Financial accelerator and the zero lower bound on interest rates*

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Abstract

Recent developments in Canada, England, the Euro Area, Japan, Sweden, Switzerland and the United States have trigger a debate on whether monetary policy is effective when the nominal interest rate is close to zero. In this context, the monetary authority is no longer in a position to pursue a policy of monetary easing by lowering nominal interest rates. However, some economists have down-sized the risk of a binding zero lower bound, at least for the US economy.

In this paper, I assess the implications of the zero lower bound in a DSGE model with financial frictions. The financial accelerator mechanism is formalized as in Bernanke, Gertler and Gilchrist (1995).

The paper attempts to address four main issues.

First, I assess whether the economy might more likely to embark in a recessionary path when the financial accelerator mechanism is operative.

Second, if financial frictions matter, I evaluate whether the zero lower bound – by limiting the use of the nominal interest rate as a policy instrument – might hamper the monetary authority from offsetting the negative effects of an adverse shock.

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Third, I analyze whether the price-level targeting, through the stabilization of private sector's expectations, might be a better monetary rule than inflation targeting in order to avoid the "liquidity trap".

Fourth, I investigate the effectiveness of fiscal stimulus (namely, an increase in government expenditure) when financial markets are imperfect and the nominal interest rate is close to its zero lower bound. In this context, two questions should be address: first, do financial frictions weaken the effect of a fiscal expansion? Second, how results are transformed when the zero lower bound is binding?

To address these questions, I introduce a negative demand shock (i.e. a risk premium shock) and an adverse financial shock. I find that in the model with financial frictions, when the nominal interest rate is lower-bounded, the initial impact of a negative shock is amplified and the economy is more likely to embark on a recessionary path. By adopting a price-level targeting rule, the monetary authority might alleviate the recession generated by the interaction of financial frictions and lower-bounded nominal interest rates. Alternatively, an increase in government expenditure has a positive impact on output, but fiscal multipliers are below one, due to a strong crowding-out effect of private consumption. This effect is muted when the nominal interest rate is lower bounded. In analyzing discretionary fiscal policy, this paper does not neglect two crucial aspects: the duration of the fiscal stimulus and the presence of implementation lags.

JEL classification: E31, E44, E52, E58.

Keywords: Optimal monetary policy, financial accelerator, lower bound on nominal interest rates, price-level targeting, fiscal stimulus.

Contents

Non-technical summary

Recent macroeconomic developments in major industrialized economies such as the United States, the Euro Area, Japan and England, have crucially brought a renewed emphasis on the effectiveness of monetary policy when the nominal interest rate is close to zero. In such a context, the monetary authority is no longer in a position to pursue a policy of monetary easing by using its traditional policy instrument. However, some economists have down-sized the risk of a binding zero lower bound. For instance, according to Coenen Orphanides & Wieland (2003) and Schmitt-Grohe and Uribe (2007), the probability of the nominal interest rate approaching the zero bound in US is negligible.

The purpose of this paper is three-fold. First, I analyze the extent to which the presence of financial frictions does affect the probability of hitting the zero lower bound on nominal interest rates. Then, starting from a model with financial frictions, I assess the implication of the zero lower bound on the nominal interest rate. Finally, I appraise whether there is a room for macroeconomic policies to escape or down-size the effects of the zero lower bound.

The structure of the model is a closed economy DSGE model which contains standard features, such as investment adjustment costs and sticky prices. In addition, I add financial frictions that are formalized as in Bernanke Gertler and Gilchrist (1995) and Bernanke and Gertler (1989, 1998). The source of the financial accelerator is the asymmetric information that will make costly for lenders to evaluate the quality of firm's investments. Therefore, lenders require a premium for external funds over the real opportunity

costs equivalent to the riskless interest rate. In the short run, the presence of a financial risk premium distorts the dynamic allocation of capital and investments and leads to inefficiently low level of capital, and hence output. The underlying mechanism works in the following way. An adverse shock lowers current cash flows, reducing the ability of firms to self-finance investment projects. This decline in net worth raises the average external finance premium and the cost of new investments. Declining investments lower economic activity and cash flow in subsequent periods, amplifying and propagating the effect of the initial shock. In such a framework, the presence of financial frictions in conjunction with a zero lower bound constraint on nominal interest rates might have valuable implications for the dynamics of the economic recovery after a negative shock. As a fact, in the face of an adverse shock that pushes the premia upward, it could be appropriate to lower the nominal interest rate in order to mitigate – at least partially – the recession. This may not be possible if the zero lower bound on nominal interest rates starts to bind.

The framework of this paper is closely related to work by Christensen and Dib (2006). My original contribution is that I evaluate the implications of the zero lower bound. Furthermore, I appraise the effectiveness of macroeeconomic policies in avoiding the "liquidity trap" and stimulating the economy. In order to easily insulate the effect of the zero lower bound in the conduct of monetary policy, I decide to analyze this issue in a closed economy. In such a framework, the monetary economy is implemented *via* interest rates. Therefore, other transmission channels that are normally operating in an open economy (e.g. the exchange rate, as suggested by Svensson) are not at work.

The paper attempts to address four main issues. First, I investigate whether the zero lower bound is more likely to be hit when the financial accelerator mechanism is operative. Second, if financial frictions matter, I evaluate whether the zero lower bound – by limiting the use of the nominal interest rate as a policy instrument – might hamper the monetary authority from offsetting the negative effects of an adverse shock. Third, I analyze whether the price level is a better target than inflation in order to avoid the "liquidity trap" that might be generated by a binding zero lower bound. The motivation is the following: when agents are forward-looking and the monetary authority credibly commits to a price-level targeting rule, private sector's expectations work as automatic stabilizers. Therefore, the initial disinflation – and hence the variability of the interest rates – are dampened. Fourth, I investigate the effectiveness of fiscal policies when financial markets are imperfect and interest rates are very close to the lower bound. I believe that it is a relevant issue to explore because, to face with the prospect of a severe global recession started in 2008-2009, many governments have put forward plans of massive fiscal stimulus in order to recover the economy. However, many developed economy, such as US are experiencing low interest rates that fuel the risk of embarking in a liquidity trap. In this context, two question should be address: first, do financial frictions weaken the effect of a fiscal expansion? Second, how results are transformed when the zero lower bound is binding?

To address these issues, I introduce two types of shocks: a negative demand shock (e.g. a risk premium shock) and a financial shock. Intuitively, these types of shocks, putting downward pressure on both output and inflation, can cause a binding zero lower bound. The output will fall, resulting in lower inflation in the same period. Both effects are translated into a lower nominal interest rate. Furthermore, this type of shocks worsen entrepreneurial balance sheets and hence trigger the financial accelerator mechanism.

Four main findings are worth to be highlighted. First, the presence of financial frictions result to bring closer a binding zero lower bound. Second, in the model with financial frictions, when the zero lower bound is binding, the real interest rate is limited in its possibility to recover the economy, after a negative shock. Furthermore, as the real interest rate can not freely decrease, the payment of interests on the existing debt are tightened. These two effects worsen the entrepreneurial balance sheets and hence magnified the recession. Third, when the central bank adopts a price-level targeting rule (instead of an inflation targeting rule), the probability to hit the lower bound is reduced. The logic underlying this result is that when agents are forward-looking and the monetary authority credibly commits to a price-level targeting rule, such a rule yields lower variability of inflation and of nominal interest rates. Agents expect that the monetary authority will correct the deviation from the target, aiming at an above-average inflation rate. Private sector's expectations of a future inflation after a deflationary shock dampen the initial disinflation and hence stabilize interest rates. Fourth, an increase in government expenditure has a positive impact on output, but fiscal multipliers are below 1, due to a strong crowding-out effect of private consumption. The zero lower bound increases the fiscal multipliers substantially: when the nominal interest rate is lower bounded, the government spending multiplier is larger than one. This result is consistent with the most recent literature. Indeed, the duration of fiscal stimulus turns out to be a crucial aspect to take into account in implementing fiscal policy, especially when the nominal interest rate is close to the zero lower bound. I find that a permanent fiscal stimulus is less effective than a temporary one, if it occurs as long as the zero lower bound is still binding. Instead, if it continues beyond the period at which the zero lower bound ceases to bind, then it has even contractionary effects on output. Moreover, it has often been argued that one of the disadvantages of discretionary fiscal policy is the it is not timely, due to implementation lags. I find that if government spending is delayed but still comes on line in future periods when the nominal interest rate is zero, the effects on output remain quite large. Nevertheless, the stimulative effects on output are weaken than those generated by a "timely" fiscal intervention. A further step will be to work in the direction of distinguish several types of fiscal instruments.

1 Introduction

For several decades, many central banks around the world have enacted disinflationary policies and have successfully brought down inflation. As a consequence, during last years interest rates have resulted to be so low that to brought the potential threat of deflation and a binding zero bound on nominal interest rate into focus. In this context, the monetary authority is no longer in a position to pursue a policy of monetary easing by lowering nominal interest rates.[1] By the second quarter of 2009, policy interest rates will have fallen below one percent in Canada, England, the Euro Area, Sweden, Switzerland and the United States. The Japanese example offered the most considerable case: since late 1990s, Japan have experienced deflation and a short rate very close to zero leaving monetary policy almost helpless to boost economic activity. These developments have trigger a debate on whether monetary policy is impotent at the zero bound.

However, some economists have downsized the risk of a binding zero lower bound, at least for the US and the Euro Area (Viñals (2001); Coenen Or-

[1]Under these circumstances, monetary policy may still be effective via other transmission channels than nominal interest rates. Therefore, a binding zero lower bound is a necessary but not a sufficient condition for the liquidity trap to prevail. I follow Buiter & Panigirtzoglou (2000) in their definition of a liquidity trap. An economy is said to be in a liquidity trap if all channels of monetary transmission are blocked. Only in one case, the liquidity trap and the zero bound on nominal interest rates are identical concepts. This applies if the nominal interest is the only monetary transmission channel.

phanides & Wieland (2003); Schmitt-Grohe and Uribe (2007)). This strand of literature does not take into account the role played by financial frictions.

The purpose of this paper is to analyze the extent to which the presence of financial frictions does affect the probability of hitting the zero lower bound on nominal interest rates. The structure of the model is a closed economy DSGE model which contains standard features, such as investment adjustment costs and sticky price. In addition, I add financial frictions that are formalized as in Bernanke Gertler and Gilchrist (1995) and Bernanke and Gertler (1989, 1998). The source of the financial accelerator is the asymmetric information that will make costly for lenders to evaluate the quality of firm's investments. Therefore, lenders require a premium for external funds over the real opportunity costs equivalent to the riskless interest rate. In the short run, the presence of a financial risk premium distorts the dynamic allocation of capital and investment and leads to inefficiently low level of capital, and hence output. The underlying mechanism works in the following way. An adverse shock lowers current cash flows, reducing the ability of firms to self-finance investment projects. This decline in net worth raises the average external finance premium and the cost of new investments. Declining investments lower economic activity and cash flow in subsequent periods, amplifying and propagating the effect of the initial shock. The presence of a binding zero lower bound constraint on nominal interest rates might further enhance the recessionary spiral triggered by the financial accelerator mechanism. In the face of an adverse shock that pushes the premia upward, it could be appropriate to lower the nominal interest rate in order to mitigate – at least partially – the recession. This may not be possible if the zero lower bound on nominal interest rates starts to bind.

