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# Optimal monetary policy in a small open economy with financial frictions


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**Abstract**

I analyze how the introduction of financial frictions can affect the trade-off between output stabilization and inflation stability and whether, in the presence of financial frictions, the optimal outcome can be realized – or approached more closely – if monetary policy is allowed to react to aggregate financial variables. Moreover, I explore the issue of whether an inflation targeting *cum* exchange rate stabilization and a price-level targeting are more suitable rules in minimizing distortions generated by the presence of liabilities defined in foreign currency and in nominal terms. I find that, when the financial accelerator mechanism is working, a price-level targeting rule dominates. One *caveat* is that the source of the shock plays an important role. Once the financial shock is not operative, the gain from a price-level targeting rule decreases significantly.



*JEL classification:* E31, E44, E52, E58

*Keywords:* Monetary policy, Taylor rule, financial accelerator, price-level targeting, asset prices.

## Non-technical summary

The goal of this paper is to analyze the optimal monetary policy reaction function in the context of a New Keynesian small open economy model. Two features are worth highlighting because of their potential importance for emerging market economies. The first key factor is the presence of two sectors: a non-tradable sector and a tradable sector. This particular set-up allows the introduction of different degrees of stickiness. In this framework, while firms set their prices as monopolistic competitors in the non-tradable sector, firms are price-takers in the export sector. The second key factor is the dollarization of liabilities that assumes particular importance in the context of emerging economies because it introduces an additional source of vulnerability to external shocks.

This model is closely related to the analytical framework developed in Gertler, Gilchrist and Natalucci (2003) and in Devereux, Lane and Xu (2004). Unlike this strand of literature, I highlight mainly the effects of changes in financial variables, rather than in the exchange rate. The underlying reason for this is that financial frictions are closely related to the financial premium. Therefore, it is straightforward to investigate the performance of a rule that also includes a response to this variable.

I compare outcomes under four alternative Taylor rules: a "standard" inflation targeting rule (hereafter, IT), an "augmented" Taylor rule (that is an inflation targeting rule which also responds to financial variables), an inflation targeting *cum* exchange rate stabilization rule, and a price-level targeting rule (hereafter, PLT). The analysis is based on a social loss function that penalizes the deviation of output and inflation from their steady-state values. Moreover, a large floating in the nominal domestic interest rate is also penalized.

A first finding is that, in a model with both nominal and financial frictions, a simple policy rule is not able to close the output gap and realize a zero inflation rate at the same time. Indeed, I find that, in a model with both nominal and financial frictions, a simple policy rule delivers a higher value of loss than in a model without financial frictions. Moreover, the presence of financial frictions requires more inertia in the optimal rule in order to stabilize interest rates. In this way, the monetary rule is successful in

minimizing the risk embedded in the repayment of nominal debt. Nevertheless, this argument depends on the source of the shock. Indeed, the gain from a super-inertial rule is significantly reduced if the economy is not affected by the financial shock.

A second result is that a monetary rule responding to changes in the aggregate financial premium does not improve on loss, but needs a lower degree of inertia.

A third result is drawn from the analysis of a monetary rule that stabilizes CPI inflation, output and the exchange rate. I find that reducing the volatility of the exchange rate limits the ability of the central bank to enact stabilizing monetary policy by devaluating the exchange rate. Then, the monetary authority is forced to increase the interest rate. This exacerbates the contraction in investment spending, which, in turn, affects net worth and output.

Finally, a PLT rule produces the best outcomes in terms of the variance of inflation and volatility of nominal interest rates. This result arises from the fact that a PLT rule introduces a desirable inertia into the monetary rule. One *caveat* is that the source of the shock plays an important role. Once the financial shock is not operative, the gain from PLT decreases significantly.

**Nichttechnische Zusammenfassung**

Ziel dieses Papiers ist es, die optimale geldpolitische Reaktionsfunktion im Rahmen eines neokeynesianischen Modells einer kleinen offenen Volkswirtschaft zu untersuchen. Aufgrund der potenziellen Bedeutung für Schwellenländer sind hierbei zwei Merkmale hervorzuheben. Zum einen ist dies das Vorhandensein von zwei Sektoren, und zwar des Sektors der nicht handelbaren Güter und des Sektors der handelbaren Güter. Dieser spezielle Aufbau ermöglicht es, unterschiedliche Rigiditätsgrade einzuführen. Innerhalb dieses Rahmens legen Unternehmen aus dem Sektor der nicht handelbaren Güter ihre Preise als monopolistische Wettbewerber fest, während Unternehmen aus dem Exportsektor Mengenanpasser sind. Zum anderen ist dies die Dollarisierung von Verbindlichkeiten, die speziell für Schwellenländer von Bedeutung ist, da sie eine zusätzliche Schwachstelle in Bezug auf externe Schocks darstellt.

Das vorliegende Modell steht in engem Zusammenhang mit dem von Gertler, Gilchrist und Natalucci (2003) sowie von Devereux, Lane und Xu (2004) entworfenen analytischen Rahmen. Im Gegensatz zu der genannten Fachliteratur werden in dieser Studie jedoch in erster Linie die Effekte von Veränderungen finanzieller Variablen und nicht jene von Wechselkursänderungen behandelt. Grund hierfür ist, dass finanzielle Friktionen eng mit finanziellen Prämien verbunden sind. Es ist daher unkompliziert, die Effizienz einer Regel zu untersuchen, die auch eine Reaktion auf diese Variablen enthält.

In der vorliegenden Arbeit werden die Ergebnisse anhand von vier verschiedenen Taylor-Regeln verglichen, und zwar einer „Standardregel“ mit Inflationsziel (nachfolgend als IT bezeichnet), einer „erweiterten“ Taylor-Regel (also einer Regel mit Inflationsziel, die auch auf finanzielle Variabeln reagiert), einer Regel mit Inflationsziel *und* Wechselkursstabilisierung sowie einer Regel mit Preisniveauziel (nachfolgend als PLT bezeichnet). Die Analyse beruht auf einer Wohlfahrtsverlust-Funktion, die Abweichungen der Produktion und der Inflation von ihren Gleichgewichtswerten

sanktioniert. Außerdem werden auch große Schwankungen beim inländischen nominalen Zinssatz sanktioniert.
Die Studie kommt erstens zu dem Ergebnis, dass eine einfache geldpolitische Regel in einem Modell mit nominalen und finanziellen Friktionen nicht gleichzeitig die Produktionslücke schließen und eine Inflationsrate von null erzielen kann. Tatsächlich führt eine einfache geldpolitische Regel in einem Modell mit nominalen und finanziellen Friktionen zu einem höheren Verlustwert, als dies in einem Modell ohne finanzielle Friktionen der Fall wäre. Darüber hinaus erfordert das Vorhandensein finanzieller Friktionen bei der optimalen Regel ein größere Persistenz, um eine Stabilisierung der Zinssätze zu erreichen. Insofern ist die geldpolitische Regel erfolgreich, wenn es um die Minimierung des aus der Rückzahlung der nominalen Verschuldung resultierenden Risikos geht. Allerdings hängt dieses Argument vom Ursprung des Schocks ab. Tatsächlich werden die Vorteile einer Regel, die eine sehr große Persistenz aufweist, erheblich geschmälert, wenn die Volkswirtschaft durch den finanziellen Schock nicht berührt wird.
Zweitens verbessert sich eine geldpolitische Regel, die auf Veränderungen der finanziellen Prämie insgesamt reagiert, hinsichtlich der Verlustfunktion nicht. Allerdings ist ein niedrigerer Grad an Persistenz erforderlich.
Drittens hat die Analyse einer geldpolitischen Regel, durch die die VPI-Inflation, die Produktion und der Wechselkurs stabilisiert werden, ergeben, dass eine Verringerung der Wechselkursvolatilität die Fähigkeit der Zentralbank beschränkt, durch eine Abwertung des Wechselkurses stabilisierend zu wirken. Die Währungsbehörde ist dann gezwungen, die Zinssätze anzuheben, wodurch der Rückgang der Investitionstätigkeit verschärft wird. Dies wiederum wirkt sich auf das Vermögen und die Produktion aus.
Schließlich ist festzuhalten, dass eine PLT-Regel die besten Ergebnisse im Hinblick auf die Varianz der Inflation und die Volatilität der nominalen Zinssätze liefert. Dies ergibt sich aus der Tatsache, dass eine PLT-Regel eine erstrebenswerte Persistenz in der geldpolitischen Regel einführt. Eine *Einschränkung* ist jedoch, dass der Ursprung des Schocks eine wichtige Rolle spielt. Wenn ein finanzieller Schock vorliegt, sind die Vorteile einer PLT-Regel erheblich geringer.

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## 1 Introduction

The financial crises over the past decade have generated interest in the design of monetary policy for emerging market economies. Many economists have argued that if credit frictions are quantitatively important for cyclical fluctuations, models used for monetary policy analysis should take them more seriously in order to offset the propagation of transitory shocks.

The goal of this paper is to analyze the optimal monetary policy reaction function in the context of a New Keynesian small open economy model. Two features are worth highlighting because of their potential importance for emerging market economies. The first key factor is the presence of two sectors: a non-tradable sector and a tradable sector. This particular set-up allows the introduction of different degrees of stickiness. In this framework, while firms set their prices as monopolistic competitors in the non-tradable sector, firms are price-takers in the export sector.

The second key factor is the dollarization of liabilities. This assumption does not seem to stretch plausibility, given that, essentially, all lending to emerging markets is denominated in the world's four major currencies. The dollarization of liabilities assumes

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particular importance in the context of emerging economies because it introduces an additional source of vulnerability to external shocks. With foreign-currency-denominated debt, the depreciation of the exchange rate reduces the entrepreneurial net worth, enhancing the role of financial frictions. A number of authors have stressed the significance of having debt denominated in foreign currency in order to explore which exchange rate regime is more desirable for insulating emerging market economies from external shock. Moreover, I will stress the role of nominal liabilities denominated in foreign currency when the economy is affected by financial shocks. Assets in nominal terms induce private risk generated by the uncertain returns. In particular, nominal debt contracts generate an unnecessary redistribution of wealth between borrowers and lenders as a result of unexpected changes in price level. Variations in the price level generate distortions in the allocation of resources and thus affect economic activity.

I consider four kinds of shocks: two sector-specific productivity shocks, a price markup shock and a financial shock. A kind of financial shock could be a risk premium shock, such as a shock to the elasticity of the premia to the leverage ratio.

At a first step, I consider the case where the central bank targets the same variables as in the historical rule, i.e. aggregate CPI inflation and the output gap. Moreover, the central bank should allow for a moderate degree of nominal interest rate smoothing.

I analyze the optimal policy and the trade-off that may arise between output stabilization and price stability both in the model with financial accelerator and in the model without financial accelerator. A first result is that, in a model with both nominal and financial frictions, a simple policy rule is not able to close the output gap and realize a zero inflation rate at the same time. At a later stage, I investigate whether the optimal outcome can be realized again – or approached more closely – if monetary policy is allowed to react to the aggregate or the sector specific financial variables. This further analysis has to be framed in the recent debate on whether or not the setting of short-term interest rates should actively consider movements in asset prices. This view stems from the fact that financial bubbles lead to excessive investments and consumption. More investments stimulate aggregate demand and output in the short run, but, in the end, create overcapacity and result in a collapse of real output and prices. Some authors argue that a central bank should react to the asset price in order to reduce the overall volatility in economic activity.

As summarized above, many authors have used a two-sector small open economy set-up in order to stress the impact of exchange rate fluctuations on the indebtedness and, therefore, on the net worth position of the firm. They have drawn policy guidelines for the choice of the exchange rate regime more suited to absorbing shock. I also explore whether reducing the volatility of the exchange rate may be better for mitigating the effect of financial frictions.

Finally, I explore the issue of whether the price level is a better target for monetary policy. This analysis is justified by the opinion that not only fluctuations in the exchange rate, but also movements in the price level affect the real value of the debt denominated in foreign currency. The "deflationary effect" is one of the main sources of the financial accelerator mechanism, as it generates an increase in financial premia and it propagates the negative effect of a shock through the balance sheet effects. To this extent, I investigate whether, in the presence of a deflation, it is preferable a monetary policy that is targeting the price level instead of the inflation rate. Moreover a price-level targeting rule is more successful in controlling expectations. Therefore, the volatility of the interest rate and exchange rate remains small. I investigate whether it may help in minimizing distortions introduced by the presence of debt defined in nominal terms and in foreign currency. With the debt denominated in foreign currency, the depreciation of the exchange rate increases the domestic value of foreign debt, thus reducing entrepreneurial net worth and enhancing the financial accelerator mechanism. Therefore, one would expect that the dollarization of liabilities makes the flexible exchange rate regime less attractive.

The paper is structured as follows. In section 2, I present an overview of the existing literature on the optimal monetary policy in models with financial frictions. I develop the model in section 3. In section 4, I present the Impulse Response Functions (IRFs) analysis to show whether the financial accelerator mechanism amplifies the initial shocks.

Section 5 describes the optimal monetary policy. First, I consider the optimal monetary policy both in a model with financial frictions and in a model without financial frictions. Then, I compare results under the "standard " Taylor rule and a Taylor rule that responds to financial variables. Moreover, I analyze the performance of an inflation targeting rule in which the nominal interest rate also responds to fluctuations in the exchange rate. Finally, I analyze the case of a price level target rule instead of an inflation target rule. Section 6 concludes.

# 2 Review of literature

Recently, many economists have argued that monetary policy in an open economy does not operate only through traditional interest-rate and exchange-rate channels. They have emphasized the role played by credit markets and imperfect information in the transmission of monetary policy to the real economy. Under perfect capital markets, firm's financial structure is irrelevant to its real investment decisions, and internal financing is a perfect substitute for external financing. Otherwise, if there are imperfections in capital markets, internal and external financing are no longer perfect substitutes, and investments decisions will depend on financial factors: problems in capital markets, as asymmetric information, will make it costly for lenders to evaluate the quality of firms' investments. To overcome these frictions, lenders need to be compensated by raising a premium over the risk-free interest rate or requiring significant levels of collateral. If credit frictions are quantitatively important for cyclical fluctuations,[2] models used for

[2] Despite the widespread perception that a deterioration in financial conditions can contribute to economic downturns and suddens stops (Braggion, Christiano and Roldos (2007), Curdia (2007)), the conclusions arising from estimated medium-scale DSGE models with financial market frictions cast some doubts on the macroeconomic relevance of financial frictions. Some studies conclude that financial market frictions are relevant for the US and the euro area (Christiano et al. (2006); Levin, Natalucci, and Zakrajsek (2004); Quejo (2004)). These studies show not only that credit markets provide an additional source of shocks, but also that financial frictions are important to understand the transmission of non-financial aggregate shocks. Conversely, other studies reach opposite conclusions (see, for example, Meier and Muller (2006)).

monetary policy analysis should take them more seriously in order to offset the propagation of transitory shocks.

