why monetary policy was ineffective in offsetting the decline in long-term interest rates, even though it probably had a dampening effect on aggregate demand.

### 4.2 Outbreak of the Crisis

The 2007 GFC was triggered by the realization that U.S. house prises had become unsustainably high and that, therefore, U.S. mortgage backed securities were worth substantially less than initially thought. This became increasingly clear in June 2007 when investment bank Bear Stearns needed to bail out two of its hedge funds that were heavily exposed to the U.S. housing market. Financial turmoil continued as the market for asset backed securities became illiquid and Lehman Brothers, another investment bank, collapsed in September 2008. Eventually it was not before the first half of 2009 that the value of bank equity started to show some upward movement again.

[18] For a plausible parameterization of our model, looser bank equity requirements put negative pressure on the long-term interest rate as well. Results available on request.

Within our model the outbreak of the crisis can be seen as a sharp drop in bank equity $E$ combined with increases in $\lambda$ as investors are only willing to finance banks with relatively high equity buffers (a 'wake-up call').[19] As before, the impact of a decline in $E$ can be analyzed with reference to Figure 6, which highlights the sharp decline in aggregate demand after a decline in bank equity. This decline in aggregate demand is further aggravated by the increase of $\lambda$. In addition, the drop in $E$ contributes to an increase in the long-term interest rate, which could have been aggravated by the increase in $\lambda$ (see, fn.18).

Casual calculations using our model go some way in explaining why a small decline in bank equity could have such a large impact on aggregate demand. Consider, for instance, the case where the size of the aggregate balance sheet of the banking sector equals total output: $L = Y$. In this case a one-percent loss on bank assets implies a decline in bank equity equal to one percent of aggregate demand. This, in turn, has two consequences. First of all, for $\lambda = 0.03$ it implies that bank equity loses one third of its value, which may explain the sharp drop in bank equity values displayed in Figure 7. Second, from (20) we know that for $s = 0.25$, $d = 0.5$ and $Y_G = 1$, a decline of bank equity equal to one percent of aggregate demand multiplies into a fall of aggregate demand by $1.5 * m \approx 45$ percent. Of course, this number is inflated by our assumption that all money supply and intermediation of savings and investments operates through the banking sector. However, it highlights why a decline in banking sector equity could have had the depressing effect on the real economy displayed in the middle panel of Figure 7. In addition, the sudden decline in bank equity after the Lehman collapse was associated with a drastic reduction of bank money supply and a shutdown of the money market, which helps explain the spike in the long-term interest rate observed in the lower panel of the figure.

### 4.3 Policy Response to the Crisis

In response to the turmoil in financial markets, the Federal Reserve started to lower the Federal Funds Target Rate in September 2007. After initially reducing the Target Rate by 50 basis points, the Federal Reserve steadily reduced the rate further, eventually hitting the zero lower bound in December 2008. In tandem with the actions of the Federal Reserve, also the European Central Bank and the Bank of England both reduced their Target Rates, eventually hitting the zero lower bound as well. In spite of these large and concerted monetary expansions, the international banking sector remained notoriously unstable. Hence, in order to restore stability, policy makers required banks to recapitalize either by forcing them to withhold dividends and/or issue new shares or by bailing them out directly (e.g., Northern Rock, ABN-Amro, and Citigroup).

[19] See also Eggertsson and Krugman (2012) for an analysis of a sudden exogenous decline in the acceptable level of leverage – a so-called Minsky moment.

First of all, within our model the unprecedented reductions in monetary policy rates can be analysed as a decline in the short-term interest rate $r_s$. Section 3.2 reveals that this causes and outward shift of both the LM and IS-curve leading to upward pressure on aggregate demand and to an ambiguous impact on the long-term interest rate. In light of the sharp contraction in aggregate demand experienced during the crisis, the reduction in the short-term interest rate necessary to restore the pre-crisis level of demand is likely to be extensive. In fact, monetary policy rates may well hit the zero lower bound before aggregate demand has been restored.[20]

Second of all, with the interest rate at the zero lower bound, the alternative option for policy makers was to provide large scale direct support to the banking sector. Such support occurred through asset purchases and guarantees but also very explicitly through bank bailouts. Within our model this can be considered as a direct injection by the government of equity $E$ into the banking sector.In principle, in order to restore aggregate demand through a capital injection, the amount injected should equal the amount lost during the crisis, hence neutralizing the effect. However, as the crisis triggered bank financiers to demand higher equity buffers than before, the actual bail out necessary is larger than the equity loss incurred during the crisis. Still, it is much smaller than the increase in government expenditure that would be required to restore aggregate demand using a conventional fiscal expansion (see the discussion in Section 3.5). Bank bailouts may thus be a particularly powerful tool for restoring aggregate demand in the wake of a financial crisis.[21]

The above discussion sheds new light on why the drastic reduction of monetary policy rates toward the zero lower bound did not prevent a marked shortfall in economic activity. While fiscal consolidations are sometimes presented as culprits for the decline in aggregate demand, depressed bank equity values are likely to have contributed to such a decline as well. In fact, even by the start of 2015, despite several bank recapitalization rounds, bank equity values were still 46 percent below their pre-crisis peak, while since then the MSCI World Index experienced a growth of 6 percent.