The paper attempts to address four main issues. First, I investigate whether the zero lower bound is more likely to be hit when the financial accelerator mechanism is operative. Second, if financial frictions matter, I evaluate whether the zero lower bound might strengthen the effects of a negative shock by hampering the monetary authority from offsetting the negative effects of an adverse shock. Third, I investigate how monetary policy should intervene in order to make the zero lower bound less binding. To this extent, I analyze whether the price level is a better target than inflation in order to avoid the "liquidity trap" that might be generated by a binding zero lower bound. The motivation is the following: when agents are forward-looking and the monetary authority credibly commits to a price-level targeting rule, private sector's expectations work as automatic stabilizers. Therefore, the initial disinflation – and hence the variability of the interest rates – are dampened. Fourth, I investigate whether fiscal policy can alleviate the effects of a binding zero lower bound constraint. To this purpose, I assess the effectiveness of fiscal policies when financial markets are imperfect and interest rates are very close to the lower bound. I believe that it is a relevant issue to explore because, to face with the prospect of a severe global recession started in 2008-2009, many governments have put forward plans of massive fiscal stimulus in order to recover the economy.[2] However, many developed

[2]To list some examples: the American Recovery and Reinvestment Act in the United States; the "Konjukturpakete I und II" in Germany; the "Plan de reliance"in France; The "Pacchetto fiscale"in Italy; the "El Plan E."in Spain; the pre-Budget Report in United Kingdom.

economy, such as US are experiencing low interest rates that fuel the risk of embarking in a liquidity trap. In this context, two question should be address: first, do financial frictions weaken the effect of a fiscal expansion? Second, how results are transformed when the zero lower bound is binding?

To address these issues, I introduce two types of shocks: a negative demand shock (e.g. a risk premium shock) and a financial shock.[3] Intuitively, these types of shocks, putting downward pressure on both output and inflation, can cause a binding zero lower bound. The output will fall, resulting in lower inflation in the same period. Both effects are translated into a lower nominal interest rate.

The paper is structured as follows. In section 2, I present an overview of the existing literature. I develop the model in section 3. In section 4, I assess the relevance of the lower bound on the nominal interest rate. I start from a baseline model without financial frictions and then I investigate whether the introduction of the financial accelerator makes the lower bound constraint more likely. Robustness of results is checked by evaluating the probability of hitting the zero lower bound under alternative optimal Ramsey monetary policies. Then, in section 5, I proceed investigating whether the lower bound enhances the negative effects of an adverse shocks. In section 6 and section 7, I discuss the role played by monetary and fiscal policy when the zero lower bound is binding. More precisely, in section 6, to evaluate the role of the monetary policy, I assess whether the price level is a better target than

[3]I point out that the financial shock is not eligible for comparing the baseline model with financial frictions with the alternative model specification that does not allows for financial frictions.

inflation in order to avoid a "liquidity trap" generated by a binding zero lower bound. In section 7, I introduce an exogenous government spending shock in order to appraise the role of the fiscal stimulus. I provide an assessment of the use of fiscal stimulus to achieve full recovery from a severe recession when the potency of monetary policy weakens after hitting its zero interest-rate bound. To this purpose, first I investigate how fiscal multipliers are affected by the presence by the introduction of financial frictions. Then, I also assess whether fiscal multipliers are larger when the zero lower bound on nominal interest rate is binding. Section 8 provides concluding remarks and outlines further extensions that can be addressed in future works.

2 Review of literature

Recently, several papers have analyzed the implication of zero lower bound on nominal interest rates in the conduct of the optimal monetary policy. In this section I first overview part of the theoretical literature on the zero lower bound; then I present some works on the empirical or historical evaluation of issues related to the zero lower bound.

From a theoretical point of view, four main strands of the literature can be distinguished to discuss the zero lower bound.

The first one has been pioneered by Krugman (1998) who has emphasized the importance of lifting expected inflation in order to reduce the real interest rate. In this view, two possible solutions have been proposed.

The first way to lift inflation expectations is to set a history-dependent rule, such as a price-level target rule[4] or a super-inertial rule, that would be able to control the expectations and hence would deliver a lower variability in the nominal interest rate and inflation. Similarly, Svensson (2000) and Smets (2000) argue that price-level targeting might be a better way to anchor expectations than an inflation target. Reifschneider and Williams (2000) show that simple policy rules formulated in terms of a price-level target can significantly reduce these real distortions associated with the zero lower bound on interest rates. Eggertsson and Woodford (2003) consider a simple stochastic setup in which the economy never falls into a liquidity trap. They show that a credible commitment to the right sort of history-dependent policy can largely mitigate the distortions created by the zero bound. In their model, optimal policy involves a commitment to adjust interest rates so as to achieve a time-varying price-level target, when this is consistent with the zero bound. They characterize the optimal economy in such a setting and they show that it indeed involves a commitment to a history-dependent policy. In particular, price-level target commits the central bank to undo any deflation by subsequent inflation; a larger disturbance, that creates a larger initial deflation, automatically creates greater inflation expectations in response. Thus, there is an "automatic stabilizer" built into the price-level target, that is lacking under a strict inflation targeting regime.

A second way to lift inflation expectations is to choose an positive inflation target (around 2%).[5] Nevertheless, Svensson (2000) argues that the

[4]Duguay (1994) and Coulombe (1998) also document that a price level target path implies expectations to help resisting deflation and profund downturns if the economy falls into a zero lower bound situation.

[5]Stochastic simulations with macroeconometric models suggest that, at an average

mere announcement of an positive inflation target is not likely to be enough to fuel inflationary expectations. Coenen Orphanides & Wieland (2003) also criticizes this argument, asserting that it might also be difficult to raise inflationary expectations because price stickiness can make the expected future price also sticky.

To conclude, according to this first strand of literature, the key to effective central-bank action to escape a "liquidity trap" and to combat a deflationary slump is the management of expectations.

The second strand of literature buds from Buiter & Panigirtzoglou (2000) and Goodfriend (2000) who have suggested the introduction of so-called Gesell money. This would imply decreasing the zero nominal interest floor by taxing money.

A third theoretical approach has been proposed by Svensson (2001). He suggests a "foolproof " way to escape from the binding zero lower bound in an open economy framework. The idea is to jump-start the economy by a real depreciation of the currency via unlimited interventions and in so doing increase inflationary expectations. Initially, an exchange rate peg is established, which is later replaced by a price-level or inflation target when the price-level target has been reached. In so doing the risk of overheating is avoided.

Finally, Christiano (2004) opens the way for a fourth approach to the problem of the zero lower bound. He extends the analysis of Eggertsson and

inflation rate of 2%, the fraction of time spent at the zero lower bound is likely to be around 2%. And even for an average inflation rate of 1%, the corresponding figure is only up to around 5%. For further details, see the studies surveyed in Yates (2003)

Woodford (2003) and shows that, when capital and government spending are introduced into the analysis, the zero bound is not likely to bind, and if it does the consequences may not be severe. Moreover, the multiplier on government spending is predicted to be very large in the event of a binding zero bound, so that an increase in government spending should help substantially to recover the economy when monetary policy is not fully active due to the zero bound on nominal interest rate. Similar conclusions are reached by Christiano, Eichenbaum and Rebelo (2009) and Erceg and Linde (2009) in more recent works. They argue that the spending multiplier can be much larger than in the normal situation if the liquidity trap is very persistent, and fiscal stimulus can be rapidly implemented. Moreover, the budgetary costs may be minimal as the large response of output boosts tax revenues, allowing for something close to a "fiscal free lunch."

Concerning the empirical or historical evaluation of issues related to the zero lower bound, the literature is copious. Some authors have down-played the risk of hitting the zero lower bound, at least for the Euro Area and the US. According to Coenen, Orphanides & Wieland (2003), the risk of hitting the zero bound would be negligible for the US with an average nominal interest rate over the cycle of 3%. To get this result, they use stochastic simulations of a small structural rational expectations model. They suppose stochastic shocks similar in magnitude to those over the 1980s and 1990s. Only with a lower level of the average nominal interest rate, they found a significant risk of a binding zero bound. Using a similar model, Viñals (2001) has compared the US and the Euro Area chance of hitting the zero lower bound. His findings for the US are more or less in line with those of

Coenen Orphanides & Wieland (2003). For the Euro Area, his results suggest an even smaller chance than for the US of hitting the zero lower bound, due to the structural characteristics of the Euro Area. However, the probability of a binding zero lower bound depends on the likelihood of a combination of extreme shocks. Since the frequency of such shocks is limited, they are hard to assess econometrically. Schmitt-Grohe and Uribe (2007) analyze the zero bound problem in a medium-scale DSGE model (calibrated to US data) with distortionary taxes and three shocks: aggregate productivity, investment-specific productivity, and government spending shocks. They conclude that the probability of the nominal interest rate approaching the zero bound is negligible. Christiano (2004) argues that additional research allowing for a broader range of shocks may improve our understanding of the factors that occasionally force central banks to face the zero bound on nominal interest rates. Starting from this argument, Amano and Shukayev (2009) consider a broader range of economic shocks. Their results indicate that even under a zero inflation policy, historically-measured aggregate shocks - such as productivity, investment-specific productivity, government spending and money demand shocks - do not drive the nominal interest rate to its zero bound. The only shock in our analysis that forces the central bank to face the zero bound is a risk premium shock.

Moving to an open economy context, Bodenstein Erceg and Guerrieri (2009) analyze the transmission of foreign demand shocks to the US economy using a two-country DSGE model. They find that when interest rates are bounded, the impact of an adverse foreign demand shock on the United States is greatly amplified. If the shock occurs against the backdrop of a liquidity trap in the US, the output contraction is mainly attributable to rising real interest rates, as short-term nominal rates remain frozen while expected inflation falls. As a result, the contraction in net exports associated with weaker foreign demand is reinforced by a sharp contraction in private domestic demand. On the contrary, in the "normal" situation in which policy rates can freely adjust, lower real interest rates would cause private domestic demand to expand, and hence cushion the impact on US output.

Finally, I mean to point out that most of the existing literature considers a stochastic backward-looking setup. Adam and Billi (2004) analyze the optimal policy under commitment in a fully stochastic and forward-looking model. They argue that optimal policy reacts to a binding zero lower bound on nominal interest rates by generating inflationary expectations in the form of a commitment to let future output gaps and inflation rates increase above zero. The policy-maker thereby effectively lowers the real interest rates that agents are confronted with. Since reducing real rates using inflation is costly (in welfare terms), the policy-maker has to trade-off the welfare losses generated by too high real rates with those stemming from higher inflation rates. Therefore, Adam and Billi add that nominal interest rates may have to be lowered more aggressively in response to shocks than what is instead suggested by a model without lower bound. Such "preemptive" easing of nominal rates is optimal because agents anticipate the possibility of binding shocks in the future and reduce already today their output and inflation expectations correspondingly. Such expectations end up amplifying the adverse effects of shocks and thereby trigger a stronger policy response.

3 Model presentation

The structure of this model is a closed economy DSGE model similar to Christensen and Dib (2006). The model contains standard features, such as adjustment cost on investment and sticky prices. In addition, I add financial frictions as in Bernanke Gertler and Gilchrist (1995) and Bernanke and Gertler (1989, 1998). The source of the financial accelerator is the asymmetric information that will make costly for lenders to evaluate the quality of firm's investments.

There are five types of actors in the economy: households, entrepreneurs, capital producers, retailers and final good producers. In addition, there is the monetary authority that sets the nominal interest rate, according to a standard Taylor rule. Entrepreneurs borrow from a financial intermediary that converts household deposits into business financing for the purchase of capital. The presence of asymmetric information between entrepreneurs and lenders creates financial frictions which make entrepreneurial demand for capital depend on their financial position. Capital producers build unfinished capital and sell it to entrepreneurs. Competitive final good firms combine the final capital good produced by entrepreneurs and labour supplied by households. They combine these two factors to produce a homogeneous final good. Retailers are the source of nominal frictions. They differentiate the homogeneous final good and sell it in monopolistically competitive retail markets. They set nominal prices in a staggered fashion à la Calvo (1983).

3.1 Households

Preferences of a given household $j \in [0,1]$ at a given time t are described by:

$$\max U_t^{(j)} = E_0 \sum_{t=0}^{\infty} \beta^t u(C_t^{(j)}, H_t^{(j)})$$

where β is the discount factor, C_t is a composite consumption index and H_t is labor supply.