## 2.1 Open economy models with financial frictions

Two topics are worth being discussed further in this subsection: the role of financial frictions and the presence of a trade-off between inflation and output in an open economy environment. The theoretical literature on credit market imperfections is immense. Models may be distinguished with regard to the way they introduce financial frictions. In this paper, the mechanism of transmission operates through firms' balance sheets.[3] Credit market imperfections may create a wedge between the cost of internal and external financing. In Bernanke, Gertler and Gilchrist (1995, 1998) this wedge arises because of agency costs and asymmetric information that makes monitoring costly for lenders. As a consequence, investment decisions will depend on variables, such as cash flows, that would not play a role if information were perfect. The underlying mechanism works in the following way. A recession will worsen firms' balance sheets, reducing the availability of internal funds, forcing firms to turn to external sources and increasing agency costs. This leads to a reduction in investment spending, amplifying the recession.

In Bernanke and Gertler (1989), shocks to the economy are amplified and propagated by their effects on borrowers' cash flows. 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.[4]

[3] This mechanism of transmission has been introduced both in two-country models (Gilchrist, Hairault and Kempf (2002)) and in small open economy models (Bernanke, Gertler and Gilchrist (1998); Cespedes, Velasco and Chang (2004); Devereux Lane and Xu (2004); Gertler, Gilchrist and Natalucci (2003)).

[4] Recent literature has relaxed the assumption of a single instrument of external finance. De Fiore and Uhlig (2005) build a financial accelerator model where heterogeneous firms at risk of default choose between two instruments of external finance, namely corporate bonds and bank loans. This framework is used to explain long-run differences in corporate finance between the US and the euro area, and to

Concerning the trade-off between output volatility and inflation volatility[5], three main conclusions about optimal policy characterize closed economy models. First, the central bank faces an inflation-output gap volatility trade-off only in the presence of cost-push shocks. Second, aggregate demand shocks should be completely stabilized. Third, even in the absence of the standard Barro-Gordon inflation bias under discretionary policy, there are still gains from commitment (or a conservative central banker), but these gains depend on the serial correlation properties of the cost-push shock and not on those of the aggregate demand.

In this paper, I depart from a closed economy framework and I use a two-sector small open economy set-up. Two main components distinguish the open economy framework from a closed economy: i) an output equation including demand for both domestic goods and import goods; ii) an interest rate parity equation reflecting the importance of the exchange rate.

In the open economy environment, the real exchange rate affects both inflation and aggregate demand. The former is affected through the interest rate parity, while the latter is affected through the expenditure-switching effect. Thus, if domestic currency depreciates, domestic goods are cheaper abroad and foreign consumption is increased. Moreover, domestic demand is also affected through interest rate movements. In response to the currency depreciation and the increase in the exchange rate, the central bank may raise the interest rate to compensate for the currency depreciation that reduces the value of the return to foreign investors. If the real interest rate faced by consumers and firms rises, output decreases.

Now, if the exchange rate acts purely as a demand shock, optimal policy would completely stabilize the domestic economy from exchange rate disturbances. Otherwise,

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analyze the effects of monetary policy on the composition of firms' external finance and on business cycle fluctuations.

[5] A growing literature explores the shape of this trade-off, both in theoretical models and in empirical works. See, for example, Rudebusch and Svensson (1997), Fuhrer (1997), McCallum and Nelson (1998), Cecchetti (1999), Haldane and Batini (1998), Conway, Drew, Hunt, and Scott (1998), Clarida, Galí, and Gertler (1999), Erceg, Henderson, and Levin (1999).

when exchange rate also affects inflation, stabilizing aggregate demand in the face of exchange rate disturbances leads to fluctuations in inflation. Thus, the optimal policy trades off some output variability for reduced inflation variability. Moreover, unlike the case in a closed economy, aggregate demand disturbances also force the central bank to trade off output and inflation variability. If the central bank adjusts the interest rate to neutralize the output effects of a demand shock, the exchange rate will move. This generates fluctuations in inflation. As a consequence, the potential gains from a central bank that attaches special importance on inflation stability depends on the time series properties of demand and exchange rate disturbances as well as on those of the cost-push shock.

An interesting issue to model is the way that changes in the exchange rate affect the price of import goods and how they are then passed through to domestic prices. Devereux, Lane and Xu (2004) stress the role of the degree of exchange rate pass-through in a two-sector small open economy. They show that the trade-off between inflation and output is stressed when the pass-through is high. In this case, there is a clear trade-off between real stability (of output and employment) and inflation stability (as well as nominal and real exchange rate stability). Conversely, in a low pass-through environment, the prices of all goods in the consumption basket respond sluggishly to inflation, and the exchange rate no longer acts as an "expenditure-switching" device, altering the relative price of home and foreign goods. The low rate of pass-through ensures that exchange rate shocks do not destabilize the price level. Therefore, the central bank can simultaneously strictly target inflation, but still allow high nominal exchange rate volatility in order to stabilize the real economy in the face of external shocks.

In the context of open economy models with financial frictions, many authors have stressed the impact of exchange rate fluctuations on indebtedness and, therefore, on the net worth position of the firm. They have drawn policy guidelines for the choice of the exchange rate regime more suitable to absorbing shock. This feature becomes particularly relevant for emerging economies, where partial dollarization is under way, especially if they have a history of high inflation. In these economies, while liabilities are denominated in foreign currency, assets are denominated in domestic currency. Due to such a currency mismatch, borrowers can be forced into bankruptcy by an unexpected depreciation of the exchange rate that may reduce entrepreneurial net worth, enhancing the role of financial frictions. In this field on analysis, Cespedes, Chang and Velasco (2000) focus on the relationship between exchange rate risk premium and the presence of financial frictions. They provide a closed form solution for a model with endogenous risk premium à la Bernanke and Gertler (1989). Moreover, they perform a simulation for two different parameters configuration corresponding to financially fragile and robust economies depending on the level of indebtedness. A main point of their analysis is the "dollarization" of liabilities which makes effects of real devaluation more drastic for entrepreneurial net worth, and hence for investments, due to the presence of financial frictions.

Devereux, Lane and Xu (2004) argue that with high pass-through, stabilizing the exchange rate involves a trade-off between real stability and inflation stability, and the best monetary policy rule is to stabilize non-traded goods prices. With delayed pass-through, the trade-off disappears and the best monetary policy rule is CPI inflation stability. An important feature of low pass-through is that it eliminates the trade-off between output volatility and inflation volatility in a comparison of fixed relative to floating exchange rates. By following a price stability rule, the policy maker can do better than a fixed exchange rate: both output volatility and inflation volatility may be lower than under a fixed exchange rate.

The framework of this paper is closely related to work by Devereux, Lane and Xu (2004). They study optimal monetary policy in a similar model with micro-founded financial frictions, but the focus of that paper is the analysis of welfare-based simple rules and the implications of the degree of pass-through. They do not characterize the fully optimal Ramsey policy. Compared with Devereux, Lane and Xu (2006), the original contribution of this paper is twofold.

First, I assume that debt contracts hold by entrepreneurs are in nominal terms as opposed to Bernanke, Gertler and Gilchrist, where the debt is specified in real terms.

By contrast, I will stress the role of nominal liabilities denominated in foreign currency when the economy is affected by financial shocks. Assets in nominal terms induce private risk generated by the uncertain returns. In particular, nominal debt contracts generate unnecessary redistribution of wealth between borrowers and lenders as a result of unexpected changes in price level. Variations in the price level generate distortions in the allocation of resources and thus affect economic activity. This is an original contribution of this paper. This assumption is quite realistic since most financial contracts are not fully indexed to the price level. In contrast to the real version of debt, the presence of non-indexed contracts implies a direct dependence of the external finance premium on expected inflation. Thus, price deflation is one of the sources of the financial accelerator mechanism. The "debt deflationary effect" exerts upward pressures on the risk premium. Hence, the monetary authority would have a stronger incentive to inflate the economy. Surprise inflation would indeed increase the value of nominal net worth, thereby reducing the ex-post value of real debt and the cost of the loan. This argument, which is consistent with the Fisherian theory of debt deflation, might call for sizeable deviations of optimal monetary policy from the price stability target.

In this way, expansionary effects generated by deflationary shock are dampened due to the presence of the financial accelerator mechanism. In this case, an optimal response would imply a lower nominal interest rate in order to avoid a recession.

Second, this set-up is more realistic as it allows for sticky wages as well as sticky prices.[6] A knowledge about wage-setting is fundamental to understanding both the monetary policy transmission process and the potential trade-offs monetary policy may be faced with. Because of sticky wages, fluctuations in CPI inflation will induce undesired fluctuations in the real wage, and therefore, in the wage mark-up acting as an endogenous cost-push shock. Given that movements in CPI inflation translate into fluctuations in the wage mark-up, the higher the volatility of CPI inflation is, the higher will be the volatility of the endogenous cost-push shock. This translates into a stronger trade-off faced by the monetary authority between stabilizing inflation and closing the output gap.

[6] As discussed in Woodford (2002, chap. 3)

## 2.2 Asset prices and monetary policy

An interesting recent debate in the field of monetary policy has focused whether or not the setting of short-term interest rates should actively consider movements in asset prices[7].

On the one hand, some literature suggests that the monetary policy can play a potential stabilization role by responding to misalignments in asset prices. This view stems from the fact that changes in asset prices affect the availability of credit to firms and, owing to market incompleteness, have a direct impact on the real sector of the economy. Among these authors, are Cecchetti, Genberg, Lipsky, & Wadhwani (2000) and Quadrini (2007). The main reason to react to asset prices misalignments is that asset price bubbles create distortions in investment and consumption, leading to excessive increases and then falls in both real output and inflation. Raising interest rates modestly as asset prices rise above what are estimated to be warranted levels will tend to offset the impact of these bubbles on output and inflation, thereby enhancing overall macroeconomic stability. In the particular case of an emerging economy where the financial accelerator plays a significant role, a financial bubble leads to higher investment as firms can borrow more easily, given the higher value of their collateral. More investments stimulate aggregate demand and output in the short run, but in the end create overcapacity and result in a sharp downturn. Therefore, in this view, a central bank should react to the asset price in order to avoid boom and bust in economic activity.

Recently, Cúrdia and Woodford (2008) have showed that, in the presence of credit frictions, it is always optimal to include a spread adjustment to a simple Taylor rule. The main open issue is the magnitude of adjustment that would be appropriate, depending

[7] Siklos Werner and Bohl (2004) consider house prices and the exchange rate as a kind of asset prices. Models of the financial accelerator have been used to analyze not only the financing of the corporate sector through loans, but also the financing of households through mortgages or credit lines (see, for example, Iacoviello (2005), and Aoki et al. (2004)). For instance, Aoki et al. consider a DSGE model with frictions in the credit market used by households to investigate the impact of house prices on consumption via their role as collateral for household borrowings. They also consider the implication for monetary policy of recent structural changes in the United Kingdom's retail financial markets.

on the source of the shock. In some cases, it is desirable to lower the interest rate by the full amount of the increase in the spread between the deposit rate and the lending rate. In other cases, a much smaller adjustment would lead to a more nearly optimal policy. Furthermore, sometimes even an adjustment several times larger than the increase in credit spreads would not be sufficient.

However, other papers are more critical about the potential benefits of a monetary policy reaction to asset prices. In this view, Bernanke & Gertler (1999, 2001) show that, as long as interest rates react aggressively to expected inflation, there is no need to respond to asset prices if the monetary authority controls inflation.

Batini and Nelson (2000) evaluate the performance of alternative simple monetary policy rules under both bubble and no-bubble scenarios and investigate whether policy makers should react to the deviation from the steady-state of the real exchange rate which can be considered as one of the key asset prices in the economy. They conclude that, in a forward-looking model, in the absence of a bubble, responding to the exchange rate separately reduces exchange rate variability but in most cases, does not improve overall welfare because inflation variability increases. With a bubble present, reacting to the exchange rate does not even necessarily reduce exchange rate volatility, and in general leads to poorer welfare outcomes.[8]

Faia and Monacelli (2005) argue that strict inflation stabilization is a robust optimal monetary policy prescription. Using two different macroeconomic frameworks, they conclude that, in both models, reacting to asset prices does not improve on welfare in the conduct of monetary policy.

Smets (1997) and Dupor (2002) argue that the direction of the policy response to asset prices depends on the underlying source of the asset price increase. For example, when equity prices rise because of a permanent rise in total factor productivity, monetary policy may want to accommodate the boom by keeping the real interest rate unchanged.

[8] Ball (1999) finds that adding the exchnge rate to the Taylor rule improves macroeconomic performance only if the exchange rate has a significant role in the transmission mechanism of structural shocks and monetary policy.

In contrast, when equity prices rise because of non-fundamental shocks in the equity market (e.g. over-optimistic expectations about future productivity), the optimal policy will be to respond by raising interest rates. Nevertheless, the assessment of the source of the shock will not be an easy task.

# 3 Model presentation

The structure is a standard two-sector small open economy model. Two goods are produced: a domestic non-traded good and an export good, the price of which is fixed on world markets.

Three central aspects are highlighted: a) the existence of nominal rigidities; b) the presence of lending constraints on investment financing; and c), the dollarization of liabilities.

Referring to the existence of nominal rigidities, the specific assumption made is that the prices of non-traded and imported goods are set by individual firms and adjusted only over time, following the specification à la Rotemberg. By contrast, I assume that exporters are price-takers so that the law of one price must hold for exported goods.

The second feature that should be highlighted is the presence of lending constraints on investment financing. The lending mechanism outlined represents a transmission channel linking balance sheet conditions to real spending decisions. I follow the BGG approach, which assumes that entrepreneurs should take up external funds to undertake investment projects. As lenders should bear agency costs to observe the returns on investments, entrepreneurs face higher costs of external financing of investments relative to internal financing. This leads investments to depend on entrepreneurial net worth. In particular these financial frictions can be summarized by two key variables: the elasticity of the premium on external funds with respect to the leverage and the degree of leverage itself. In countries where the financial system is weak and the percentage of investments financed through external funds is high, it is more likely that significant amplifications of shocks will be experienced through such a channel.