### 4.4 Aftermath of the Crisis

The slow recovery after the GFC not only reflects a decline in bank money supply but has also been attributed to depressed credit growth. While to some extent lower credit supply was a correction of pre-crisis excesses, policy makers worried that a credit crunch could impede the economic recovery. Hence, in November 2008, the Federal Reserve announced that it would start buying U.S. mortgage backed securities in financial markets in order

[20] As reserve requirements are absent, our model does not have a role for the increase in reserves supplied by central banks to stabilize the financial sector. This is in line with Kydland and Prescott's (1990) observation that central banks at all times provide any desired amount of reserves to the financial sector. In that sense, the promise by central banks after the Lehman collapse to provide unlimited reserves to the banking sector simply confirms normal policy.

[21] Naturally, the moral hazard implications of both policies are quite different.

to boost credit availability – the so-called credit easing program. Since then, the Federal Reserve accumulated over 1.5 trillion dollars worth of mortgage backed securities, which has contributed substantially to the decline of U.S. mortgage rates (Hancock and Passmore, 2011). In addition, in March 2009 the Federal Reserve expanded the program by buying what would end up to be 2.5 trillion worth of U.S. Treasury securities so as to combat sliding inflation expectations – the so called quantitative easing program. Likewise, the European Central Bank and the Bank of England adopted similar policies as well.

Our model can be used to analyze a credit crunch by focusing on the risk premium $\sigma$ and on inflation expectations $\pi^e$, the latter of which were introduced in Section 3.2.2. The risk premium may have risen once the crisis alerted shareholders that bank loan portfolios are less safe then they thought, or once declining asset values trigger an increase in the market price of risk. Such an increase in the risk premium causes the IS-curve to shift inward, which lowers both aggregate demand and the long-term interest rate. In fact, the impact on aggregate demand of an increase in risk premiums is as large as the impact of a comparable increase in the short-term interest rate. In addition, with monetary policy stuck at the zero lower bound, the drop in inflation expectations $\pi^e$ effectively raised the short-term interest rate $r_s$.

The above discussion helps to understand the slow recovery in the aftermath of the crisis. The observed increase in risk premiums $\sigma$ and the decrease in inflation expectations $\pi^e$ are likely to have depressed aggregate demand, while the increase in risk premiums depressed the long-term interest rate.[22] The observed decline in long-term rates should thus not be automatically interpreted as evidence that bank lending rates came down as well, but could signal that lending rates increased due to higher risk premiums. To the extent that central banks' large scale asset purchases offset the increase in risk premiums and the decline in inflation expectations they contributed to raising aggregate demand. Still, the analysis suggests that the current anemic state of the economy is likely to persist until risk premiums, inflation expectations and bank equity values are restored to their pre-crisis levels.

# 5 Conclusion

A caveat of the recent surge of interest in understanding the role of banks in the macroeconomy is the complexity of the modeling frameworks available. Indeed, various observers have pointed out that state of the art macroeconomic models can be too complicated for even the sophisticated reader to grasp the essence of economic policy making. The present paper therefore complements the literature by integrating a banking sector in a descriptive macroeconomic model that is accessible to the broader academic community as well as to informed policy makers. Our starting point was the classic Keynesian aggregate demand set-up, which is known for its "principal virtue [...] that many students and policy makers

[22] The decline in inflation expectations has the same ambiguous effect on the long-term rate as an increase in the short-term rate $r_s$.

with little or no previous experience can, after some effort, master its mechanics, understand its intuition, and apply it to novel situations" (Romer, 2000). What results is an easy to use analytical framework that demonstrates its worth by providing alternative explanations for key developments observed around the Global Financial Crisis and the ensuing Great Recession. As such, we hope that the model can assist policy makers, academics and students in thinking about the interaction between banking and the business cycle.

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## Appendix: Derivations

This appendix contains the derivations of the impact on aggregate demand and the long-term interest rate of changes to bank equity requirements. To derive the impact of changes in the equity requirement $\lambda$ on aggregate demand begin by observing that the IS-curve can be written alternatively as:

$$Y = \frac{1}{s}\left(\bar{I} + G - (b+f)r_s - (b+f)\,\lambda(r - r_s + \sigma)\right), \tag{A.1}$$

so that for a positive interest rate spread $r - r_s$, an increase in the equity requirement lowers aggregate demand. Turning to the LM-curve, which is given by:

$$Y = \frac{e}{d}r + \frac{m}{d}E - \frac{e}{d}r_s, \tag{A.2}$$

and using the definition $m \equiv \frac{1-\lambda}{\lambda}$, which implies that $\frac{\partial m}{\partial \lambda} = m_\lambda < 0$ reveals that the impact on aggregate demand emanating from the LM-curve is:

$$\frac{\partial Y}{\partial \lambda} = \frac{m_\lambda}{d}E < 0. \tag{A.3}$$

Hence, in the both the IS and the LM-curve the increased equity requirements decrease aggregate demand, which allows us to conclude that equilibrium aggregate demand declines as equity requirements are tightened. This establishes the result mentioned in the main text.

To observe the ambiguity of the relationship between the interest rate and $\lambda$ observe that the interest rate spread is given by:

$$r - r_s = \frac{d}{d\,(b+f)\,\lambda + es}\left(\bar{I} + G - (b+f)\,(r_s + \sigma) - \frac{sm}{d}E\right). \tag{A.4}$$

As $r_s$ is, by definition, unaffected by changes in $\lambda$, any change in the spread due to a change in $\lambda$ must be absorbed by changes in $r$. While the fraction in front of the brackets is negatively affected by an increase in $\lambda$, the term between brackets is positively affected. Hence, the full impact depends on the exact parameter values.

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