Let the functional form of u be given by:

$$u(C_t^{(j)}, H_t^{(j)}) = \frac{1}{1-\sigma}(C_t^{(j)})^{1-\sigma} - \eta \frac{H_t^{(j)1+\psi}}{1+\psi}$$

A consumer's revenue flow in any period comes from her supply of hours of work to firms for wages W_t, profits Π_t from firms and return on assets B_t

.

$$P_t C_t = W_t^{(j)} H_t^{(j)} + \Pi_t + (R_t + Z_t)B_t - B_{t+1}$$

The first order conditions (hereafter, f.o.c.) from the maximization problem are:

$$E_t \beta[(R_t + Z_t)(C_{t+1})^{-\sigma}] = (C_t)^{-\sigma}$$

$$W_t = \left(-\frac{U_{Lt}}{U_{Ct}}\right) = \eta H^{\psi}(C_t)^{\sigma}$$

The disturbance term Z_t represents a wedge between the interest rate controlled by the central bank and the return on assets held by households.

Z_t follows the first-order autoregressive process:

$$Z_t = \rho_Z Z_{t-1} + \varepsilon_{Z_t}$$

where $\rho_Z \in (0,1)$ is an autoregressive coefficient and ε_{Z_t} is normally distributed with mean zero and standard deviation σ_Z .

A positive risk premium shock increases the return on assets held by households and hence increases savings and reduces current consumption. At the same time, this shock also increases the cost of capital and reduces investments. In such a way, the risk premium shock helps explaining the comovements of consumption and investments.[6]

Finally, for the Fisher condition, real interest rate is defined as follows:

$$R_t = R_t^n \frac{P_{t+1}}{P_t}$$

3.2 Production sector

3.2.1 Capital producers

Production of unfinished capital goods is also carried out by competitive firms. The produced capital goods replace depreciated capital and add to the capital stock. I assume that capital producers are subject to quadratic capital adjustment costs, so that the marginal return to investment in terms of capital goods is declining in the amount of investment undertaken, relative to the current capital stock.

[6] This latter effect makes this shock different from a discount factor shocks as in Christiano, Eichenbaum and Rebelo (2009).

Capital producers make their production plans one period in advance. They maximize

$$\max E_{t-1}\left\{\left[Q_t I_t - I_t - \frac{\chi}{2}\left(\frac{I_t}{K_t} - \delta\right)^2\right] K_t\right\}$$

The f.o.c. gives the standard Tobin's Q equation:

$$Q_t = 1 + \chi\left(\frac{I_t}{K_t} - \delta\right)$$

Furthermore, capital stock evolves according to:

$$K_t = I_t + (1-\delta)K_{t-1}$$

Final output is the sum of consumption and investment goods

$$Y_t = C_t + I_t + G_t$$

In addition, total output is also determined by government exogenous spending G_t. I assume that exogenous spending follows a first-order autoregressive process with a IID-Normal error term:

$$G_t = \rho_G G_{t-1} + \varepsilon_{G_t}$$

where $\rho_G \in (0,1)$ is an autoregressive coefficient and ε_{G_t} is normally distributed with mean zero and standard deviation σ_G .

3.2.2 Entrepreneurs

The entrepreneurs' behaviour is similar to that proposed by Bernanke Gertler and Gilchrist (1998). The probability that an entrepreneur will survive until the next period is ν, so the expected lifetime horizon is $\frac{1}{1-\nu}$. This assumption ensures that entrepreneurs' net worth (the firm equity) will never be enough to fully finance the new capital acquisition, so they issue debt contracts to finance their desired investment expenditures in excess of net worth.

The entrepreneurs' demand for capital depends on the expected marginal return and the expected marginal external financing cost is

$$E_t(F_{t+1} + Z_t) = E_t \left\{ \frac{r_{t+1}^K + (1-\delta)Q_{t+1}}{Q_t} \right\}$$

where F_{t+1} is the external funds rate and and r_{t+1}^K is the marginal productivity of capital, at $t+1$. The risk premium disturbance affects the cost of capital.

Following Bernanke Gertler and Gilchrist (1998), I assume the existence of an agency problem that makes external finance more expensive than internal funds. The entrepreneurs costless observe their output which is subject to a random outcome. The financial intermediaries incur an auditing cost to observe an entrepreneur's output. After observing her project outcome, an entrepreneur decides whether to repay her debt or to default. If she defaults, the financial intermediary audits the loan and recovers the project outcome less monitoring costs. Accordingly, the marginal external financing cost is equal to a gross premium for external funds plus the gross real opportunity costs equivalent to the riskless interest rate. Thus, the demand for capital should satisfy the following optimality condition that states that the real return on capital is equal to the real cost on external funds:

$$F_{t+1} = \left(\frac{K_t Q_t}{N_t} X_t\right)^{\omega}$$

At time t, the gross external financial premium $\left(\frac{K_t Q_t}{N_t} X_t\right)^{\omega}$ depends on borrowers' leverage ratio $\left(\frac{K_t Q_t}{N_t}\right)$, the elasticity of the external finance premium with respect to the leverage ratio (ω) and the disturbance term X_t. The shock X_t follows the first-order autoregressive process:

$$X_t = \rho_X X_{t-1} + \varepsilon_{X_t}$$

where $\rho_X \in (0, 1)$ is an autoregressive coefficient and ε_{X_t} is normally distributed with mean zero and standard deviation σ_X .

The entrepreneur's net worth is defined as follows:

$$N_{t+1} = \nu \left[F_t Q_t K_t - R_t \left(\frac{K_t Q_t}{N_t} X_t\right)^{\omega} (K_t Q_t - N_t) \right] + (1 - \nu) g_t$$

Here, $(1 - \nu)$ is the share of new entrepreneurs entering the economy and g_t is the transfer or "seed money" that newly entering entrepreneurs receive from entrepreneurs that die and depart from the scene. Since the costs of pure debt finance are infinite, I include the transfer g_t to ensure that new entrepreneurs can operate. I take g_t as given; in this quantitative exercises it is of negligible size.

In a model without financial frictions, the leverage ratio is equal to 1 and the elasticity is $\omega = 0$.

A fall in the price of capital has effects on the leverage ratio.[7] As the leverage ratio rises, the risk premium also rises. On the one side, the higher risk premium will increase the cost of borrowing. On the other side, the lower price of capital will decrease the return on capital. Therefore, the entrepreneurial net worth will decrease at the end of the period and *ceteris paribus*, the leverage ratio will be higher, amplifying the recession.

3.2.3 Final good producers

Production is carried out by firms that follow a costant-return-to-scale technology. To produce output Y_t, firms combine final capital goods and labour. The technology is defined as follows:

$$Y_t = AK_t^{\alpha} H_t^{1-\alpha}$$

where A is the productivity parameter.

Firms minimize production costs, so the first order conditions are:

$$W_t = MC_t(1-\alpha)\frac{Y_t}{H_t}$$

$$r_t^K = MC_t\alpha\frac{Y_t}{K_t}$$

where MC_t denotes the marginal production cost for a firms.

[7] Fluctuations in the price of capital Q_t create a link between asset price movements and credit cycle literature (e.g. Kyotaki and Moore (1997) and in Christiano, Gust and Roldos (2002)).

3.2.4 Retailers

The retailers purchase the wholesale goods at a price equal to nominal marginal costs and differentiate them at no cost. They then sell these differentiated retail goods on a monopolistically competitive market.

I introduce a monopolistic competition framework à la Dixit and Stiglitz:

$$P_{t+l} = (\int_0^1 p_{jt+l}^{1-\vartheta} dj)^{1/1-\vartheta}$$

$$Y_{t+l} = (\int_0^1 Y_{jt+l}^{\vartheta-1/\vartheta} dj)^{\vartheta/\vartheta-1}$$

where ϑ is the elasticity of substitution between varieties of goods.

The aggregate price is

$$P_t^{1-\vartheta} = (1-\varphi)(P_t^*)^{1-\vartheta} + \varphi P_{t-1}^{1-\vartheta}$$

Following Calvo, I am assuming that firms cannot change their selling prices unless they receive a random signal. The constant probability to receive such a signal is $(1-\varphi)$. Each firm j sets the price $p_t^*(j)$ that maximizes the expected profit for l periods, where $l = \dfrac{1}{1-\varphi}$ is the average length of time that a price remains unchanged.

The maximization problem is

$$MaxE_0 \sum_{t=0}^{\infty} \left[(\beta\varphi)^l \lambda_{t+l}(p_t^*(j) - mc_{t+l}) \frac{Y_{t+l}(j)}{P_{t+l}} \right]$$

$$s.t.\ Y_{t+l}(j) = (\frac{p_t^*(j)}{P_{t+l}})^{-\vartheta} Y_{t+l}$$

The first order condition is:

$$p_t^*(j) = \frac{\vartheta}{\vartheta - 1} \frac{E_0 \sum_{t=0}^{\infty} [(\beta\varphi)^l \lambda_{t+l} mc_{t+l}) \frac{Y_{t+l}(j)}{P_{t+l}}]}{E_0 \sum_{t=0}^{\infty} [(\beta\varphi)^l \lambda_{t+l} \frac{Y_{t+l}(j)}{P_{t+l}}]}$$

These equations lead to the following New Keynesian Phillips curve:

$$\pi_t = \frac{(1-\beta\varphi)(1-\varphi)}{\varphi} m\hat{c}_t + \beta E_t \pi_{t+1}$$

where $\pi_t = \dfrac{P_t}{P_{t-1}}$ is the gross inflation rate and $m\hat{c}_t$ is the log deviation of real marginal cost in the non-traded sector from its steady state level.

3.3 Monetary Policy

I introduce the zero lower bound (hereafter, ZLB) on the nominal interest rate, defining the Taylor rule in the following way:

$$R_t^n = dummy^{MP} \bar{R}^n + (1 - dummy^{MP}) \left[\left(\frac{\pi_t}{\bar{\pi}} \right)^{\gamma_\pi} (R^n)^{1-\rho_{RN}} \left(R_{t-1}^n \right)^{\rho_{RN}} \right]$$

When the nominal interest rate falls below the zero lower bound ($\bar{R}^n$), the variable $dummy^{MP}$ becomes active and assumes value 1. Otherwise, it is set equal to 0.

The parameter γ_π governs the degree to which the inflation rate is targeted around the desired target $\bar{\pi}$. Moreover, I am assuming that monetary authority does not react immediately and adjust interest rate with a degree of inertia measured by ρ_{RN}.

One *caveat* is that imposing the ZLB through the introduction of a dummy variable implies that agents are not able to rationally anticipate the possibility of hitting the ZLB. Therefore they will not reduce today their output and inflation expectations correspondingly. Therefore, the policy response is less aggressive than in a model in which agents were able to anticipate the possibility to hit the ZLB.[8]

3.4 Calibration

Following the literature, I set the steady-state rate of depreciation of capital (δ) equal to 0.025 which corresponds to a rate of depreciation equal to 10 % annual; the discount factor β equal to 0.99, which corresponds to an annual real rate in steady-state of 4 %.

Other parameters are quite standard. The relative risk aversion coefficient (σ) is set equal to 1.2. The steady-state share of capital in (α) is equal to 0.5. The probability ν that entrepreneurs will survive for the next period is set equal to 0.9728, therefore on average entrepreneurs stay alive 36 years. The elasticity of labor supply (ψ), and the coefficient of labor in utility (η) are both set equal to 1. The steady-state value of the elasticity of substitution between varieties of goods is equal to 6, which implies a mark-up of 20%.

[8] For a further discussion on the role of expectation in models with a zero lower bound on interest rates, see Adam ad Billi (2004)

The Calvo price parameter is set equal to 0.75.

The parameters of the monetary policy rule are based on the estimates of Clarida, Gali, and Gertler (2000) for the post-82 period. The coefficients on inflation γ_π is set equal to 1.5, while the he interest rate smoothing parameter, ρ_{RN} is equal to 0.8.