Finally, a number of authors have stressed the importance of having debt denominated in foreign currency. When the firm debt is expressed to a large extent in foreign currency, exchange rate fluctuations have a strong impact on indebtedness and, therefore, on the net worth position of the firm. Through this mechanism, the emerging economies are much more vulnerable to exchange rate fluctuations and the related volatility in capital inflows than are countries with a more developed capital market.

There are four sets of domestic actors in the model: consumers, firms, entrepreneurs, and the monetary authority. In addition, there is a "rest of world" sector where foreign-currency prices of exports and imports are set and where lending rates are determined.

## 3.1 Households

I will describe the model in terms of the representative consumer who has preferences given by

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

where $\beta$ is the discount factor, $C_t$ is a composite consumption index, $H_t$ is the labour supply, and $M_t$ are real money balances.

Let the functional form of $u$ be given by

$$u = \frac{1}{1-\sigma}(C_t - hC_{t-1})^{1-\sigma} + \frac{b_t}{1-\varepsilon}(\frac{M_t}{P_t})^{1-\varepsilon} - \eta\frac{H_t^{1+\psi}}{1+\psi}$$

where $h$ measures the coefficient of habit in consumption.

Composite consumption is a CES function of consumption of non-traded goods and of imported goods

$$C_t = [a_c^{1/\rho_c} C_{Nt}^{1-1/\rho_c} + (1-a_c)^{1/\rho_c} C_{Mt}^{1-1/\rho_c}]^{\rho_c/\rho_c - 1}$$

where $\rho_c > 0$ is the elasticity of substitution between non-traded goods and import goods.

The implied consumer price index is

$$P_t = [a_c P_{Nt}^{1-\rho_c} + (1-a_c) P_{Mt}^{1-\rho_c}]^{1/1-\rho_c}$$

and the CPI inflation is defined as
$\pi_t = \dfrac{P_t}{P_{t-1}}$.

Each $j$ household maximizes the utility function subject to the following budget constraint:

$$P_t C_t = W_t^{(j)} H_t + \Pi_t + S_t B_t^h + M_t - M_{t-1} - R_{t-1}^{*n} S_t B_{t-1}^h - Tax_t - P_t \frac{\varphi_w}{2}\left[\frac{W_t^{(j)}}{W_{t-1}^{(j)}} - 1\right]^2$$

where the quadratic adjustment costs are defined in terms of the price of the final good.

Therefore, a consumer's revenue flow in any period comes from her supply of hours of work to firms for wages net of adjustment costs $P_t \frac{\varphi_w}{2}\left[\frac{W_t^{(j)}}{W_{t-1}^{(j)}} - 1\right]^2$, profits from firms $\Pi_t$ in both the domestic and import sectors, the real money balance $M_t$, less taxes $Tax_t$ paid to the government and less debt repayment $S_t R_t^{n*} B_t^h$. Here, $S_t$ is the nominal exchange rate, $B_t^h$ is the outstanding amount of foreign-currency debt hold by households.

An additional constraint is represented by the optimal demand for labour:

$$H_t^{(j)} = (\frac{W_t^{(j)}}{W_t})^{-\vartheta_w} H_t$$

The first-order conditions from the maximization problem are:

$$E_t[R_t^n (C_{t+1} - hC_t)^{-\sigma}] = \frac{1}{\beta}\frac{P_{t+1}}{P_t}(C_t - hC_{t-1})^{-\sigma}$$

$$\zeta(M_t)^{-\varepsilon} = \frac{R_t^n - 1}{R_t^n}(C_t - hC_{t-1})^{-\sigma}$$

$$W_t = \frac{\vartheta_t^w}{\vartheta_t^w - 1} P_t \left(\frac{U_{Lt}}{U_{Ct}}\right) - \frac{P_t}{H_t}\frac{\varphi_w}{\vartheta_t^w - 1}\pi_t^W(\pi_t^W - 1) + \beta \frac{U_{Ct+1}}{U_{Ct}}\frac{P_t}{P_{t+1}}\frac{P_{t+1}}{H_t}\frac{\varphi_w}{\vartheta_t^w - 1}\pi_{t+1}^W(\pi_{t+1}^W - 1)$$

The first equation represents the Euler equation for optimal consumption, while the second equation gives the implicit money demand function. Money demand depends on domestic nominal interest rates. The third equation defines the labour supply and the wage setting process. If the parameter $\varphi^W$ is zero, households simply set the wage as a mark-up$\frac{\vartheta^W}{\vartheta^W - 1}$ over the marginal rate of substitutions between labour and consumption, $(mrs_{L,C})_t = -\frac{U_{Lt}}{U_{Ct}}$

For the uncovered interest parity condition, foreign nominal interest rate $(R_t^{*n})$ is defined as

$$R_t^n = R_t^{*n}\frac{S_{t+1}}{S_t}$$

For the Fisher condition, real interest rate is defined as

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

Moreover, the household will choose non-traded and traded goods to minimize expenditures conditional on total composite demand $C_t$. The consumption of non-tradable and imported goods is, respectively, defined as

$$C_{Nt} = a_c(\frac{P_{Nt}}{P_t})^{-\rho_c}C_t$$

$$C_{Mt} = (1 - a_c)(\frac{P_{Mt}}{P_t})^{-\rho_c}C_t$$

Combining the two equations above yields:

$$C_{Nt} = \frac{a_c}{1 - a_c}(\frac{P_{Nt}}{P_{Mt}})^{-\rho_c}C_{Mt}$$

## 3.2 Firms

### 3.2.1 Production

Production is carried out by firms in each sector. The two sectors, tradable and non-tradable, differ in their production technologies. Both types of goods are produced by combining labour and capital.

The technology in the non-tradable sector is defined as

$$Y_{Nt} = A_N K_{Nt}^{\alpha} H_{Nt}^{1-\alpha}$$

where $A_N$ is the productivity parameter.

Similarly, exporters use the production function[9]

$$Y_{Xt} = A_X K_{Xt}^{\gamma} H_{Xt}^{1-\gamma}$$

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

$$W_{Nt} = MC_{Nt}(1-\alpha)\frac{Y_{Nt}}{H_{Nt}}$$

$$r_{Nt}^{K} = MC_{Nt}\alpha\frac{Y_{Nt}}{K_{Nt}}$$

$$W_{Xt} = P_{Xt}(1-\gamma)\frac{Y_{Xt}}{H_{Xt}}$$

$$r_{Xt}^{K} = P_{Xt}\gamma\frac{Y_{Xt}}{K_{Xt}}$$

The first two equations describe the choice of employment and capital which achieves cost minimization in the non-traded goods sector, where $MC_{Nt}$ denotes the marginal cost in that sector. The third and fourth equations characterize cost minimization in the export sector. Note that the price of the traded export good is $P_{Xt}$. Since the export sector is competitive, $P_{Xt}$ represents the unit cost of production. Movements in this price, relative to the import price $P_{Mt}$, represent terms of trade fluctuations for the small economy.

Moreover, because of labour mobility, I assume that the nominal wage in the tradable sector is equal to the nominal wage in the non-tradable sector:

$$W_{Nt} = W_{Xt} = W_t$$

### 3.2.2 Investments

Production of capital goods is also carried out by competitive firms. These firms combine imported and non-traded goods to produce capital goods. There are investment adjustment costs, so that the marginal return to investment in terms of capital goods declines in the amount of investment undertaken, relative to the current capital stock.

[9] For simplicity, I assume that all domestically produced tradable goods are exported.

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. Therefore, in both sectors $j = X, N$, capital stock evolve according to

$$K_{jt} = \left[ \frac{I_{jt-1}}{K_{jt-1}} - \frac{\chi}{2} \left( \frac{I_{jt-1}}{K_{jt-1}} - \delta \right)^2 \right] K_{jt-1} + (1-\delta) K_{jt-1}$$

where the parameter $\chi$ measures adjustment costs in the investment sector.

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

$$\max E_{t-1} \left\{ \left[ \frac{I_{jt}}{K_{jt}} - \frac{\chi}{2} \left( \frac{I_{jt}}{K_{jt}} - \delta \right)^2 \right] K_{jt} Q_{jt} - P_{It} I_{jt} \right\}$$

The f.o.c. gives the standard Tobin's Q equation modified to allow for the investment delay:

$$Q_{jt} = \frac{P_{It}}{1 - \chi \left( \frac{I_{jt}}{K_{jt}} - \delta \right)}$$

Similarly to the composite consumption good, the composite investments good is defined by a CES function as

$$I_t = [a_I^{1/\rho_I} I_{NNt}^{1-1/\rho_I} + (1-a_I)^{1/\rho_I} I_{Mt}^{1-1/\rho_I}]^{\rho_I/\rho_I - 1} \ , \rho_I > 0$$

The implied price index is defined as:

$$P_{It} = [a_I P_{Nt}^{1-\rho_I} + (1-a_I) P_{Mt}^{1-\rho_I}]^{1/1-\rho_I}$$

From the optimization problem, the demand for investment goods in each sector is

$$I_{NNt} = a_I (\frac{P_{Nt}}{P_{It}})^{-\rho_I} I_t$$

$$I_{Mt} = (1-a_I)(\frac{P_{Mt}}{P_{It}})^{-\rho_I} I_t$$

Combining the above two equations,

$$I_{NNt} = \frac{a_I}{1-a_I} (\frac{P_{Nt}}{P_{Mt}})^{-\rho_I} I_{Mt}$$

For simplicity, it is assumed that $a_c = a_I = a$ and $\rho_c = \rho_I$ so that $P = P_I$.

### 3.2.3 Price-setting and local currency pricing

In the export sector, the law of one price implies that

$$P_{Xt} = S_t P^*_{Xt}.$$

where $P^*_{Xt}$ is exogenously given.

If prices were fully flexible, the following equations for domestic and import prices would hold:

$P_{Nt} = MC_t$

$P_{Mt} = S_t P^*_{Mt}$ .

where $P^*_{Mt}$ is exogenously given.

To introduce nominal price-setting in the non-traded goods sector and import sector, it is assumed that the consumption is differentiated as

$$C_{Nt} = [\int_0^1 C_{Nt}(i)^{1-\theta p} di]^{1/1-\theta p} \quad \theta p > 1$$

$$C_{Mt} = [\int_0^1 C_{Mt}(i)^{1-\theta p} di]^{1/1-\theta p} \quad \theta p > 1$$

Firms in both the domestic sector and import sector set their prices as monopolistic competitors. I follow Rotemberg (1982) in assuming that each firm bears a small direct cost of price adjustment. As a result, firms will only adjust prices gradually in response to a shock to demand or marginal cost. Firms are owned by domestic households. Thus, a firm will maximize its expected profit stream, using the households discount factor $\Gamma_{t+1} = \beta \frac{U_{Ct+1}}{U_{Ct}} \frac{P_t}{P_{t+1}}$

Each firms $(i)$ in the non-tradable sector chooses its price $P^{(i)}_{Nt}$ to maximize

$$\max \sum_{t=0}^{\infty} \Gamma_t \left\{ P^{(i)}_{Nt} Y^{(i)}_{Nt} - MC_t Y^{(i)}_{Nt} - P_t \frac{\varphi_N}{2} \left( \pi^{(i)N}_{t+1} - 1 \right)^2 \right\}$$

$$s.t.\ Y^{(i)}_{Nt} = \left( \frac{P^{(i)}_{Nt}}{P_{Nt}} \right)^{-\vartheta_{Pt}} Y_{Nt}$$

The third expression in parentheses describes the cost of price change that is incurred by the firm. The constraint $Y_{Nt}^{(i)} = \left( \dfrac{P_{Nt}^{(i)}}{P_{Nt}} \right)^{-\vartheta_{Pt}} Y_{Nt}$ represents total demand for firm $i$'s production.

Let us define inflation in both the domestic and import sectors as follows:

$\pi_t^N = \dfrac{P_{Nt}}{P_{Nt-1}}$

$\pi_t^M = \dfrac{P_{Mt}}{P_{Mt-1}}$

The optimal price-setting equation in the non-tradable sector can be written as

$$P_{Nt} = \frac{\vartheta_{P_t}}{\vartheta_{P_t} - 1} MC_t - \frac{\varphi_N}{\vartheta_{P_t} - 1} \frac{P_{Nt}}{Y_{Nt}} \pi_t^N (\pi_t^N - 1) + \frac{\varphi_N}{\vartheta_{P_t} - 1} \beta \frac{P_t}{P_{t+1}} \frac{U_{Ct+1}}{U_{Ct}} \frac{P_{Nt+1}}{Y_{Nt}} \pi_{t+1}^N (\pi_{t+1}^N - 1)$$

If the parameter $\varphi_N$ is zero, firms set prices as a mark-up over the marginal cost, as in the economy with flexible prices.

In a similar way, each firm $i$ in the import sector chooses its price $P_{Mt}^{(i)}$ to maximize

$$\max \sum_{t=0}^{\infty} \Gamma_t \left\{ P_{Mt}^{(i)} Y_{Mt}^{(i)} - S_t P_{Mt}^{*} Y_{Mt}^{(i)} - P_t \frac{\varphi_M}{2} \left( \pi_{t+1}^{(i)M} - 1 \right)^2 \right\}$$

$$s.t. \ Y_{Mt}^{(i)} = \left( \frac{P_{Mt}^{(i)}}{P_{Mt}} \right)^{-\vartheta_{P_t}} Y_{Mt}$$

The optimal price setting equation in the import sector can be written as

$$P_{Mt} = \frac{\vartheta_{P_t}}{\vartheta_{P_t} - 1} (S_t P_{Mt}^{*}) - \frac{\varphi_M}{\vartheta_{P_t} - 1} \frac{P_{Mt}}{Y_{Mt}} \pi_t^M (\pi_t^M - 1) + \frac{\varphi_M}{\vartheta_{P_t} - 1} \beta \frac{P_t}{P_{t+1}} \frac{U_{Ct+1}}{U_{Ct}} \frac{P_{Mt+1}}{Y_{Mt}} \pi_{t+1}^M (\pi_{t+1}^M - 1)$$

## 3.3 Entrepreneurs

There are two groups of entrepreneurs. One group provides capital to the non-tradable sector, while the other provides capital to the traded sector. The entrepreneurs' behaviour is similar to that proposed by BGG (1998). The probability that an entrepreneur will survive until the next period is $\nu$, so the expected lifetime horizon is $\dfrac{1}{1-\nu}$. This assumption ensures that entrepreneurs' net worth (the firm equity) will never be enough to fully finance the new capital acquisition. Thus, entrepreneurs issue debt contracts to finance their desired investment expenditures in excess of net worth.