There is no consensus on the parameter χ describing investment adjustment costs. I set this parameter equal to 1.42.

Finally, the elasticity of risk premia to the leverage ratio (ω) is assumed to be equal to 0.05 and the steady-state value of the leverage ratio equal to 2. The value I choose for the leverage ratio is consistent with a strand of literature that normally sets this parameter at a value of 2 for US.[9]

4 Is it more likely to hit the ZLB when there are financial frictions?

In this section, I examine whether the ZLB is more likely to be hit when the financial accelerator mechanism is operative. To this purpose, I add a negative demand shock, e.g. a risk premium shock. This type of shock presents two features that make it suitable to analyze the dynamics when the ZLB is binding. First, contrary to the situation after a downward supply shock, a downward demand shock, putting downward pressure on both output and inflation, can cause a binding ZLB. Therefore, this is potentially a more se-

[9] To be precise, BGG define the leverage at time t as $\frac{N_t}{Q_{t-1}K_t}$ and so they choose steady-state value equal to 0.5.

vere situation. Second, among the class of demand shocks, the risk premium shock helps affects both consumption and investments. Therefore, it is not necessary to introduce large shocks in order to make the ZLB binding.

Here, the risk premium shock is modelled as an $AR(1)$ process with a fairly degree of persistence (the autoregressive coefficient is set equal to 0.9).

I start from a baseline model with the financial accelerator mechanism (hereafter, FA). Then, I remove financial frictions in order to investigate whether financial frictions, by increasing the probability of hitting the ZLB, may exacerbate or alleviate the recession triggered by a demand shock.

Results are displayed in Figure 1. A risk premium shock reduces both private consumption and investments. On one side, this type of shock stimulates private savings by increasing the required return on assets held by households. On the other side, the price of capital drops as it depends positively on its expected value and the expected rental capital rate and negatively on the ex-ante real risk-free interest rate and the risk premium disturbance. The collapse of capital price is translated into lower capital and lower investments. The drop of both consumption and investments results in lower output and lower inflation.

If the financial accelerator mechanism is operative, the initial shock is amplified. The reason is that, in the presence of friction in financial markets, the price of capital depends negatively on the risk-free real interest rate augmented by the financial risk premium. Then, the initial collapse of price of capital and capital stock is translated into a higher leverage ratio. As a consequence, at a first stage, the financial risk premium increases worsening the entrepreneurial net worth. Then, the decline in net worth raises the average external finance premium and the cost of new investments. Declining investments lower economic activity and cash flow in subsequent periods, amplifying and propagating the effect of the initial shock.

Output fall results in lower inflation and both effects are translated into a lower nominal interest rate. As the recession is magnified by the financial accelerator mechanism, in the model with financial frictions the decrease in the nominal interest rate is more accentuated and prolonged. Therefore, the presence of financial frictions results to bring closer a binding ZLB.

4.1 Robustness of results under alternative optimal Ramsey monetary policies

Results shown in the previous section have been derived under a baseline simple monetary rule as described in subsection 3.4 ($\gamma_\pi = 1.5$; $\rho_{RN} = 0.8$). Even though the calibration used is pretty standard, it is interesting to study how robust these results are, once departing from simple monetary rules. In this subsection, I present a comparison between the model with and without financial frictions in an optimal Ramsey policy context.

Here, I discuss the particular case in which the objective function is quadratic and dynamics is linear.[10] Let assume that the dynamics of the economy is defined by

$$A_+ E_t y_{t+1} + A_0 y_t + A_- y_{t-1} + B u_t + C e_t = 0$$

[10] For further details, see – among others – Juillard and Pelgrin (2006)

where y_t is the vector of endogenous variables, u_t is the vector of instruments and e_t is a vector of zero-mean shock uncorrelated with past values.

The intertemporal loss function is

$$\frac{1}{2}E\sum_{t=1}^{\infty}\beta^{t-1}z_t'Wz_t$$

where $z_t = (y_t' \ \ u_t')'$ and $z_t'Wz_t$ is the instantaneous objective function. W is given by

$$W = \begin{pmatrix} W_{yy} & W_{yu} \\ W_{yu}' & W_{\mathrm{uu}} \end{pmatrix}$$

The Ramsey policy is based on the resolution of the following Lagrangian

$$E_1\sum_{t=1}^{\infty}\beta^{t-1}\left[\frac{1}{2}(y_t'W_{yy}y_t + 2y_t'W_{yu}u_t + u_t'W_{\mathrm{uu}}u_t) + \lambda_t'\left(A + E_ty_{t+1} + A_0y_t + A_{-}y_{t-1} + Bu_t + Ce_t\right)\right]$$

I assume that the loss function has three stabilization objectives: inflation, output gap and nominal interest rate, namely:

$$Loss = \frac{1}{2}\left[\pi_t^2 + \lambda_y(Y_t - Y_t^{flex})^2 + \lambda_{RN}(R_t^n)^2\right]$$

I consider three alternative specifications of the loss function: in the first, the relative weight on the output-stabilization objective (λ_y) is zero; in the second, it is equal to 0.5 and in the third is equal to 1.

Figure 2 shows that, in all these three cases, the presence of financial frictions increases the probability of hitting the ZLB only slightly. In a Ramsey policy framework, the difference between model with FA and model without FA is strongly reduced.

Another result to be pointed out is that, for positive value of λ_y, the probability of hitting the ZLB is higher. The reason is that a higher relative weight on the output-stabilization objective implies a stronger reaction of the nominal interest rate to recessionary shocks.

5 The effects of the ZLB constraint

In this section, I assess whether, in a model with financial frictions, the ZLB constraint might be responsible to push the economy into a recession. I contrast the effects under normal situations (i.e. when the central bank has the ability to lower interest rates in response to the demand shock) with a situation when the nominal short term interest rate is subject to the lower bound. Then, I analyze whether the economy is likely to be pushed into a recession when the ZLB binds.

From now on, I will handle the model specification that allows for financial frictions. Being the financial accelerator mechanism active, I am allowed to introduce not only a negative risk premium shock (as in Section 4), but also an adverse financial shock. This latter shock is modelled as an $AR(1)$ process with a fairly degree of persistence (the autoregressive coefficient is set equal to 0.9).

5.1 Risk premium shock

In Figure 3, I compare the responses to a risk premium shock under two alternative specifications of the model: the baseline model (namely, the model with financial frictions and without the ZLB constraint, as described in the section 4) and a model which features both financial frictions and a binding lower bound on nominal interest rate. In this latter specification, real interest rate is limited in its possibility to stimulate the economy, after the initial drop in consumption and output. Therefore, the presence of the ZLB makes the drop in investments – and hence in the accumulated capital – more severe. As discussed in section 4, in a model with financial frictions, a risk premium shock produces a deterioration of the leverage ratio, an increase of the financial risk premium and a collapse of the entrepreneurial net worth. This mechanism is tressed when the ZLB constraint is binding and hence the increase in the financial risk premium is more exacerbated. As a consequence, the cost of new investments heightens and the recession is amplified. Furthermore, the increase in the real interest rate increases the real cost of repaying the existing debt and further magnifies the recession.

5.2 Financial shock

Figure 4 displays the response of the main macro variables to a financial shock that pushes up the financial risk premium, worsening entrepreneurs' balance sheets. As enterprises are limited in their ability to self-finance, the level of investments falls down and the economy is pushed onto a recessionary-deflationary path. The recession is amplified if the lower bound on nominal interest rate is binding, as the monetary authority is no longer able to offset the negative effects of an adverse shock by using the nominal interest rate as an instrument.

6 Is the price-level targeting a solution to avoid the ZLB?

In this section, I explore the issue of whether price-level (hereafter, PLT) is a better target for monetary policy in order to limit the probability to hit the ZLB. The motivation is that – when expectations are forward-looking – a PLT rule introduces a desirable inertia that affects the private sector's expectation appropriately; hence it results in less volatile interest rates.

The mechanism operates as follows. Assume that a deflationary or disinflationary disturbance leads to a fall in the price level relative to the target (e.g. a negative demand shock). Economic agents observing the shock understand that the central bank will correct the deviation from the target aiming at an above-average inflation rate. As a result, inflation expectations increase, which helps to mitigate the initial impact of the deflationary shock. Under a credible price level target, inflation expectations operate as automatic stabilizers.[11]

The main difference between inflation-targeting (hereafter, IT) and PLT is that, under IT, unexpected disturbances to the price-level are ignored,

[11] The beneficial impact of a PLT rule on inflation expectations was lacking in the first strand of theoretical analysis based on backward-looking models, as in Lebow, Roberts, and Stockton (1992), Haldane and Salmon (1995), Fillion and Tetlow (1994).

while under PLT they are reversed. This implies that, under PLT, the price level has a predetermined targeted path and uncertainty about the future price level is bounded.

Figure 5 and Figure 6 show the response of nominal interest rate and other key variables, respectively to the risk premium shock and to the financial shock. As displayed, the probability to hit the ZLB is lower if the monetary authority decides to target the price level instead of the inflation rate. When agents are forward-looking and the monetary authority credibly commits to a PLT rule, such a rule yields lower variability of inflation and of nominal interest rates. Agents expect that the monetary authority will correct the deviation from the target aiming at an above-average inflation rate. Private sector's expectations of a future inflation after a deflationary shock dampen the initial disinflation and – hence – stabilize interest rates.[12] Therefore, a PLT rule will lower the probability to hit the ZLB for the nominal interest rate.

7 The effectiveness of fiscal stimulus in times of crisis

The recent worldwide economic crisis has renewed attention to the role of fiscal policies during both the economic downturn and the "exit" strategy phase. To face with the prospect of a severe global recession started in 2008-2009, at a first stage many governments have put forward plans of massive

[12] Similar conclusions are drawn by Giannoni (2000); Black, Macklem and Rose (1997); Vestin (2006).

fiscal stimulus in order to recover the economy. Then, at a second stage many countries are expected to implement significant fiscal consolidation packages, once the economy has started to gradually recover and the current fiscal stimulus policies have been phased out. As a response to the revamped interest in the role of fiscal policy, the literature has attempted to investigate the role of fiscal policy in the presence of financial frictions (Röger and in't Veld (2009), Erceg and Lindè (2009), Villaverde (2010)).

Moreover, it is sometimes feared that, when nominal interest rates reach their lower bound, monetary policy will become impotent in facing deflationary shocks or stimulating demand. In these circumstances, fiscal policy may offer a necessary tool when the nominal interest rate hits its ZLB. A recent strand of literature (Christiano, Eichenbaum and Rebelo (2009); Erceg and Lindé (2009); Woodford (2010)) has stated that large fiscal multipliers are especially plausible when the monetary policy is constrained by the ZLB on nominal interest rate. The underlying motivation is that in the case when the ZLB binds, the fiscal intervention has much more stimulative effects on the economy. This stimulative effect stems from the fact that the rise in government expenditures drive up the potential real interest rate and when the nominal interest rate is bounded at zero then the real interest rate gap will fall by the same amount, and this will trigger an expansion in the output gap and an increased inflation rate, which drives down the actual real interest rate as well because the nominal interest rate is fixed and thus further contributes to the decline in the real interest rate gap.

One practical objection to using the fiscal policy when the ZLB binds is that there are long lags in implementing an increase in government spending. Christiano, Eichenbaum and Rebelo (2009) study the size of government spending multipliers in the presence of implementation lags. They find that the key determinant of the size of multipliers is the state of the word in which new government spending actually comes on line. If it comes on line in future periods when the nominal interest rate is zero, there is a large effect on output. If it comes on line in future periods where the nominal interest rate is positive, the current effect on government spending is smaller. On the contrary, Erceg and Lindé (2009) show that if fiscal expansion is plagued by implementation lags and eventually needs to be financed by distortionary taxes, then fiscal expansion can have contractionary effects on economic activity that are magnified if the ZLB on nominal rates is binding. Indeed, "timing" seems to become a crucial aspect to take into account in implementing fiscal policy when the nominal interest rate is close to the ZLB. Corsetti, Meier and Müller (2009) and Corsetti, Kuester, Meier and Müller (2010) state that the prospect of future spending cuts enhance the short-run stimulus effect, because it reduces inflation expectations and hence eases long-term interest rate. This argument holds also when the nominal interest rate is lower bound. Nevertheless, if the monetary policy is constrained by the ZLB, the timing of the spending reversals is crucial. Reverting expenditure too early – while the ZLB is still binding and the economy is facing the risk of deflation – might lead to further delay in the exit from the ZLB. Postponing the reversal, instead, would reduce the stimulative short-term effects of fiscal policy.

In the previous section, I have investigated whether a PLT monetary rule might help to avoid the ZLB. Instead, in this section, I explore whether fiscal policy is a necessary tool when ZLB is hit. To this purpose, I examine the effect of fiscal stimulus if the economy entails frictions in financial markets and embarks in a liquidity trap. As a fact, by second half of 2008, the world-wide economy has experienced a severe financial crisis and nominal interest rates in U.S. and other major world economies have reached historically low levels and in some cases have gone all the way down to zero.

Following Corsetti, Kuester, Meier and Müller (2010), I do not distinguish between Ricardian and no-Ricardian agents and I assume an exogenous path for the government expenditure. Fiscal stimulus is modelled as a government spending shock that follows an $AR(1)$ process with a high degree of persistence ($\rho_G = 0.9$)

Figure 7 displays the response of total output and its components (namely, consumption and investments) to a risk premium shock in order to assess the effect of the fiscal stimulus. The series marked by spheres describes the reaction in a model affected only by the risk premium shock, while the series marked by triangles describes a model which allows also for the fiscal stimulus. I distinguish three alternative specifications of the model: the baseline model with FA (Figure 7a), the model without FA (Figure 7b) and the model with FA and the ZLB (Figure 7c). If the monetary policy is not constrained by the ZLB, the government spending shock is leading to a crowding-out of private consumption.

Table 1 (rows 2-4) displays the value of the government spending multiplier in the three alternative specifications on the model. If the ZLB is not binding, the net impact on output is positive but the value of the fiscal multiplier[13] is below 1. The financial accelerator mechanism weakens the effects of the fiscal stimulus, as displayed in the second row. The reason is that, in the presence of frictions in financial markets, the initial collapse of price of capital and capital stock is translated into a higher leverage ratio, higher costs of new investments and hence a lower economic activity. In such a way, the financial accelerator mechanism dampen the expansionary effect of government spending, leading to a lower multipliers.

The ZLB increases multipliers substantially. As displayed in the fourth row, the government spending multiplier is slightly larger than one. The reason underlying this result is that, with nominal interest rates held constant, the higher inflation generated by an expansionary fiscal policy will lead to a decrease in real interest rates and this indirect monetary channel amplifies the GDP impact of the fiscal stimulus. This result is in line with the literature reported above.

An opposite conclusion is reached in Cogan et al. (2009). Using an empirical New Keynesian model calibrated for the US economy, they predict small multiplier effects of increased government purchases during a situation in which the ZLB is binding. The crucial difference is that they assume a permanent increase in government spending that lasts as long as the ZLB is binding.

Indeed, the duration of fiscal stimulus turns out to be a crucial aspect to take into account in implementing fiscal policy, especially when the nominal interest rate is close to the ZLB. There exists a general agreement across models on the weak effects of prolonged fiscal stimulus. Coenen et al. (2010)

[13] The short-term effect of fiscal stimulus is calculated over a one-year horizon.

summarizes and compares the keys results in a broad class of models.[14] They state that, if fiscal expansion is not perceived to be temporary, it results in long-run crowding out of private spending.

Table 1 (row 5) shows that a prolonged fiscal stimulus lasting 4 periods (namely, as long as the nominal interest rate is at the ZLB) generates multiplier effects that are still positive and higher than those arising in a situation in which the ZLB is not binding. Nevertheless, the prolonged fiscal stimulus is less effective than a temporary one.

Fiscal stimulus becomes even counter-productive, if it is in a large part expected to continue beyond the point at which the ZLB ceases to bind. Table 1 (row 6) proves that if the fiscal stimulus is lasting 5 periods, it has contractionary effects on output, as proved by the negative value of the multiplier.

It has often been argued that one of the disadvantages of discretionary fiscal policy is the it is not timely, due to implementation lags. In the last row, Table 1 assesses the size of government spending multipliers in the presence of implementation lags. If government spending still comes on line in future periods when the nominal interest rate is zero, but it is delayed, the effects on output remain quite large, even though weaker than those generated by a "timely" fiscal intervention.

[14] Specifically, the seven models considered are: the QUEST model (European Commission), the GIMF model (IMF), FRB-US and SIGMA (the Board of Governors of the Federal Reserve System, BoC-GEM (Bank of Canada), the NAWM model (European Central Bank), and the OECD Fiscal model.

8 Conclusions and further extensions

Recent economic events have reinforced the relevance of the zero bound on nominal interest rates for monetary policy. Some economists have downsized the risk of a binding ZLB. For instance, according to Coenen Orphanides & Wieland (2003) and Schmitt-Grohe and Uribe (2007), the probability of the nominal interest rate approaching the zero bound in US is negligible. However, this strand of literature is based on models that do not feature financial frictions. In this paper, I analyze whether the economy is more likely to embark in a deflationary trap when both financial frictions and the ZLB constraint on nominal interest rates are at work.

In this paper, four main findings are worth to be highlighted. First, in a model with financial frictions, the ZLB is more likely to be hit than in a model with frictionless financial markets. Second, in the model with financial frictions, when the ZLB is binding, the real interest rate is limited in its possibility to recover the economy, after a negative shock. Furthermore, as the real interest rate can not freely decrease, the payment of interests on the existing debt is tightened. These two effects worsen the entrepreneurial balance sheets and hence magnified the recession. Third, when the central bank adopts a price-level targeting rule (instead of an inflation targeting rule), the probability to hit the lower bound is reduced. When agents are forward-looking and the monetary authority credibly commits to a price-level targeting rule, such a rule yields lower variability of inflation and of nominal interest rates. Agents expect that the monetary authority will correct the deviation from the target, aiming at an above-average inflation rate. Private sector's expectations of a future inflation after a deflationary shock dampen the initial disinflation and hence stabilize interest rates. Fourth, an increase in government spending recovers the output fall but leads to a crowding-out of private consumption. Therefore, net impact of fiscal stimulus on output is still positive, but the value of fiscal multipliers is below 1. However, when the ZLB constraint is binding, the expansionary effects of the government spending shock are magnified and fiscal multipliers are larger than one. This result is in line with the most recent literature on fiscal stimulus.

Concerning the effectiveness of the fiscal stimulus when the nominal interest rate is close to the ZLB, two further results worth to be highlighted. First, the duration of fiscal stimulus turns out to be a crucial aspect to take into account in implementing fiscal policy. Specifically, a permanent fiscal stimulus becomes less effective than a temporary one, if it occurs as long as the zero lower bound is still binding. Instead, if it continues beyond the period at which the zero lower bound ceases to bind, then it has contractionary effects on output. Second, the presence of lags in implementing discretionary fiscal policies might weaken the expansionary effects on output. Nevertheless, if government spending is delayed but still comes on line in future periods when the nominal interest rate is zero, the stimulative effects on output remain quite large.

This analysis opens the door to further extensions and future works. First, I have so far focused the analysis only on demand shocks and financial shocks. Nevertheless, as stressed in and Amano and Shukayev (2009), additional research allowing for a broader set of shock may improve the understanding of the role of financial frictions when interest rates are lower bounded.

A second extension might be to analyze the effects of the ZLB in an open economy, in order to analyze how the conclusions drawn hereby are affected when we switch to an open economy framework. Indeed, in an open economy set up, other monetary transmission channels – different from the interest rate channel – are at work. Moreover, the open economy framework allows to introducing a broader set of shocks, such as exchange rate shocks, external demand shocks, etc...

Third, robustness of results should be checked with respect some model parameters. Specifically, a further analysis would be to explore the implications of higher nominal rigidity and of a more elastic labour supply.

Finally, a further step might be to distinguish the effects of several types of fiscal instruments, such as government spending, transfers, labour tax cuts, consumption tax cuts, etc...

References

[1] Adam, K. and R. Billi (2004), "Optimal monetary policy under commitment with a zero bound on nominal interest rates", ECB Working Paper No. 377, July (published in Journal of Money, Banking and Credit, Vol.38, No. 7, pp. 1877-1905, 2006.

[2] Amano, R. and M. Shukayev (2009), "Risk premium shocks and the zero lower bound on nominal interest rates", Bank of Canada Working Paper No. 27/2009.

[3] Bernanke, B., and M. Gertler (1989), "Agency costs, net worth and business fluctuations", American Economic Review 79, pp.14-31.

[4] Bernanke, B., and M. Gertler (1995), "Inside the black box: the credit channel of monetary policy transmission", Journal of Economic Perspectives 9, pp. 27-48.

[5] Bernanke, B., M. Gertler, and S. Gilchrist (1998), "The financial accelerator in a quantitative business cycle framework", NBER Working Paper No. 6455, March.

[6] Bodenstein, M., Erceg, C. J. and L. Guerrieri (2009), "The effects of foreign shocks when US interest rates are at zero"

[7] Buiter, W.H. and N. Panigirtzoglou (2000), "Liquidity traps: how to avoid them and how to escape them", Bank of England Working Paper Series, No. 11.

[8] Christensen I. and A. Dib (2006), "Monetary policy in an estimated DSGE model with financial accelerator", Bank of Canada Working Paper No. 06-09.

[9] Christiano, L. J. (2004), "The zero-bound, zero-inflation targeting, and output collapse", manuscript, Northwestern University.

[10] Christiano, L. J., Eichenbaum, M. and S. Rebelo (2009), "When is the government spending multiplier large?" NBER Working Papers No.15394.

[11] Coenen, G., Orphanides, A. and V. Wieland (2003), "Price stability and monetary policy effectiveness when nominal interest rates are bounded at zero", ECB Working Paper No. 231, May.

[12] Coenen, G., Erceg, C., Freedman, C., Furceri, D., Kumhof, M., Ladonde, R., Laxton, D., Lindé, J., Mourougane, A., Muir, D., Mursula, S., de Resende, C., Roberts, J., Roeger, W., Snudden, S., Trabandt, M. and J. in 't Veld (2010), "Effects of fiscal stimulus in structural models", IMF Working Paper No. 10/73, March.

[13] Cogan, J. F., Cwik, T., Taylor, J. B. and V. Wieland (2009), "New Keynesian versus old Keynesian government spending multipliers", NBER Working Paper no. 14782, March.

[14] Corsetti, G., Meier, A. and G. Müller (2009), "Fiscal stimulus with spending reversals", IMF Working Paper No. 09106, May.

[15] Corsetti, G., Kuester, K., Meier A., and G. Müller (2010), "Debt consolidation and fiscal stabilization of deep recessions", CEPR Working Paper No. 7649, January.

[16] Eggertsson, G and M. Woodford (2003), "Optimal monetary policy in a liquidity trap", NBER Working Paper No. 9968.

[17] Erceg, J.C. and J. Lindé (2009), "Is there a fiscal free lunch in a liquidity trap?", manuscript.

[18] Gerlach, S. and J. Lewis (2010), "The zero lower bound, ECB interest rate policy and the financial crisis", mimeo.

[19] Goodfriend, M. (2000), "Overcoming the zero bound on interest rate policy", Journal of Money, Credit and Banking, Vol. 32, No. 4, part 2, pp 1007-1035.

[20] Krugman, P.R. (1998), "It's back: Japan's slump and the return of the liquidity trap", Brookings Papers on Economic Activity, No. 2, pp. 137-205.

[21] Reifschneider, D. and J. C. Williams (2000), "Three lessons for monetary policy in a low-inflation era", Journal of Money Credit and Banking, Vol. 32, pp. 936-966.