In both sectors $j = N, X$, the entrepreneurs' demand for capital depends on the expected marginal return:

$$E_t F_{jt+1} = E_t \left\{ \frac{r^K_{jt+1} + \left[1 - \delta + \chi\left(\frac{I_{jt+1}}{K_{jt+1}} - \delta\right)\frac{I_{jt+1}}{K_{jt+1}} - \frac{\chi}{2}\left(\frac{I_{jt+1}}{K_{jt+1}} - \delta\right)^2\right] Q_{jt+1}}{Q_{jt}} \right\}$$

where $F_{jt+1}$ is the external funds rate and and $r^K_{jt+1}$ is the marginal productivity of capital, at $t+1$ in each $j$ sector. Following BGG (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. Foreign lenders 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, lenders audit the loan and recover the project outcome less monitoring costs. Accordingly, the marginal external financing cost is equal to a gross premium for external funds over the gross real opportunity costs equivalent to the riskless interest rate. Thus, the demand for capital should satisfy the following optimality condition which states that the real return on capital is equal to the real cost on external funds:

$$E_t F_{jt+1} = E_t \left[ \left(1 + \frac{S_t \frac{B^e_{jt+1}}{P_t}}{N_{jt+1}}\right)^{\omega_{jt}} R^{*n}_t \frac{S_{t+1}}{S_t} \frac{P_t}{P_{t+1}} \right]$$

where $\omega_{jt}$ is the elasticity of the external finance premium in each $j$ sector with respect to the leverage ratio $1 + \frac{S_t \frac{B^e_{jt+1}}{P_t}}{N_{jt+1}} = \frac{K_{jt+1} Q_{jt}}{N_{jt+1}}$. The gross external finance premium depends on the borrowers leverage ratio:

$$premium_{jt} = \frac{E_t F_{jt+1}}{R^{*n}_t \frac{S_{t+1}}{S_t} \frac{P_t}{P_{t+1}}} = E_t \left[ \left(1 + \frac{S_t \frac{B^e_{jt+1}}{P_t}}{N_{jt+1}}\right)^{\omega_j} \right] = E_t \left[ \left(\frac{K_{jt+1} Q_{jt}}{N_{jt+1}}\right)^{\omega_j} \right]$$

$\frac{B^e_{jt+1}}{P_t}$ denotes the share of total real debt denominated in foreign currency held by entrepreneurs and is given by

$$\frac{B^e_{jt+1}}{P_t} = \frac{1}{S_t}(Q_{jt}K_{jt+1} - N_{jt+1})$$

The entrepreneur's net worth and consumption are defined respectively as

$$N_{jt} = \nu \left[ F_{jt}Q_{jt-1}K_{jt} - R^*_{t-1} \left( 1 + \frac{S_{t-1}\frac{B^e_{jt}}{P_{t-1}}}{N_{jt}} \right)^{\omega_{jt}} \frac{S_t}{S_{t-1}} \frac{P_{t-1}}{P_t} S_{t-1} \frac{B^e_{jt}}{P_{t-1}} \right]$$

$$C^e_{jt} = (1-\nu) \left[ F_{jt}Q_{jt-1}K_{jt} - R^*_{t-1} \left( 1 + \frac{S_{t-1}\frac{B^e_{jt}}{P_{t-1}}}{N_{jt}} \right)^{\omega_{jt}} \frac{S_t}{S_{t-1}} \frac{P_{t-1}}{P_t} S_{t-1} \frac{B^e_{jt}}{P_{t-1}} \right]$$

In this model, there are three main determinant components of the financial accelerator mechanism.

The first one is the fluctuation in the price of capital $Q_t$. A fall in the price of capital has effects on the leverage ratio, $\frac{S_t\frac{B^e_{t+1}}{P_t}}{N_{t+1}} = \frac{S_t\frac{B^e_{t+1}}{P_t}}{Q_tK_{t+1} - S_t\frac{B^e_{t+1}}{P_t}}$. As the leverage ratio rises, the risk premium also rises.

On the one hand, the higher risk premium will increase the cost of borrowing and, on the other hand, the lower price of capital will decrease the return on capital. Then, the entrepreneurial net worth will decrease at the end of the period and, other things being equal, the leverage ratio will be higher, amplifying the recession.

The second component of the financial accelerator mechanism is the movement in the nominal exchange rate. As it is assumed that the debt is denominated in foreign currency, a devaluation will increase the value of debt denominated in foreign currency, and, hence, the risk premium and the ex-post cost of borrowing, amplifying the recession in a way similar to that described for fluctuation in the price of capital.

The third component is the price level. During a disinflation, the price level decreases and the real value of debt increases. This "deflationary effect" has a negative impact on the risk premium. On the other hand, the interest payments on the existing debt, in real terms, also decreases. This effect, at least partially, offsets the "deflationary effect".

## 3.4 Monetary and fiscal policy

The general form of the interest rate rule may be written as

$$R_t^n = \left(\frac{\pi_t}{\bar{\pi}}\right)^{\rho_\pi} \left(\frac{ygap_t}{ygap_t^{flex}}\right)^{\rho_y} \left(\frac{premium_t}{premium_{t-1}}\right)^{-\rho_{PR}} \left(\frac{S_t}{S_{t-1}}\right)^{\rho_S} (R^n)^{1-\rho_{RN}} \left(R_{t-1}^n\right)^{\rho_{RN}} \exp(\varepsilon_{RNt})$$

The parameter $\rho_\pi$ governs the degree to which the CPI inflation rate is targeted around the desired target $\bar{\pi}$ . The parameter $\rho_y$ controls the degree to which interest rates attempt to control deviation of the output gap from the target level represented by the output gap in the flexible economy. The parameter $\rho_S$ controls the degree to which interest rates attempt to control variations in the exchange rate. I am assuming that monetary authority does not react immediately and adjust interest rate with a degree of inertia measured by $\rho_{RN}$.

I include in the monetary rule a response to change in the aggregate premium.[10] The underlying logic is that when, following a shock, premia are increasing, the central bank should decrease the nominal interest rate to offset, at least partly, the recessionary effects of the shock. Instead of introducing a response to asset prices, I decide to add the financial premium as a target for the monetary policy. There are two main reasons for this choice. First, financial distortions are closely related to leverage ratio and fluctuations in the exchange rate. It therefore seems more natural to insert into the Taylor rule a financial variable, as a premium, linked to both the leverage ratio and the exchange rate. Second, as Quadrini (2007) has pointed out, the main implication of globalization for emerging countries is that the economy becomes more vulnerable to external asset price shocks. Therefore, the target of monetary policy for stabilization purposes should shift from domestic asset prices to foreign asset prices. In this framework, as the debt

[10] The aggregate premium is obtained as a weighted average, using as weights the share of sectoral output over total output, measured at their steady-state vaues, that is

$premiun_t = \frac{Y_N}{Y} premium_{Nt} + \frac{Y_X}{Y} premium_{Xt}$

is denominated in foreign currency, the financial premia constitute one of the variables more closely affected by external asset prices (i.e. the exchange rate).

If the monetary authority is concerned about price level stability, an alternative specification for the Taylor rule can be

$$R_t^n = \left(\frac{P_t/\bar{P}_t}{(P_{t-1}/\bar{P}_{t-1})^{\eta_P}}\right)^{\rho_P}\left(\frac{ygap_t}{ygap_t^{flex}}\right)^{\rho_y}(R^n)^{1-\rho_{RN}}\left(R_{t-1}^n\right)^{\rho_{RN}}\exp(\varepsilon_{RNt})$$

where $\bar{P}_t$ is the target or steady-state value for the price level at period $t$. Note that for $\eta_P = 1$, the rule is precisely the Taylor rule defined for inflation targeting, while $\eta_P = 0$ signifies pure price-level targeting. For $0 < \eta_P < 1$ the rule is a hybrid one in which the central bank is concerned about reaching the inflation target rate but also about the evolution of prices on the way to the inflation target.

Fiscal policy is modelled in a very simple way. The government raises revenues via taxes ($Tax_t$) to finance exogenous government spending ($G_t$).

$$P_tG_t = Tax_t + (M_t - M_{t-1})$$

## 3.5 Equilibrium

Domestic demand and total output are respectively equal to

$$DD_t = C_t + C_{Nt}^e + C_{Xt}^e + G_t + I_{Nt} + I_{Xt} + \frac{\varphi_N}{2}\left(\pi_t^N - 1\right)^2 + \frac{\varphi_M}{2}(\pi_t^M - 1)^2 + P_t\frac{\varphi_w}{2}(\pi_t^W - 1)^2$$

$$P_tY_t = P_tDD_t + (P_{Xt}Y_{Xt} - P_{Mt}Y_{Mt})$$

For the investment sector, the equilibrium condition implies that

$$I_{Mt} + I_{NNt} = I_{Nt} + I_{Xt} = I_t$$

Total debt is the sum of debt held by households and debt held by enterprises:

$$B_t = B_t^h + B_{Nt}^e + B_{Xt}^e$$

The evolution of net total nominal debt in foreign currency is defined as

$$\begin{aligned} S_t B_{t+1} &= P_t \left( C_t + C^e_{Nt} + C^e_{Xt} + G_t \right) + P_{It} I_t - \left( \, r^K_{Nt} K_{Nt} + r^K_{Xt} K_{Xt} + W_{Nt} H_{Nt} + W_{Xt} H_{Xt} \right) \\ & \quad -(P_{Nt} - MC_t) Y_{Nt} - (P_{Mt} - P^*_{Mt} S_t) Y_{Mt} + P_t \frac{\varphi_N}{2} \left( \pi^N_t - 1 \right)^2 + P_t \frac{\varphi_M}{2} (\pi^M_t - 1)^2 P_t \frac{\varphi_w}{2} (\pi^W_t - 1) \\ &= R^{n*}_t S_t B_t + (P_{Mt} Y_{Mt} - P_{Xt} Y_{Xt}) - (P_{Mt} - S_t P^*_{Mt}) Y_{Mt} \end{aligned}$$

where $(P_{Nt} - MC_t)Y_{Nt}$ and $(P_{Mt} - S_t P^*_{Mt})Y_{Mt}$ are profits, respectively, from the domestic sector and the import sector.

The demand for imported goods and the demand for non-traded goods are, respectively, determined by the following equations:

$$Y_{Mt} = C_{Mt} + I_{Mt} + (1-a)(C^e_{Nt} + C^e_{Xt} + G_t) + (1-a) \left[ \frac{\varphi_N}{2} \left( \pi^N_t - 1 \right)^2 + \frac{\varphi_M}{2} (\pi^M_t - 1)^2 + \frac{\varphi_w}{2} (\pi^W_t - 1)^2 \right]$$

$$Y_{Nt} = C_{Nt} + I_{NNt} + a(C^e_{Nt} + C^e_{Xt} + G_t) + a \left[ \frac{\varphi_N}{2} \left( \pi^N_t - 1 \right)^2 + \frac{\varphi_M}{2} (\pi^M_t - 1)^2 + \frac{\varphi_w}{2} (\pi^W_t - 1)^2 \right]$$

Finally, labour market conditions must be satisfied:

$$H_{Xt} = (1-a) H_t$$

$$H_{Nt} = a H_t$$

so that labour market clearing condition implies

$$H_t = H_{Xt} + H_{Nt}$$

## 3.6 Autoregressive shocks

I introduce four exogenous shocks: two productivity shocks, one in the non-traded sector (i.e. an increase in $A_N$) and the other in the tradable sector (i.e. an increase in $A_X$), a price mark-up shock (i.e. an increase in the elasticity of substitution between varieties of goods) and a financial shock (i.e. an increase in the elasticity to the leverage ratio of premia). All the shocks follow a first-order autoregressive process:

$$A_{Nt} = A_N^{1-\rho_{AN}} (A_{Nt-1})^{\rho_{AN}} \exp(\varepsilon_{ANt})$$

$$A_{Xt} = A_X^{1-\rho_{AN}} (A_{Xt-1})^{\rho_{AN}} \exp(\varepsilon_{AXt})$$

$$\vartheta_{pt} = \vartheta_{pt}^{1-\rho_\vartheta} (\vartheta_{pt-1})^{\rho_\vartheta} \exp(\varepsilon_{\vartheta pt})$$

$$\omega_t = (\omega_t)^{1-\rho_\omega} (\omega_{t-1})^{\rho_\omega} \exp(\varepsilon_{\omega t})$$

## 3.7 Calibration

Following the literature, I set the steady-state rate of depreciation of capital ($\delta$) equal to 0.025 which corresponds to a rate of depreciation equal to 10 % annually; the discount factor $\beta$ equal to 0.99, which corresponds to an annual real rate in steady-state of 4 %. The steady-state share of capital in the non-tradable output ($\alpha$) is equal to 0.3, while the steady-state share of capital in the tradable output, $g$, is set equal to 0.6. I follow Bernanke Gertler and Gilchrist (1998) in setting $\chi$ so that the elasticity of Tobin's Q with respect to the investment capital ratio is 0.3. The probability $\nu$ that entrepreneurs will survive for the next period is set equal to 0.9; therefore, on average, entrepreneurs may live 36 years. Following Gertler Gilchrist and Natalucci (2003), the elasticity of substitution between domestic goods and imported goods in consumption ($\rho$) is set equal to 1 and the share of non-tradable goods in CPI ($a$), is set equal to 0.5. Finally, the inverse of elasticity of substitution in real balance ($e$) is set equal to 2; the elasticity of labour supply ($\psi$), and the coefficient of labour in utility ($\eta$) are both set equal to 1. I set the steady-state value of the elasticity of substitution between varieties of goods equal to 6, in both the non-tradable and import sectors. This value delivers a steady-state value for the price mark-up equal to 20 %. The same calibration applies for wage mark-up. The relative risk aversion coefficient ($\sigma$) is set equal to 1; the habit persistence parameter ($h$) is set equal to 0.70. For both sectors, the elasticity of risk premia to the leverage ratio ($\omega_N$ and $\omega_X$) is assumed to be equal to 0.02 and the steady-state value of the leverage ratio equal to 3. The value I choose for the leverage ratio is not consistent with a strand of literature that normally sets this parameter at a value of 2 for US.[11] Nevertheless, as the model I present is intended to be specialized towards the emerging market environment, it is reasonable to think that these countries are more willing to bear a higher level of debt equity ratio.[12] Price and wage adjustment costs are set so to correspond to a Calvo parameters equal to 0.75.[13] The parameters of the policy rule in the benchmark model are standard: I assume that $\rho_\pi$ is equal to 1.5, $\rho_y$ is equal to 0.5 and $\rho_{RN}$ is equal to 0.8. Shocks are persistent: the autoregressive parameter is assumed to be equal to 0.9 for all the shocks.