[22] Schmitt-Grohe, S. and M. Uribe (2007), "Optimal inflation stabilization in a medium-scale macroeconomic model", in Monetary Policy Under Inflation Targeting, edited by Klaus Schmidt-Hebbel and Frederic Mishkin, Central Bank of Chile, Santiago, Chile.

[23] Smets, F. (2000), "What horizon for price stability?", ECB Working Paper Series, No. 24.

[24] Svensson, L.E.O. (2000), "How should monetary policy be conducted in an era of price stability?", NBER Working Paper Series, No. 7516.

[25] Svensson, L.E.O. (2001), "The zero bound in an open economy, a foolproof way of escaping from a liquidity trap", Bank of Japan Monetary and Economic Studies, Vol. 19, No. S-1, pp. 277-312.

[26] Viñals, J. (2001), "Monetary policy in a low inflation environment", Banco de España Working Paper, No. 0107.

[27] Villaverde, J.F. (2010), "Fiscal Policy in a model with financial frictions", mimeo.

[28] Woodford, M. (2010), "Simple analytics of the government expenditure multiplier", NBER Working Paper No. 15714, January.

A The steady-state equilibrium

At the steady-state:

$$A = 1$$

$$Q = 1$$

$$\pi = 1$$

$$R^n = \frac{1}{\beta}$$

$$R = R^n$$

$$N = \frac{1}{lev} QK$$

$$MC = \frac{\vartheta^P - 1}{\vartheta^P} P$$

$$F = \left(\frac{QK}{N} \right)^{\omega} R$$

$$premium = \frac{F}{R}$$

$$r^K = [F - (1 - \delta)] Q$$

$$I = \delta K$$

$$Y = C + I$$

B The linearized model

The log-linearized model is described as it follows:

Consumers:

$\hat{C}_t = \hat{C}_{t+1} - \frac{1}{\sigma}[\hat{R}^n_t - \hat{\pi}_{t+1} + \hat{Z}_t)]$

$\hat{\lambda}_t = -\sigma \hat{C}_t$

$\hat{W}_t = \psi \hat{H}_t - \hat{\lambda}_t$

$\hat{\pi}_{t+1} = \hat{R}^n_t - \hat{R}_t$

then, $\hat{\lambda}_{t+1} = \hat{\lambda}_t - \hat{R}_t - \hat{Z}_t$

Firms:

$\hat{Y}_t = \hat{A}_t + \alpha \hat{K}_t + (1-\alpha)\hat{H}_t$

$\hat{r}^k_t = \hat{Y}_t + \hat{M}C_t - \hat{K}_t$

$K_t = \delta \hat{I}_t + (1-\delta)\hat{K}_{t-1}$

$\hat{Q}_t = \chi(\hat{I}_t - \hat{K}_t)$

Entrepreneurs:

$\hat{F}_t + \hat{Q}_{t-1} = \frac{r^k}{F}\hat{r}^k_t + \frac{(1-\delta)}{F}\hat{Q}_t$

$\hat{F}_{t+1} = -\omega \hat{N}_t + \omega \hat{K}_t + (\hat{R}_t + \hat{Z}_t) + \omega \hat{Q}_t + \omega \hat{X}_t$

$\frac{\hat{N}_{t+1}}{\nu F} = \frac{K}{N}\hat{F}_t - (\frac{K}{N} - 1)(\hat{R}_t + \hat{Z}_t) - \omega(\frac{K}{N} - 1)(\hat{K}_t + \hat{Q}_t + \hat{X}_t) + [\omega(\frac{K}{N} - 1) + 1]\hat{N}_t$

$\hat{premium}_t = E_t \hat{F}_{t+1} - \hat{R}_t - \hat{Z}_t$

Price setting:

$\hat{\pi}_t = \beta \hat{\pi}_{t+1} + \frac{(1-\beta\varphi)(1-\varphi)}{\varphi}(\hat{M}C_t - P_t)$

Equilibrium

$\hat{Y}_t = \frac{C}{Y}\hat{C}_t + \frac{I}{Y}\hat{I}_t + \frac{G}{Y}\hat{G}_t$

Monetary Policy rule:

$\hat{R}_t^n = \gamma_\pi(\hat{\pi}_t - \bar{\pi}) + \rho_R \hat{R}_{t-1}^n$

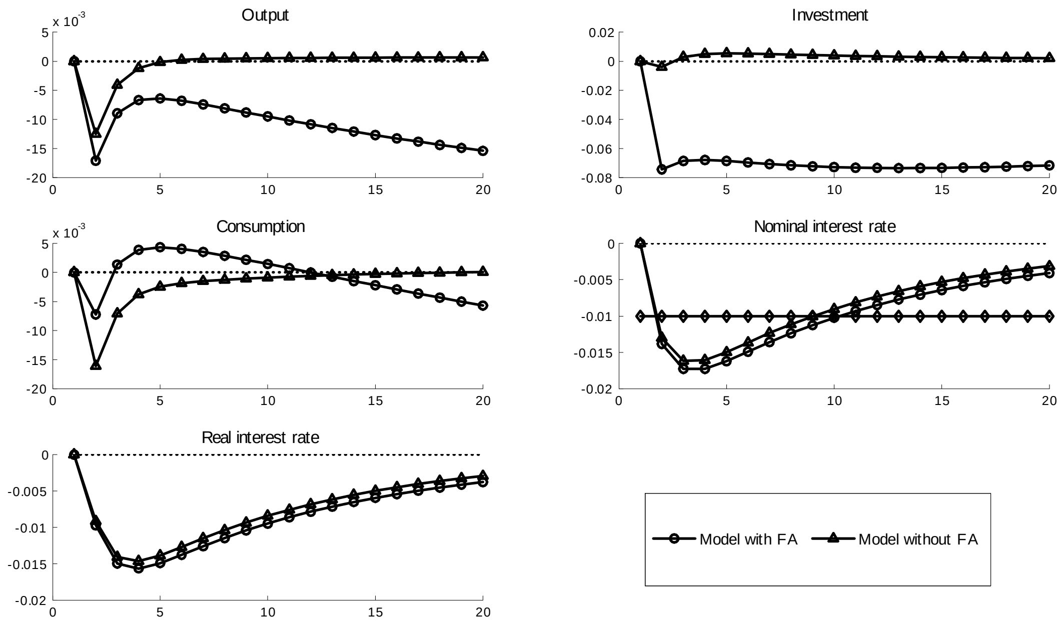

Figure 1: Risk premium shock

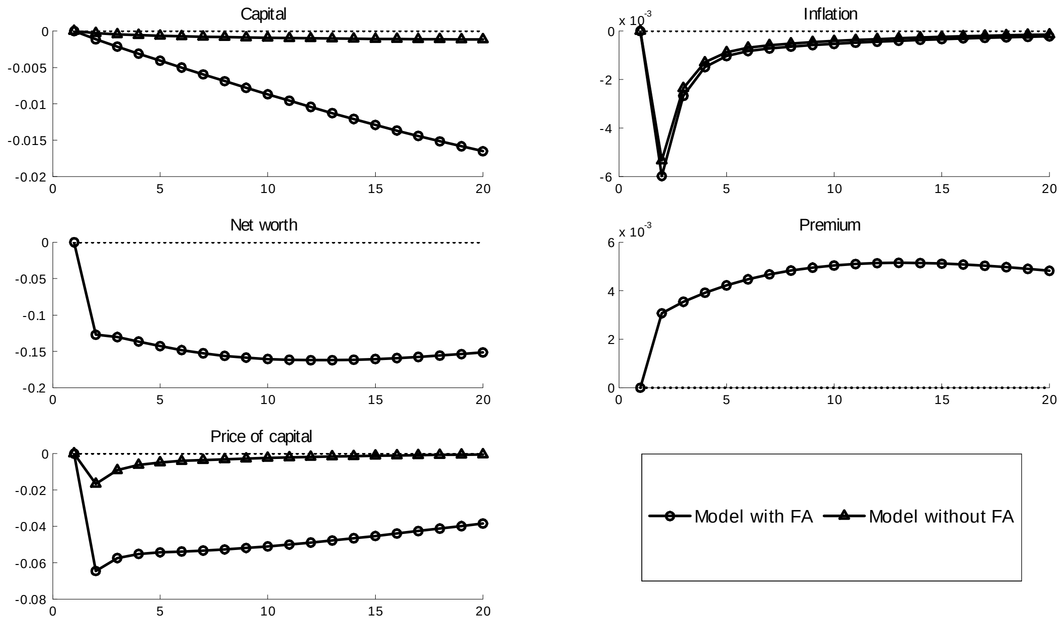

Figure 1 *bis*: Risk premium shock

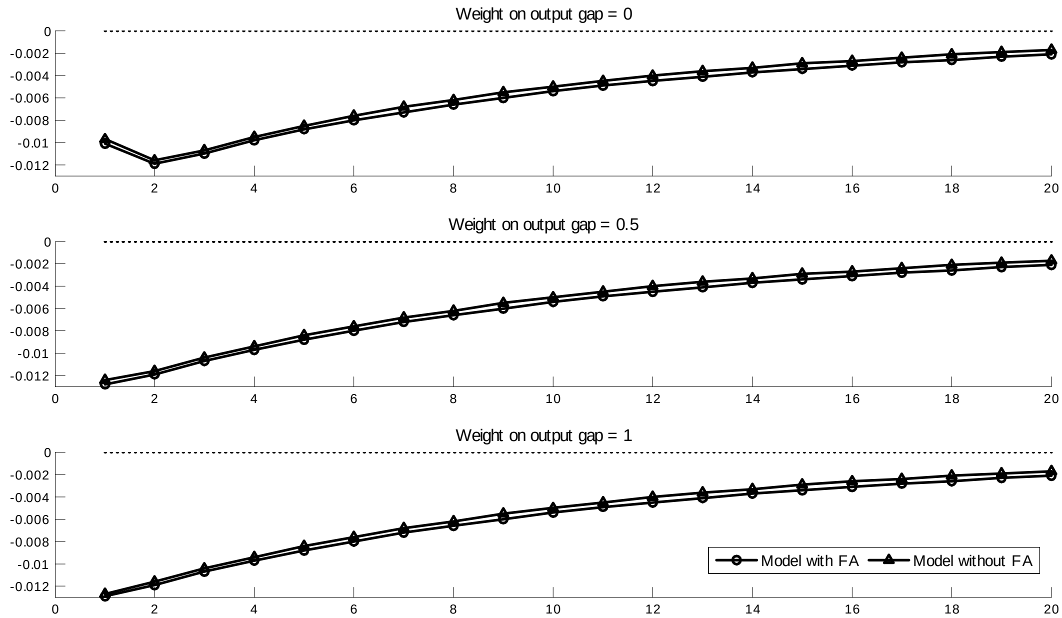

Figure 2: Nominal interest rate under alternative specifications of the loss function

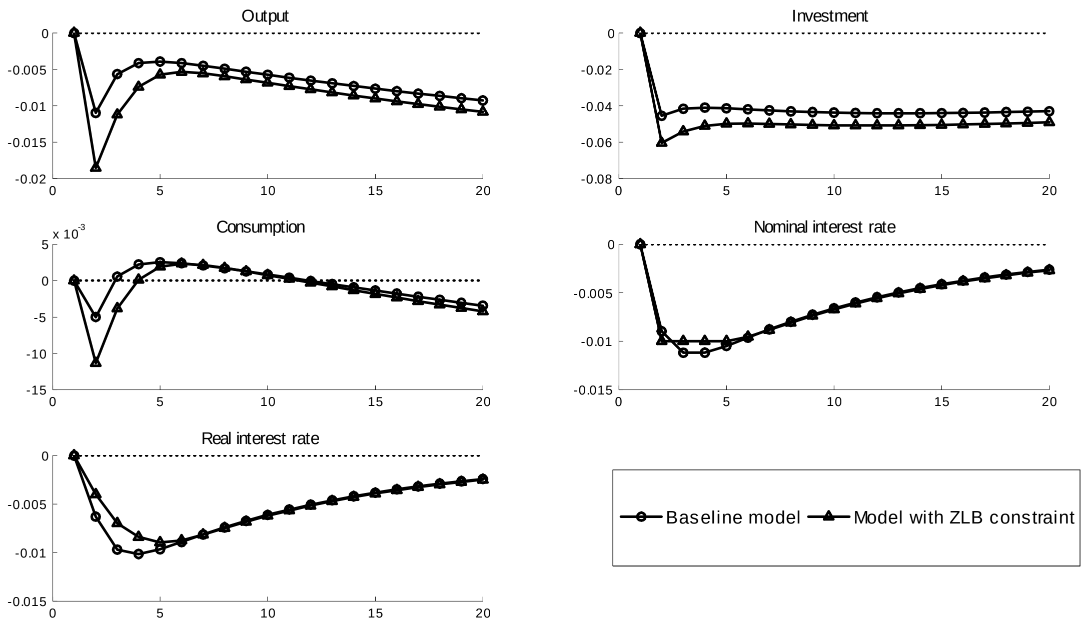

Figure 3: Risk premium shock

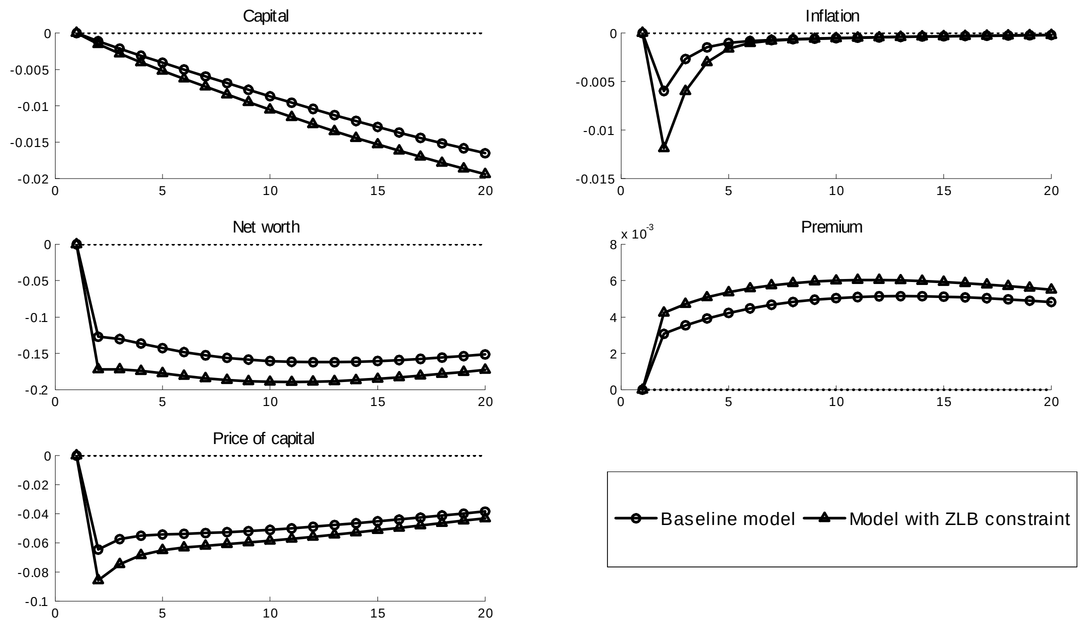

Figure 3 *bis*: Risk premium shock

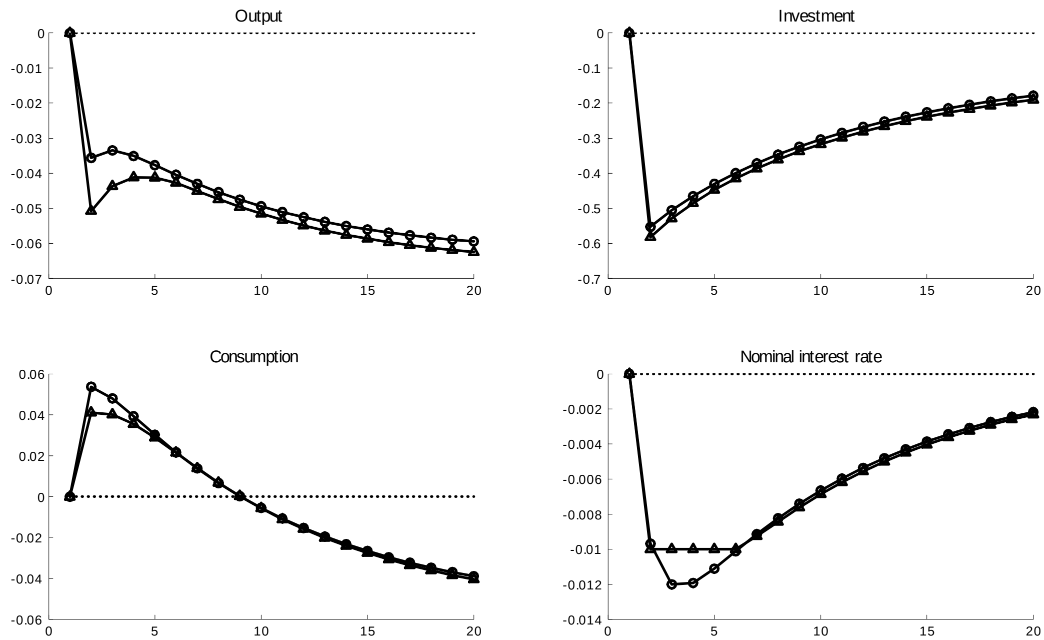

Figure 4: Financial shock

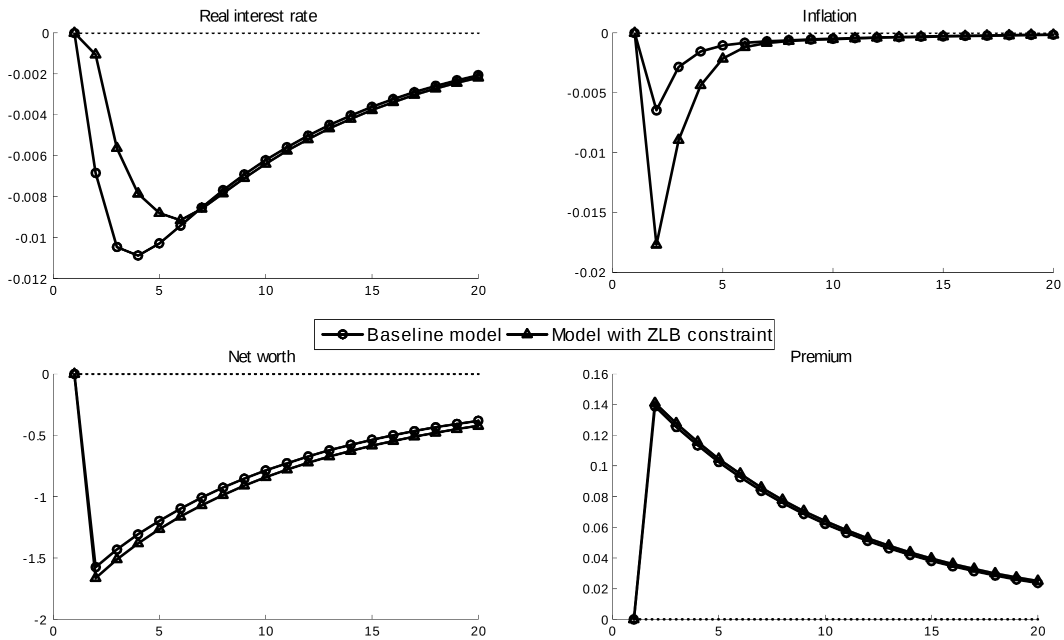

Figure 4 *bis:* Financial shock

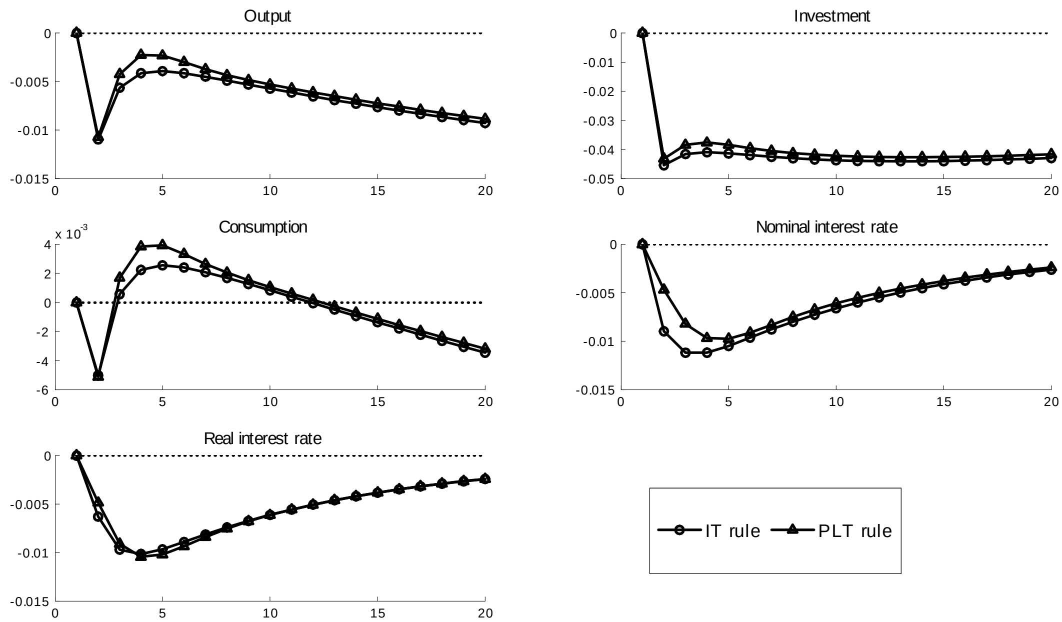

Figure 5: Risk premium shock

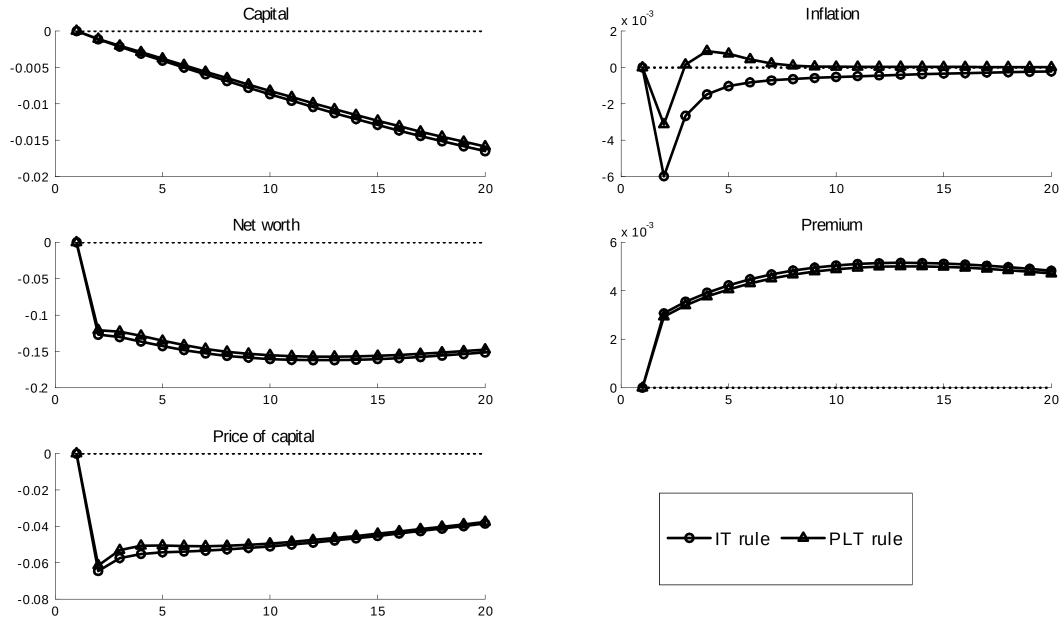

Figure 5 *bis*: Risk premium shock

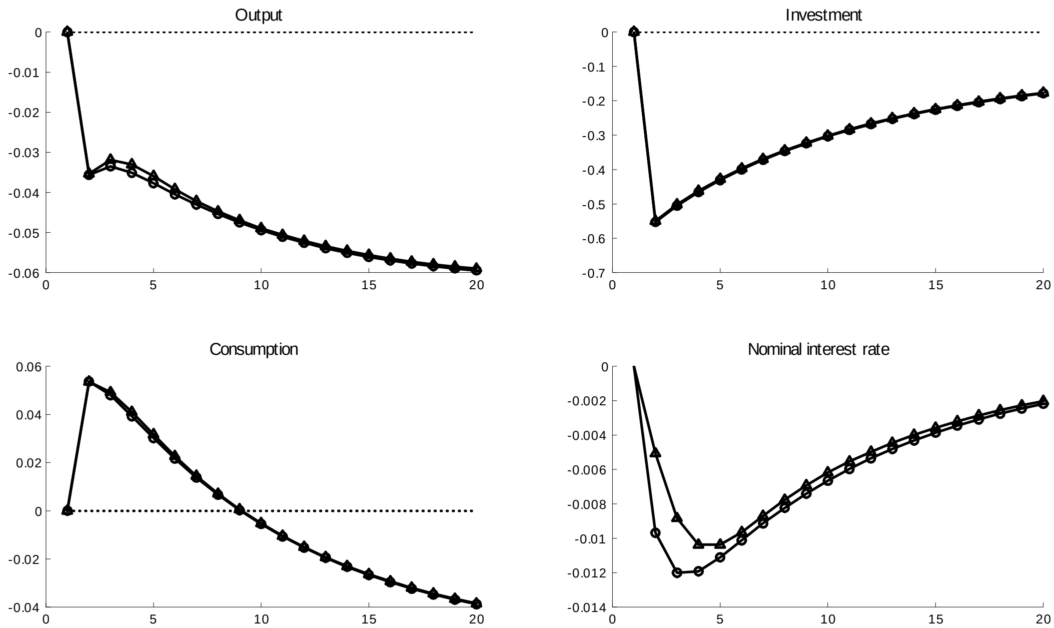

Figure 6: Financial shock

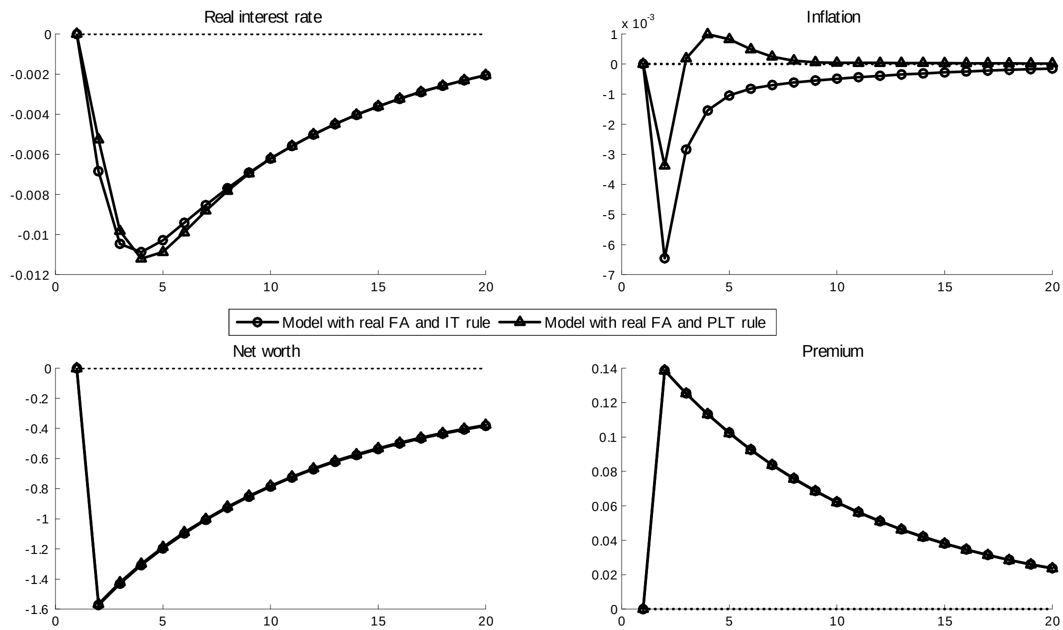

Figure 6 *bis*: Financial shock

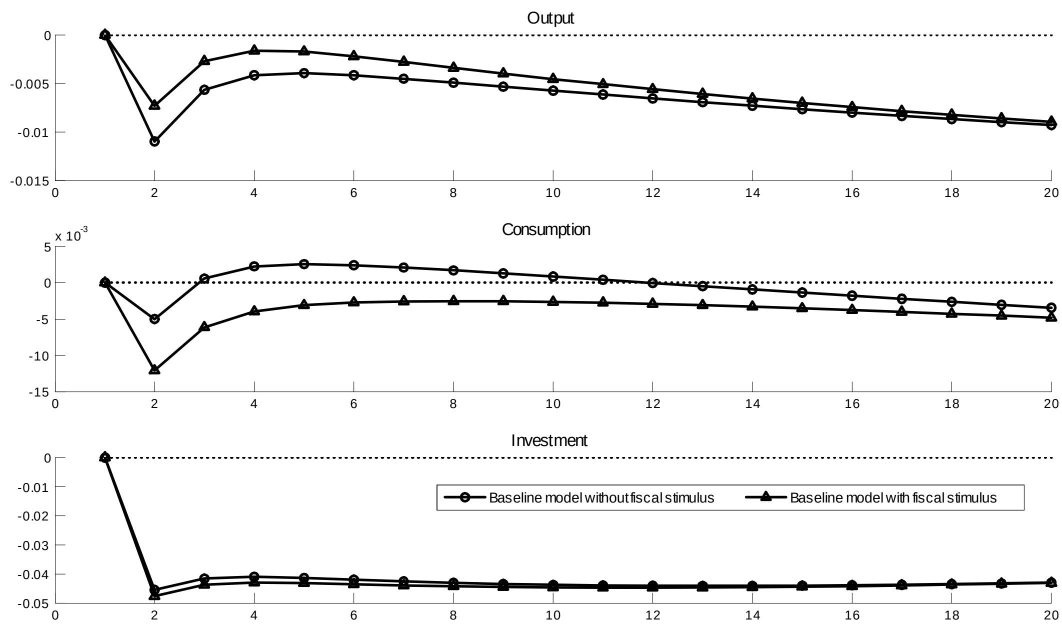