# 4 Impulse response functions analysis

In order to investigate the role played by the financial accelerator mechanism (hereafter, FA), I compare the IRFs under three alternative specifications of the model: the model without the FA mechanism ($\frac{Q_t K_{t+1}}{N_{t+1}} = 1$ and $\omega = 0.00$), the model with a weak FA mechanism ($\frac{Q_t K_{t+1}}{N_{t+1}} = 2$ and $\omega = 0.02$) and the model with a strong FA mechanism ($\frac{Q_t K_{t+1}}{N_{t+1}} = 3$ and $\omega = 0.02$).

[11] 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.

[12] As reported in Gertler, Gilchrist and Natalucci (2003), according to Krueger and Yoo (2001), in in Korea in 1997 the debt-equity ratio was 5.2 for the 30 largest chaebols, 4.8 for the five largest chaebols, 4.6 for the five largest manufacturing firms, and 3.9 for all firms in the manufacturing sector.

[13] For further details of similarities between Calvo and Rotemberg price-setting assumption, see Lombardo and Vestin (2007)

## 4.1 Sectorial productivity shocks

Figures 1-2 plot the responses to a 1 % technological shock in the non-tradable sector. Because of the higher productivity, the marginal cost falls. The CPI inflation and the CPI price level also decrease and, hence, on impact the interest rate falls. The decline in the interest rate causes an increase in inflation which closes the steady-state value after almost five periods. As a consequence of the cut in the interest rate, the exchange rate depreciates sharply initially, before slowly appreciating back to its steady-state value. The depreciation of the domestic currency and deflation are the main sources of the increase in the risk premia. An additional effect stems from the decrease in the price of capital that generates a further increase in premia.[14] Higher premia reduce the firms' net worth and their investment spending. The more the FA mechanism is stressed, the stronger are the effects on premia and the more weakened is the positive effect of the initial productivity shock. In this way, the FA mechanism dampens the positive effect of the shock, especially in the sector directly affected by the productivity shock. In the non-tradable sector, net worth decreases more sharply if the FA mechanism applies. Because of the gain in productivity, investments and output are still increasing but they do not achieve the level that could be affordable in the absence of financial frictions.

Some variables concerning the tradable sector are sometimes positively affected by the presence of the FA mechanism, at least on impact. This can be due to the stronger initial devaluation of the currency that, first, makes the marginal productivity of capital increase; second, it also stimulates the production in the tradable sector because of the gain in competitiveness. As soon as the exchange rate starts to appreciate, positive effects in the tradable sector are offset.[15]

[14] I have calibrated the model so that the price of investment goods and the CPI price level are modelled in a similar way. The price of capital assets reacts consistently with the price of investment goods:

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

[15] The strong increase in tradable output also explains the increase in the output gap. Generally, following a productivity shock, potential output should increase more than effective output and the output gap is expected to decrease. In this set-up, the depreciation of the currency makes the import

Figures 3-4 plot the response to a 1 % productivity shock in the tradable sector. Following the higher productivity, the price of tradable goods decreases, and, hence, as the law of one price applies, the national currency revaluates. On the one hand the exchange rate appreciation makes the import goods less expensive. On the other hand, the price of non-tradable goods rises due to the higher marginal cost. As the degree of openness is not remarkable, the second effect dominates and then CPI inflation rises. The combined effects of higher inflation and currency appreciation relax the real dollarized debt burden and improves firms' balance sheets through the positive effect on financial premia. For the rest, a productivity shock in the tradable sector yields conclusions that are similar (but inverse) to those that are drawn in the case of a shock in the non-tradable sector.

## 4.2 Price mark-up shock

A price mark-up shock is introduced as an increase in the elasticity of substitution between the varieties of goods. A gain in competitiveness pushes the mark-up down, from 20 % to 15 %. The responses of the main variables to a price mark-up shock are plotted in Figures 5-6. Inflation is decreasing as well and as the Taylor rule is responding to inflation, the interest rate falls and the national currency devaluates.

Results are similar to those observed for the productivity shock in the non-tradable sector.

## 4.3 Financial shock

Figures 7-8 depict the effect of a positive risk premium shock. This shock discourages investors and leads to an exchange rate depreciation. Imports goods become more ex-

prices rise and leads to an improvement in the trade balance and in total output. In the sticky economy, this effect is reinforced by the presence of price adjustment costs in the imported goods sector, so the effective output is pushed above its potential level. This "non standard" increase in the output gap no longer appears if the productivity shock is transitory. If the shock presents a low persistence, the depreciation – and, hence, the gain in competitiveness of export goods – is not so substantial.

pansive in terms of domestic currency and then CPI inflation increases. In the case of a financial shock, the financial accelerator mechanism is driven mainly by the exchange rate depreciation. The increase in premia, through its effect on firms' balance sheets, pushes the economy into a recession that is amplified if the economy is affected by financial frictions. It is worth noting that, in the case of a financial shock, the interest rate falls, responding more to the drop in the output gap than to the rise in the inflation. The more the financial accelerator mechanism is stressed, the more the economy is affected by a financial shock.

In the case of a productivity shock or a price mark-up shock, the debt deflation effect and the depreciation both push up premia. The financial accelerator mechanism is driven by these two effects that are working in the same direction. Conversely, in the case of a financial shock, these two effects work in opposite directions. The negative effect on premia generated by the currency depreciation is dominant, while the debt-deflation effect is negligible. This finding is consistent with results in Christiano, Motto and Rostagno (2007).

Finally, the IRFs analysis shows that premia – and, hence, the net worth – are reacting much more to a financial shock than to the other shocks. This results highlights the importance of financial shocks in driving the financial accelerator mechanism.

# 5 Optimal monetary policy

I consider the case in which the economy is affected by four kinds of shocks at the same time: two sectoral productivity shocks, a price mark-up shock, and a financial shock. Then, I compare outcomes under four alternative Taylor rules: a "standard" inflation targeting rule (hereafter, IT), an "augmented" Taylor rule (that is an inflation targeting rule which also responds to financial variables), an inflation targeting rule that is also concerned about exchange rate stabilization, and a price-level targeting rule (hereafter, PLT).

The analysis is based on a social loss function that penalizes the deviation of output and inflation from their steady-state values. Moreover, a large floating in the nominal domestic interest rate is also penalized. The monetary authority's loss function is the unconditional expectation of a period loss function of the form:[16]

$Loss_t = \pi_t^2 + \lambda_{ygap} ygap_t^2 + \lambda_i i_t^2$

Hence, after taking expectations, the loss function becomes

$E[Loss_t] = var(\pi_t) + \lambda_{ygap} var(ygap_t) + \lambda_i var(i_t)$

## 5.1 Inflation targeting with a standard Taylor rule

When the FA mechanism is not active (table 1, column 6), all the three variables in the loss function present a lower variability if compared to the model with financial frictions (table 2, column 2). In order to compare results for the optimal monetary policy, I have to consider a scenario without the financial shock because, in the model without the FA mechanism, the financial shock is not active.

The increase in inflation volatility is especially noteworthly. The presence of the FA mechanism in the model makes it impossible to achieve a value of the loss function which is as low as in the model without financial frictions.

When the financial accelerator applies, the optimal simple rule is highly super-inertial. The main advantage of a super-inertial rule is that it is very successful in affecting and controlling expectations, as it is an alternative source of history dependence. In the event of a disinflationary (inflationary) disturbance, a higher coefficient of inertia can lower (increase) people's expectations about future nominal interest rate. In this way, the IT rule introduces history dependence and behaves as a PLT rule, hence the monetary authority controls inflation expectations. If inflation expectations remain around the target, inflation itself remains stable and the volatility of interest rate remains small. Through the stabilization of interest rates, the monetary authority minimizes the unexpected changes in the debt service. Moreover, the stabilization of the interest rate also implies a smoother response in the exchange rate. In this way, a super-inertial monetary

[16] In this paper, weights in the loss function are set as

$\lambda_{ygap} = 1; \lambda_i = 0.05$

rule is more successful in offsetting the effects from external shocks on business cycles.[17]

This mechanism also explains why there is no room for the optimal policy to be super-inertial in an economy that is not affected by financial frictions. Figures 9-14 compare the IRFs under the optimal rules for the model with and without financial frictions. When the FA mechanism is not working, the economy is not affected by the financial shock. Therefore, figures 15-16 display the reactions to a financial shock under the optimal rule only for the model with financial frictions. If the FA mechanism applies, it is optimal to control inflation through the expectations rather than through an aggressive response to inflation that could lead to deflation and then to a tightening of the real debt burden. Conversely, if the financial accelerator does not apply, firms are fully self-financed and the economy is less vulnerable to fluctuations in the interest rate and in the exchange rate.

In a nutshell, the main advantage of a super-inertial rule is that it "smooths" the response of the interest rate to shocks. This, in turn, reduces interest payments volatility and fluctuations in the exchange rate. This beneficial impact is negligible in an economy where firms are not burdened with a high level of debt.

Finally, it is worth noting that the gain from the super-inertial rule in a model with financial frictions is at least partially linked to the occurrence of financial shocks. As highlighted in paragraph 4.3, the IRFs analysis has shown that premia are significantly affected by the financial shock, rather than by the technology shocks and the price mark-up shock. Therefore, the financial shock is the main source in triggering the financial accelerator mechanism. Table 2 also confirms results from the IRFs analysis: in the absence of the financial shock, the optimal monetary policy displays a stronger reaction to inflation and a lower degree of interest rate smoothing, even if it is still super-inertial. The value of the loss function is consistently decreases.

[17] I have double-checked this argument, fixing $\rho_{RN} = 0.7$. The minimization of the loss function yelds the following values for the coefficient in the Taylor rule: $\rho_\pi = 1.54$ and $\rho_y = 0.67$.

The variance of $\frac{S_{t+1}}{S_t}$ increases by 28%.

## 5.2 Inflation targeting with an "augmented" Taylor rule

I investigate whether the trade-off (and the loss) is smaller if monetary policy is allowed to react to financial variables, in this case an aggregate financial premium.

Instead of introducing a response to asset prices, I decide to add the financial premium as a target for the monetary policy. There are two main reasons for this choice. First, financial distortions are closely related to leverage ratio and fluctuations of the exchange rate, then it seems more natural to add into the Taylor rule a financial variable, as premium, that is linked to both leverage ratio and exchange rate. When liabilities are denominated in nominal terms, the risk premium is particularly sensitive to deflationary shocks. Second, as Quadrini (2007) has pointed out, the main implication of the globalization for emerging countries is that the economy becomes more vulnerable to external asset price shocks. Therefore, the target of monetary policy for stabilization purposes should shift from domestic asset prices to foreign asset prices. In this framework, as the debt is denominated in foreign currency, the financial premia are closely affected by external asset prices (i.e. the exchange rate).

Moreover, as suggested by Monacelli and Faia (2005), there is a room to argue that policy makers wish to respond to indicators that more directly signal the cyclical evolution of financial frictions in the economy. In this respect it seems natural to explore the effects of rules which include the external financial premium directly as an independent argument.

To consider a reaction to financial variables, Cúrdia and Woodford (2008) add a spread adjustment to the standard Taylor rule. In a similar way, here I include in the monetary rule a response to change in the aggregate financial premium. The underlying logic is that when premia are increasing, following a shock, the central bank should decrease the nominal interest rate to compensate for the recessionary effects of the shock, at least partially.[18]

[18] In Curdia and Woodford (2008), a spread adjustment would generally represent the right direction of adjustment of policy, relative to a simple Taylor rule. The main open issue is the magnitude of adjustment that would be appropriate, depending on the source of the shock. In some cases, it is

Table 1 (column 3) reports outcomes under an optimal monetary rule that reacts to the aggregate financial premium. With respect to a benchmark rule,[19] the standard IT optimal rule improves on loss by 6.5 %. When the optimal simple rule also responds to financial variables, the additional gain is less than 1 %. This result confirms that an "augmented" Taylor rule does not improve considerably on loss.

Nevertheless, the optimal policy delivers different coefficients in the Taylor rule. It is worth noting that, if the monetary authority is concerned about responding to financial variables, there is no longer any need to set a strongly super-inertial Taylor rule. The negative effect on net worth, investments and output generated by the increase in premia is partially compensated by a decrease in the interest rate itself, rather than through the expectations mechanism.

## 5.3 Inflation targeting *cum* exchange rate stabilization

In open economy models, the exchange rate allows an additional channel for the transmission of monetary policy. For this reason, it is interesting to include the exchange rate in the discussion of the monetary rule to be implemented. The crucial question is whether the interest rate should react to the exchange rate or whether monetary authority should avoid any reaction and focus instead on domestic indicators, such as inflation and real GDP. The traditional literature warns that substantial departures from PPP make such a policy reaction to the exchange rate undesirable. The underlying reason is as follows. Suppose the interest rate will react only to inflation and to real output, and suppose that there is an appreciation of the exchange rate. In most open economy models, such an appreciation will have two effects: it will lower real output by expenditure switching and it will lower inflation because the price of imported goods will not increase as rapidly with

desirable to lower the policy rate by the full amount of the increase in the spread between the deposit rate and the lending rate; but, in a number of cases, a much smaller adjustment would lead to a more nearly optimal policy, while, in other cases, even an adjustment several times larger than the increase in credit spreads would not be sufficient.