Figure 7a: Fiscal stimulus in the baseline model with FA

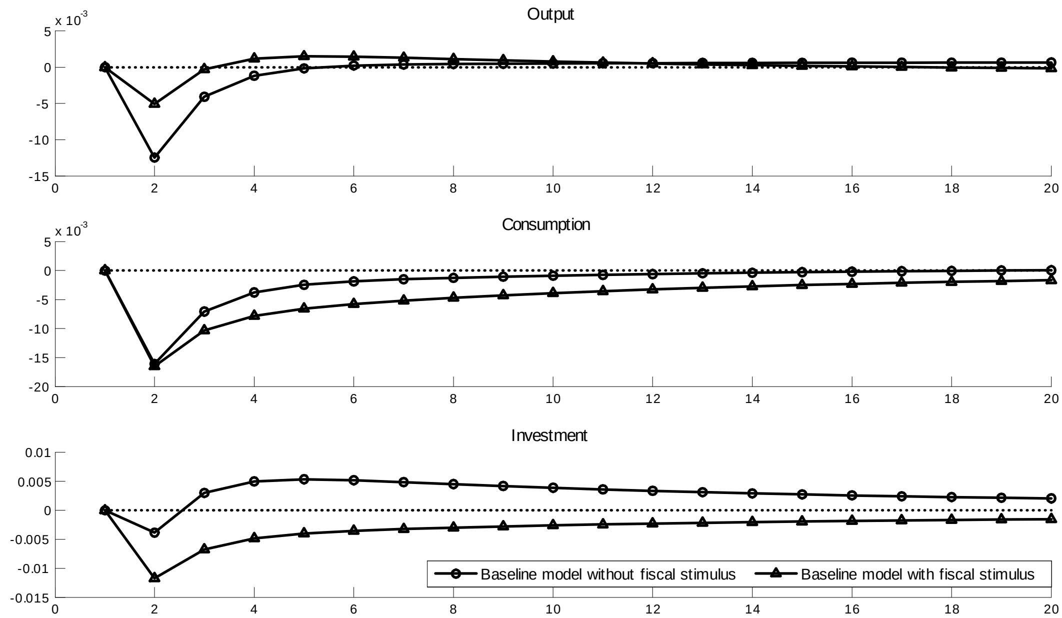

Figure 7b: Fiscal stimulus in the model without FA

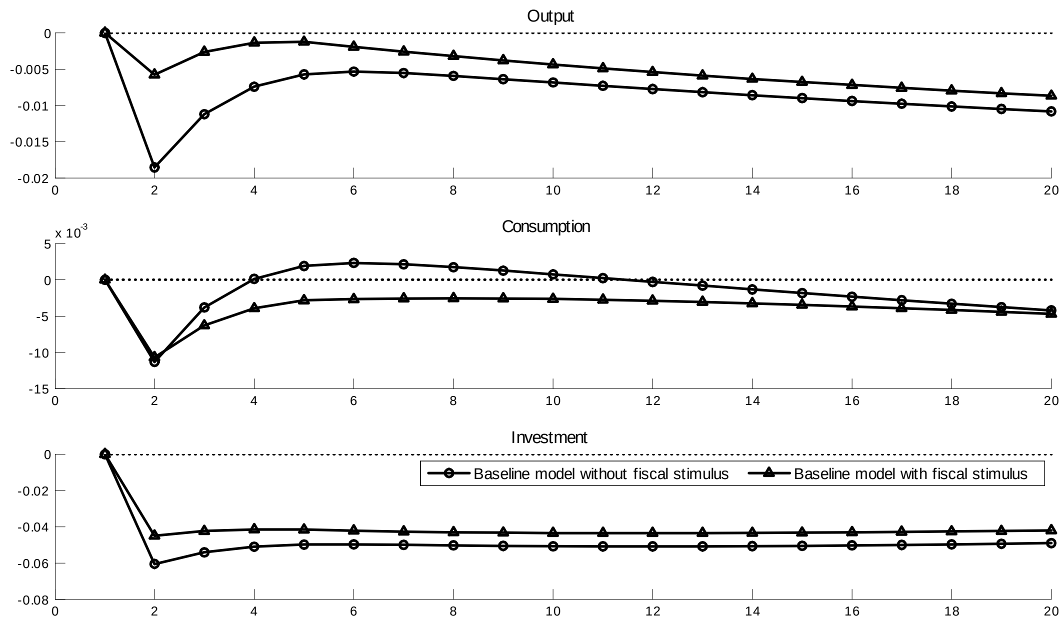

Figure 7c: Fiscal stimulus in the model with FA and the ZLB

Model specification	**Fiscal stimulus**	$\frac{\Delta Y}{\Delta G}$
Model with FA	temporary	0.502
Model without FA	temporary	0.336
Model with FA+ZLB	temporary	1.015
Model with FA+ZLB	prolonged as long as the ZLB binds	0.945
Model with FA+ZLB	prolonged beyond the ZLB binds	-0.474
Model with FA+ZLB	delayed	0.922

Table 1: Government spending multipliers