[19] By "benchmark rule", I mean the calibrated rule in which parameters are set as $\rho_{RN} = 0.8$; $\rho_{\pi} = 1.5$; $\rho_{y} = 0.5$; $\rho_{PR} = 0.0$

the appreciation of the currency. Inflation may also be lowered by the decline in output. The appreciation of the exchange rate today will increase the probability that the central bank will lower the interest rate in the future. With a rational expectations model of the term structure of interest rates, these expectations of lower future short-term interest rates will tend to lower long-term interest rates today. Thus, the appreciation of the exchange rate will result in a decline in interest rates today, even though the exchange rate is not directly incorporated into the policy rule. Moreover, under a strict inflation targeting regime, the exchange rate affects the transmission of monetary policy to inflation at a relatively short horizon. The exchange rate affects domestic currency prices of imported goods which enter the CPI index and, hence, CPI inflation. Typically, the lag of this *direct* exchange rate channel is short and, then, inducing exchange rate movements, monetary policy can affect CPI inflation with a relatively short lag. In conclusion, it seems that, according to conventional wisdom, expansionary monetary policy is optimal in response to an adverse foreign demand shock.

Nevertheless, when confronted with such a shock, some emerging market governments have followed the prescription, while others have stubbornly defended their exchange rates with high interest rates. One reason for this is that a weaker currency, which is supposed to switch demand toward domestic goods and help a recovery, can also exacerbate debt-service difficulties and cause bank and corporate bankruptcies. Understanding these different experiences requires putting financial market imperfections into otherwise standard open-economy models. It is therefore becoming increasingly important to analyze the role of risk premia and financial frictions and the consequences of the dollarization of liabilities. This combination of factors can cause the domestic effects of external shocks to be magnified and made more persistent. Arguably, it can even make devaluations contractionary, not expansionary as in the standard model without financial frictions. With the financial accelerator mechanism and foreign currency debt, the decline in the exchange rate reduces entrepreneurial net worth, thus enhancing the financial accelerator mechanism. If this is the case, the insulating role of flexible exchange rates allegedly disappears and the flexible exchange rate regime is less attractive.

Gertler, Gilchrist and Natalucci (2003) show that allowing for foreign currency debt nearly doubles the contraction in investment relative to the case of domestic currency debt. Nonetheless, even in this instance, output volatility remains significantly lower under flexible rates than under fixed rates. Put differently, the impact of exchange rates on the balance sheets under flexible rates is less damaging than the contraction in asset prices under fixed rates because monetary policy is able to move asset prices in a way that stabilizes balance sheets.

Cespedes, Chang and Velasco (2000) obtain a similar result, but for different reasons. In their work, because capital is fully depreciable, there is no fixed debt overhang. This mitigates the impact of a depreciation in the exchange rate on the domestic balance sheets. The impact of the depreciation on net export demand and firm cash flows more than offsets the effect on real indebtedness. Flexible rates dominate even though an asset price channel is not present.

In this paper, instead of an explicit fixed exchange rate regime, I consider a policy rule that attempts to stabilize a basket composed of CPI inflation, output and change in the exchange rate.[20] Table 1 (column 4) shows that the feedback from the exchange rate is close to zero and that results are similar to those obtained under the "standard" inflation target rule. In other words, responding to changes in the exchange rate is not optimal under dollarization of liabilities and in the presence of financial frictions. These two factors play a key role. On the one hand, the dollarization of liabilities strengthens the exchange rate channel of monetary policy transmission. On the other hand, implications for monetary policy are strongly dependent on the presence of the financial shock, as it is the exogenous disturbance that mainly triggers the financial accelerator mechanism. As shown in table 2 (column 3), when the economy is not affected by the financial shock, adding a small reaction to the fluctuation in the exchange rate can be optimal.

The increase in the required premium generates a contraction in the financial account

[20] Following Svensson (2000), I consider a Taylor rule where the interest rate reacts to inflation, to the output gap and to the *change* in the exchange rate. This may be a better interpretation of the idea that an appreciation of the exchange rate would call for an easing of monetary policy.

that must be matched with an increase in the current account. The optimal policy requires a depreciation together with an increase in the interest rate, as displayed in Figure 15. On the domestic economy side, the optimal policy implies an increase in the interest rate in order to discourage borrowing and consumption. On the balance of trade side, the optimal policy also implies a depreciation of the domestic currency. Under a fixed exchange rate system, the burden of adjustment is only on the domestic economy side. The central bank is forced to impose aggressive changes in the interest rate, pushing the economy into a stronger recession.

In brief, reducing the volatility of the exchange rate limits the ability of the central bank to enact stabilizing monetary policy by devaluating the exchange rate. As a result, the monetary authority is forced to increase the interest rates exacerbating the contraction in investment spending, which in turn affects net worth and output.

## 5.4 Price-level targeting

Finally, I explore the issue of whether price-level is a better target for monetary policy.

Actually, the real value of the debt denominated in foreign currency is affected not only by fluctuations in the exchange rate, but also by movements in the price level . The "deflationary effect" is one of the main sources of the financial accelerator mechanism, as it generates an increase in the premia and it propagates the negative effect of a shock through the balance sheets effect. For these reasons, I investigate whether, in the presence of a deflation, it is preferable to increase the percentage of price-stability concerns of the monetary authority that take the form of price-level targeting in the Taylor rule. In this exercise, I am considering a pure price-level targeting rule.

Table 1 (column 5) reports results under a PLT rule. The variance of all variables in the loss function (especially inflation) is lower than in the case in which the central bank sets an IT rule. The loss function decreases by 40 %. These results seem to confirm the wisdom that a PLT rule produces the best outcomes in terms of the variance of inflation and volatility of nominal interest rates.

The main gain from the optimal PLT rule is that it results in less volatile interest rates. The stabilization of the interest rate reduces the risk faced by both enterprises and households that hold debt in nominal terms. Through the stabilization of return on nominal assets and liabilities, the optimal PLT rule also reduces the variability of consumption, investments and then output. What is interesting here is that the PLT rule also improves on output variability. Jääksela (2005) find that, in a forward-looking expectations set-up, there is a trade-off between variability of inflation and the output gap. Rules that react to the price level overperform the standard inflation-targeting rule in terms of variance of inflation, but the downside of these rules is that they generate a higher variability of output gap. In this framework incorporating financial frictions, a PLT rule also delivers a lower variability of the output gap because it helps in minimizing the nominal debt distortions, and, hence, net worth, investments and output also improve in terms of volatility.

As pointed out in Dib, Mendicino and Zhang (2008), the advantage of a PLT rule is significantly linked to the occurrence of the financial shock, as it is the main trigger source for the financial accelerator mechanism. Once the financial shock is removed, the financial accelerator mechanism is weak. Therefore, there is a less pressing need to stabilize the interest rate and the exchange rate in order to minimize the distortions deriving from the nominal "dollarized" debt. Then, the PLT rule still improves on inflation variability, but it delivers an higher variability of output gap. In such a case, the trade-off arising in Jääksela between output stabilization and inflation variability is restored. If, in this setting, the monetary authority assigns a major importance to the stabilization of the output gap in the loss function, the PLT rule generates a higher value of loss. Similar conclusions are also drawn in a model without financial frictions.

The results obtained here are in line with those in Giannoni (2000)[21] who argues that 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' expectations of a future deflation after an inflationary shock dampen the initial increase in inflation, lower the variability of inflation, and, hence, stabilize output and increase

[21] Among others, see also Black, Macklem and Rose (1997); Vestin (2006).

welfare.

Nevertheless, many authors have stated that the performance of the price-level rule depends critically on the expectation formation process assumed in the model. When expectations are forward-looking (as in this framework), a PLT rule introduces a desirable inertia that affects the private sector's expectation appropriately. 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 price mark-up 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. 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).

The main difference between IT and PLT is that, under IT, unexpected disturbances to the price-level are ignored, 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. Thus, some policy implications can be outlined from these results. Given the existence of nominal assets and liabilities in the real world, unexpected decreases in the price level increase the real value of nominal debt. Uncertainty about the price level imposes a risk premium that increases the cost of capital. Thus, reducing the long-run price-level uncertainty through a PLT rule decreases the risk premium and the cost of capital, which, in turn, positively affects the economic performance.

# 6 Conclusions

The financial crises over the last decade have generated interest in the design of monetary policy for emerging market economies. Many economists have argued that if credit frictions are quantitatively important for cyclical fluctuations, models used for monetary policy analysis should take them more seriously in order to offset the propagation of transitory shocks.

In this paper, I analyze how introducing financial frictions into a small open economy with dollarization of liabilities can affect the choice of the optimal monetary policy.

Primarily, I focus on the trade-off that may arise between output stabilization and price stability both in the model with financial accelerator and in the model without financial accelerator. I find that, in a model with both nominal and financial frictions, a simple policy rule delivers a higher value of loss than in a model without financial frictions. Moreover, the presence of financial frictions requires more inertia in the optimal rule in order to stabilize interest rates. In this way, the monetary rule is successful in minimizing the risk embedded in the repayment of nominal debt. Nevertheless, this argument depends on the source of the shock. It has been shown that the gain from a super-inertial rule is significantly reduced if the economy is not affected by the financial shock.

To this extent, I investigate whether, in the presence of financial frictions, the optimal outcome can be realized or approached more closely if monetary policy is allowed to react to aggregate financial variables. It is shown that an "augmented" Taylor rule (that is a monetary rule responding to changes in the aggregate financial premium) does not improve on loss, but needs a lower degree of inertia. Stabilization works through the reaction of the interest rate itself to changes in premia, rather than through the expectations' control.

In addition, I find that responding to exchange rate fluctuations is not optimal when liabilities are denominated in foreign currency and when financial frictions are driven by the financial shock. Indeed, reducing the volatility of the exchange rate forces the central bank to undertake a more aggressive change in the interest rate in order to enact stabilizing monetary interventions. Fluctuations in the interest rate induce a rise in the cost of capital which, in turn, affects net worth and output.

Finally, I explore the issue of whether the price-level is a better target for monetary policy. This analysis stems from the initial intuition that movements in the price-level can play an important role in the propagation of shocks through the "deflationary effect" and its effect on firms' balance sheets. I find that a PLT rule produces the best outcomes in terms of the variance of inflation and volatility of nominal interest rates. This result arises from the fact that a PLT rule introduces a desirable inertia into the monetary rule. In this way, it affects price sector's expectations that operate as automatic stabilizers. As a result, the lower volatility of interest rates and the exchange rate help in minimizing distortions introduced by the presence of liability defined in nominal terms and in foreign currency.

Despite the availability of fully indexed financial contracts, in reality we observe that most financial contracts are not fully indexed. A possible explication is that the optimal financial contract is imperfectly indexed to the price level because (i) the nominal price level (e.g. the GDP deflator) is observed with delay, and (ii) there is uncertainty with respect to the measurement of prices. Another answer commonly suggested is that different agents may consume different baskets of goods and thus prefer to contract on different prices. Because of this heterogeneity, it may not be optimal to index contracts to a single price index. This paper suggests that the revaluation of nominal debt contracts makes PLT a more desirable monetary rule than inflation targeting. By reducing uncertainty about the price level, a PLT rule reduces debt revaluation risks and encourages more long-term planning and increases both aggregate output and welfare.

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# A The steady-state equilibrium

At the steady-state:

$$A_N = A_X = 1$$

$$P_M^* = P_M = P_N = P = P_I = S = 1$$

$$\varepsilon_{AN} = \varepsilon_{AX} = \varepsilon_{PM} = \varepsilon_{PX} = \varepsilon_{RN} = \varepsilon_{RN^*} = \varepsilon_G = 0$$

$$\pi = \pi^N = \pi^M = \pi^W = \Delta S = 1$$

$$G = 0.1$$

$$Tax = G$$

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

$$R = R^n$$

$$R^{*n} = R^n$$

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

$$P_M^* S = \frac{\vartheta^P - 1}{\vartheta^P} P_M$$

$$Q_N = P_I$$

$$Q_X = P_I$$

$$F_N = \left(1 + \frac{N_N}{B_N^e}\right)^{-\omega_N} R^{*n}$$

$$F_X = \left(1 + \frac{N_X}{B_X^e}\right)^{-\omega_X} R^{*n}$$

where for $j = N, X \quad \left(1 + \frac{N_j}{B_j^e}\right) = \frac{K_j Q_j}{N_j} = leverage$

$$E(F_N) = F_N$$

$$E(F_X) = F_X$$

$$premium_N = \frac{E(F_N)}{R^{*n}}$$

$$premium_X = \frac{E(F_X)}{R^{*n}}$$

$$r_N^K = \left[\left(1 + \frac{N_N}{B_N^e}\right)^{-\omega_N} R^{*n} - (1-\delta) Q_N\right]$$

$$r_X^K = \left[\left(1 + \frac{N_X}{B_X^e}\right)^{-\omega_X} R^{*n} - (1-\delta) Q_X\right]$$

$$\frac{K_N}{Y_N} = \frac{MC(\alpha)}{r_N^K}$$

$$\frac{H_N}{Y_N} = \left[ A_N \left( \frac{K_N}{Y_N} \right)^{\alpha} \right]^{-\frac{1}{1-\alpha}}$$

$$W_N = MC(1-\alpha)\frac{Y_N}{H_N}$$

$$W = \frac{W_N}{P}$$

$$W_X = W_N$$

$$\frac{M}{P} = \zeta^{1/\varepsilon[}(1-h)C]^{\sigma/\varepsilon} \left( \frac{R^n}{R^n - 1} \right)^{1/\varepsilon}$$

$$P_X = \frac{W_X^{1-\gamma}(r_X^K)^{\gamma}}{(1-\gamma)^{1-\gamma} A_X \gamma^{\gamma}}$$

$$\frac{K_X}{Y_X} = \frac{\gamma P_X}{r_X^K}$$

$$\frac{H_X}{Y_X} = \left[ A_X \left( \frac{K_X}{Y_X} \right)^{\gamma} \right]^{-\frac{1}{1-\gamma}}$$

$$P_X^* = \frac{P_X}{S}$$

$$Y_N = 0.7$$

$$Y_M = 0.3$$

$$Y = Y_N + Y_M$$

$$Y_X = \frac{P_M Y_M}{P_X}$$

$$K_N = \frac{K_N}{Y_N} Y_N$$

$$K_X = \frac{K_X}{Y_X} Y_X$$

$$H_N = \frac{H_N}{Y_N} Y_N$$

$$H_X = \frac{H_X}{Y_X} Y_X$$

$$H = H_N + H_X$$

$$I_N = \delta K_N$$

$$I_X = \delta K_X$$

$$N_N = \frac{K_N Q_N}{leverage}$$

$$N_N = \frac{K_X Q_X}{leverage}$$

$$Z_N = \frac{N_N}{\nu}$$

$$Z_X = \frac{N_X}{\nu}$$

$$B_N^e = Q_N K_N - N_N$$

$$B_X^e = Q_X K_X - N_X$$
$$C_N^e = (1-\nu) Z_N$$
$$C_X^e = (1-\nu) Z_X$$
$$C = Y - (P_X Y_X - P_M Y_M) - (I_N + I_X) - (C_N^e + C_X^e) - G$$
$$I_{NN} = a_I (I_N + I_X)$$
$$I_M = (1 - a_I)(I_N + I_X)$$
$$C_N = a_c C$$
$$C_M = (1 - a_c) C$$
$$DD = C + C_N^e + C_X^e + I_N + I_X + G$$
$$Y = DD + (P_X Y_X - P_M Y_M)$$
$$B = \frac{P_X Y_X - P_M Y_M}{1 - R^{n*}}$$

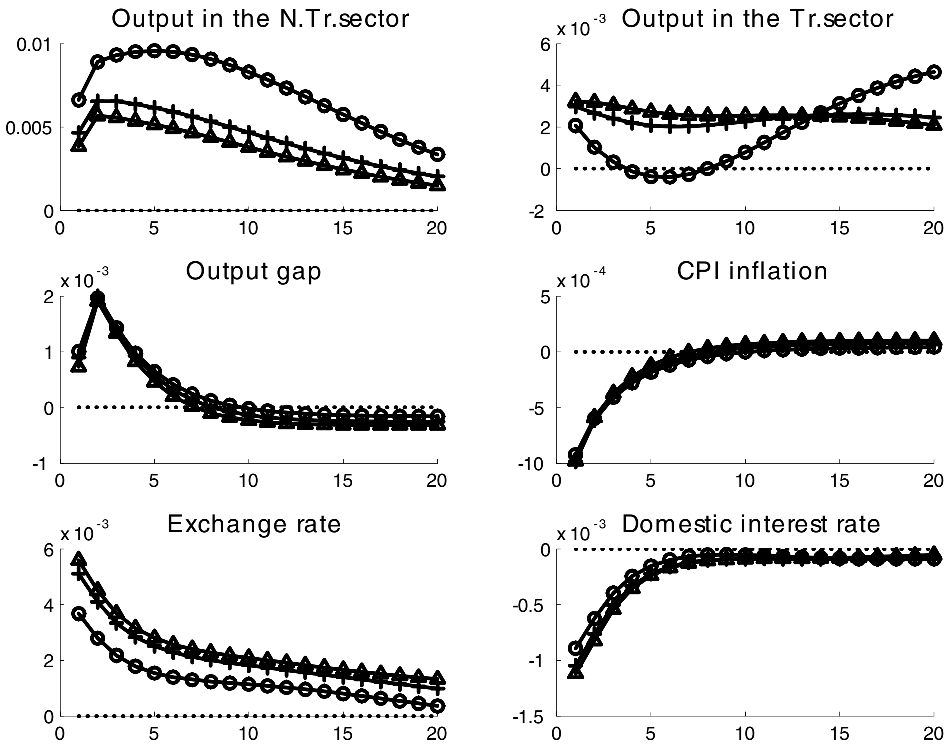


Figure 1: IRFs – productivity shock in the non-tradable sector

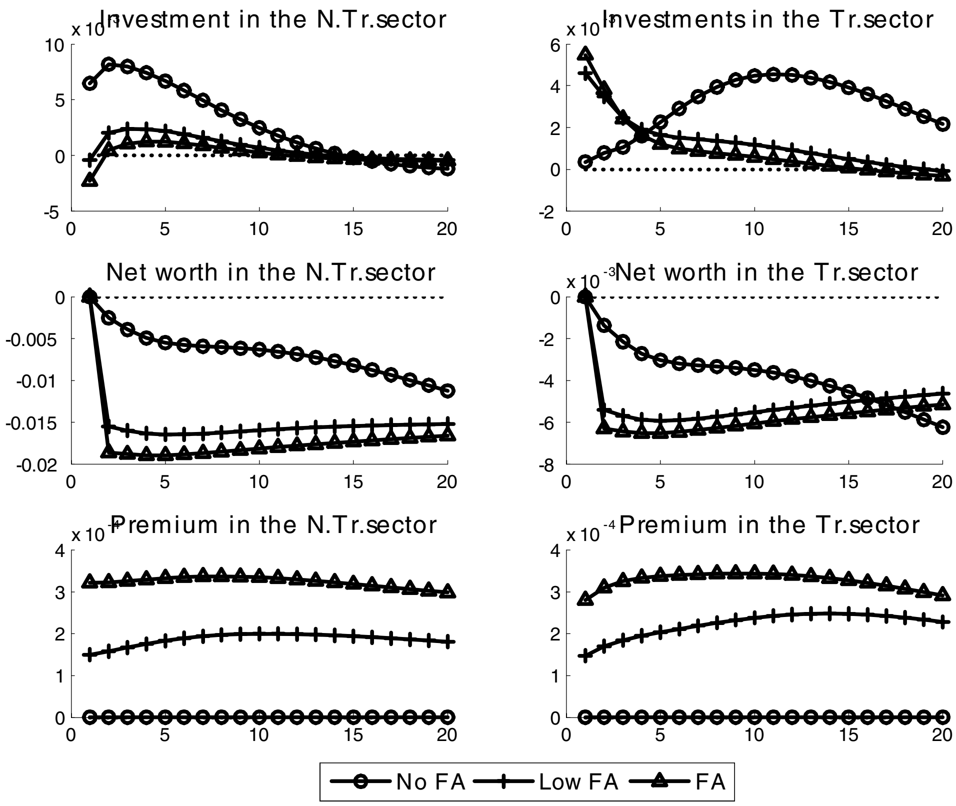


Figure 2: IRFs – productivity shock in the non-tradable sector *bis*

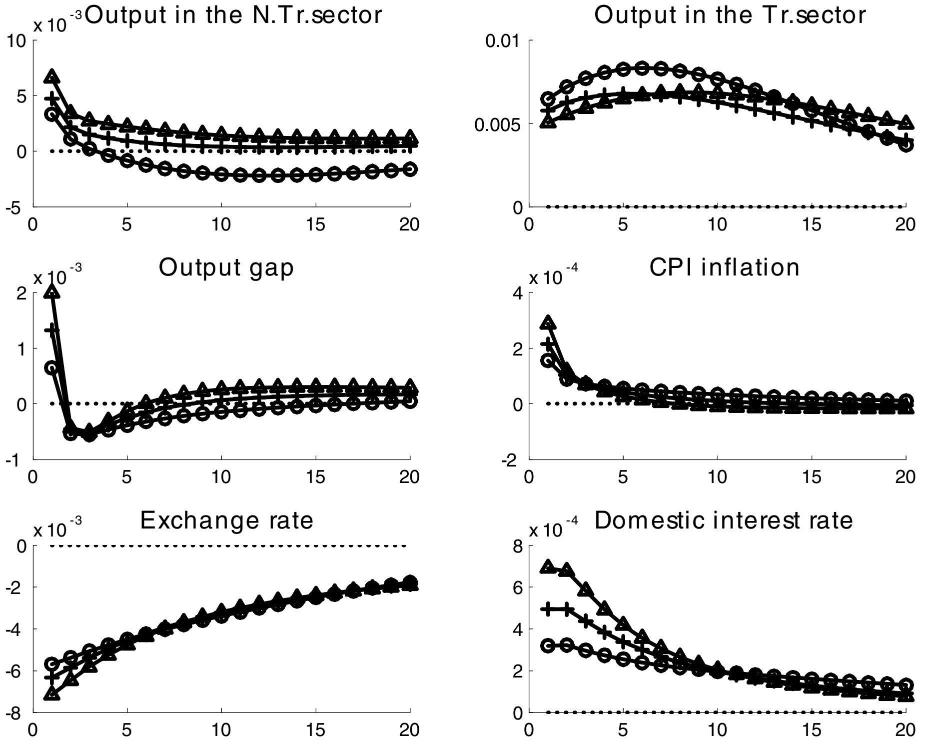


Figure 3: IRFs – productivity shock in the tradable sector

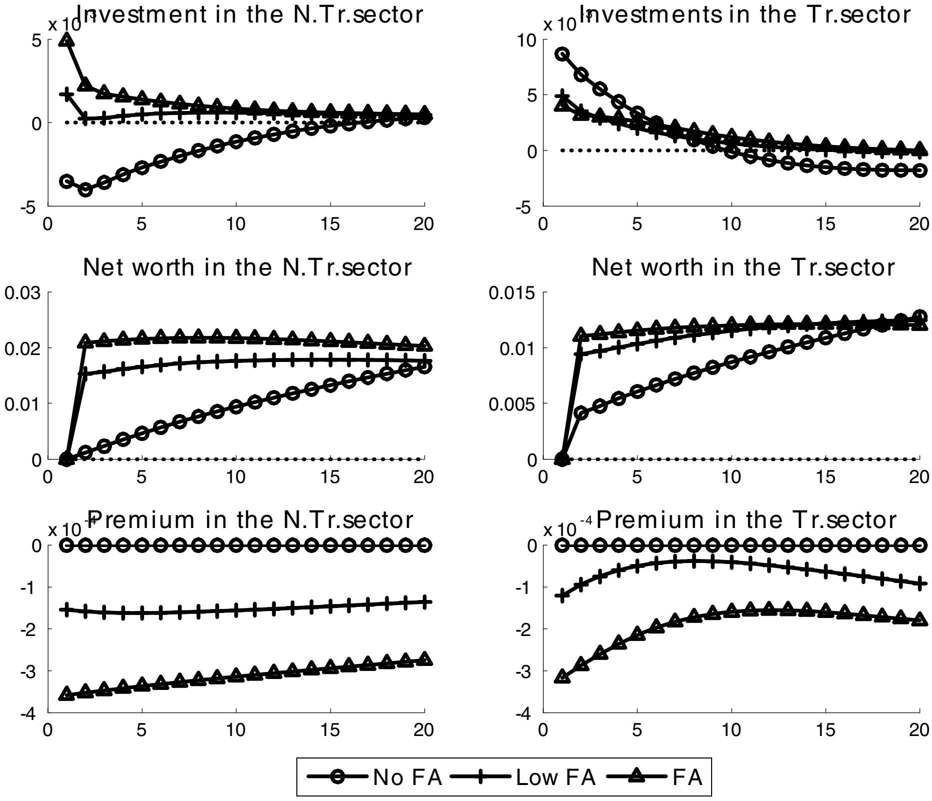


Figure 4: IRFs – productivity shock in the tradable sector *bis*

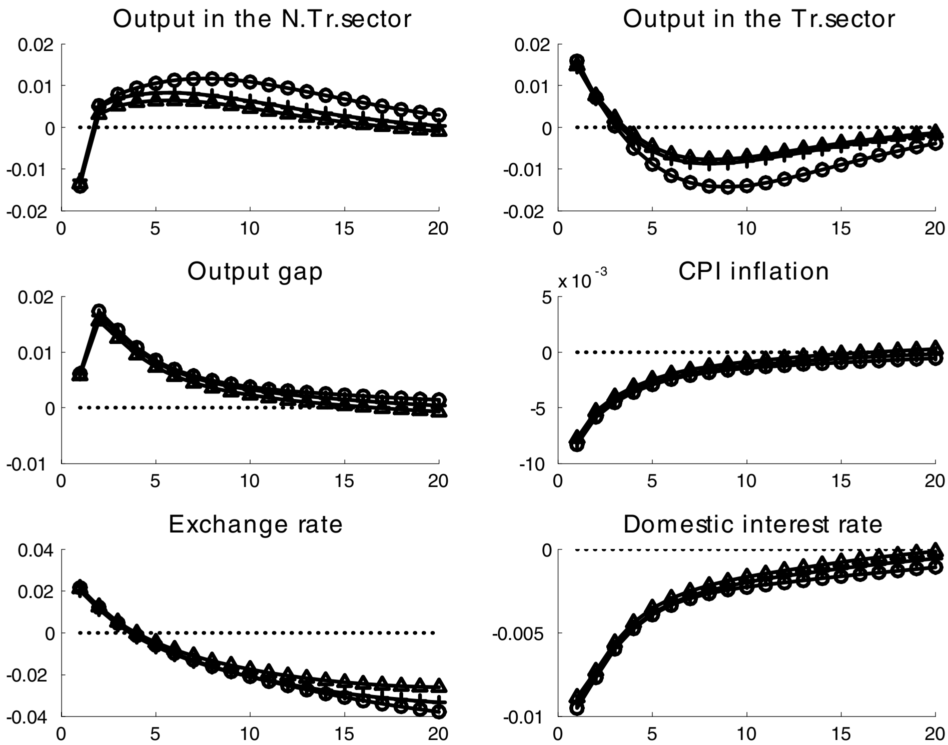

Figure 5: IRFs – price mark-up shock

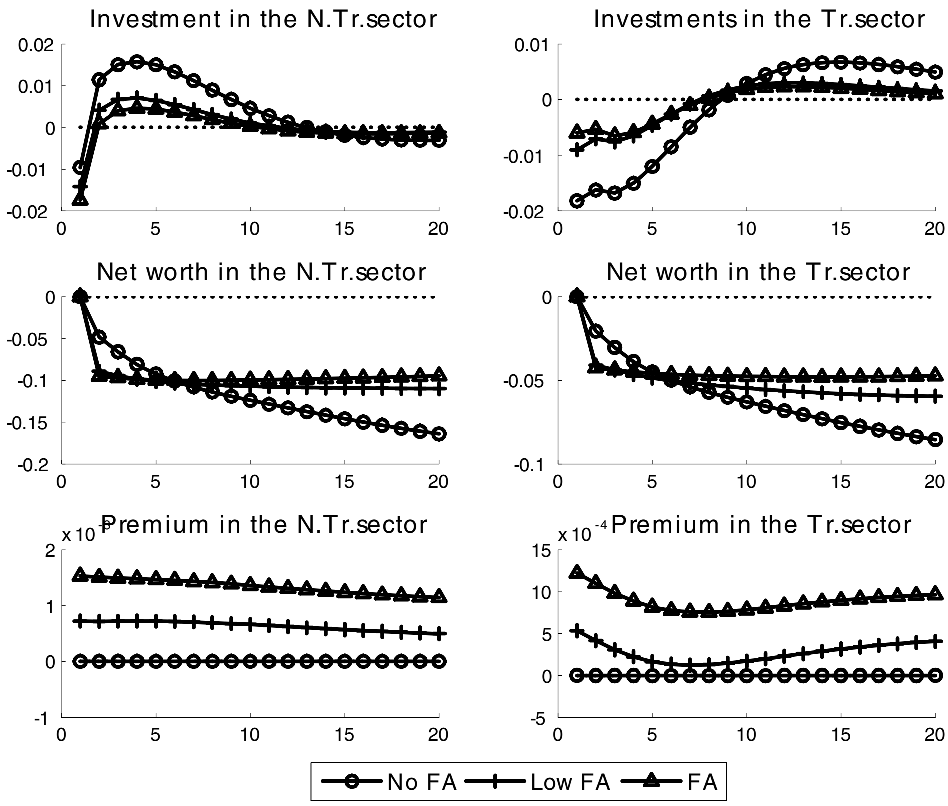


Figure 6: IRFs – Price mark-up shock *bis*

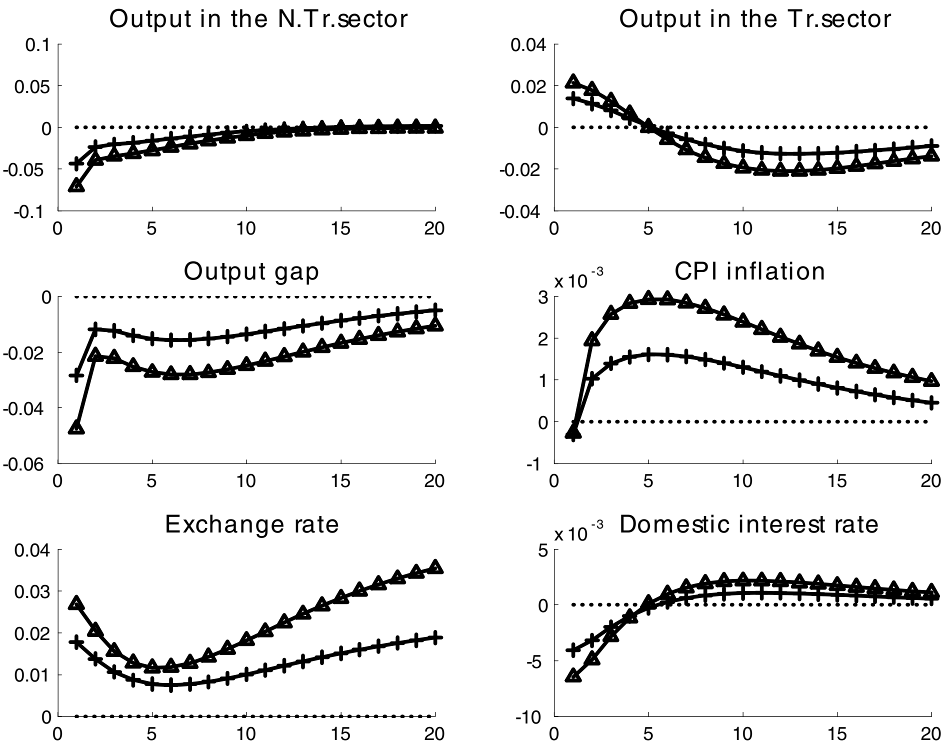

Figure 7: IRFs – financial shock

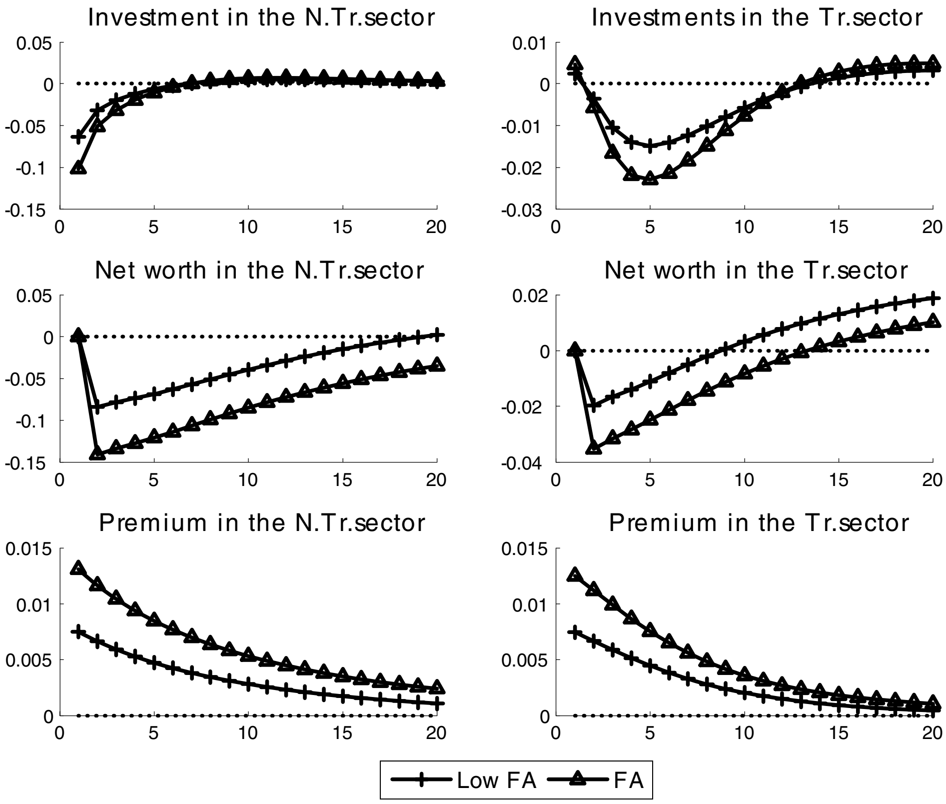


Figure 8: IRFs – financial shock *bis*

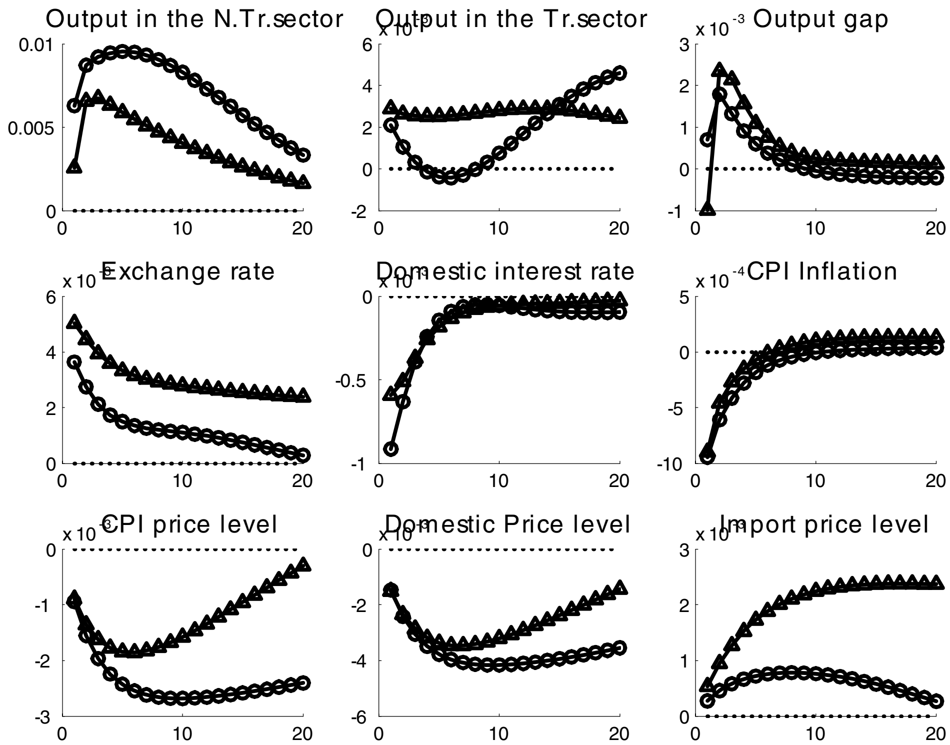


Figure 9: IRFs, optimal rule – productivity shock in the non-tradable sector

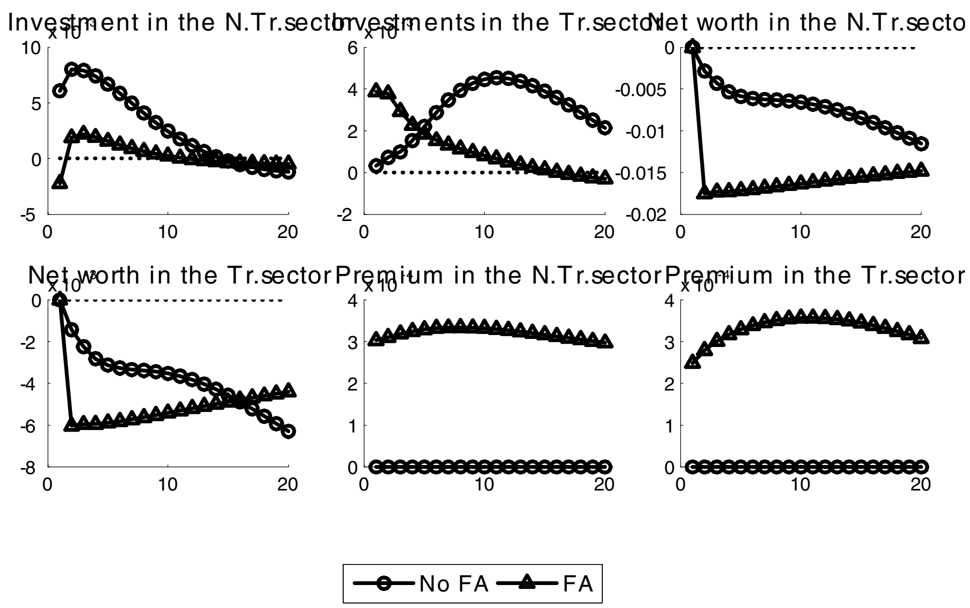


Figure 10: IRFs, optimal rule – productivity shock in the non-tradable sector *bis*

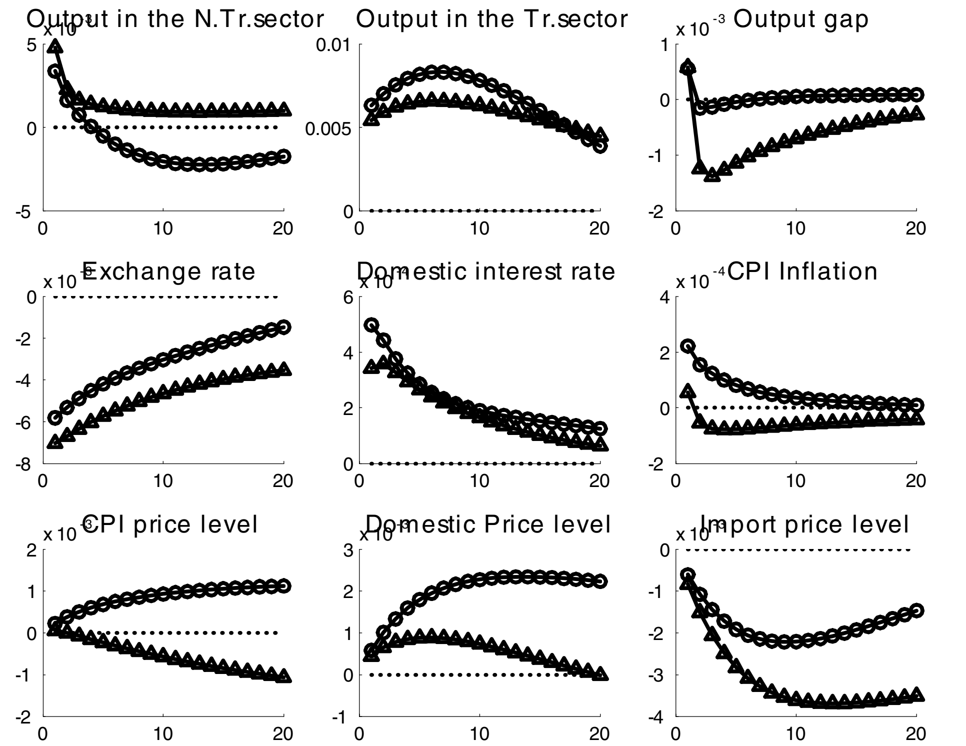


Figure 11: IRFs, optimal rule – productivity shock in the tradable sector

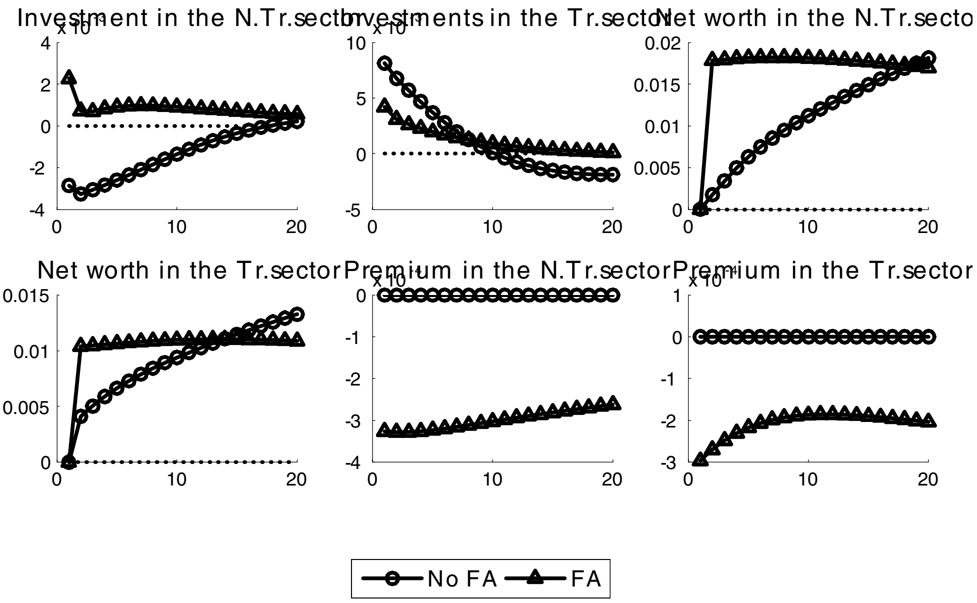


Figure 12: IRFs, optimal rule – productivity shock in the tradable sector *bis*

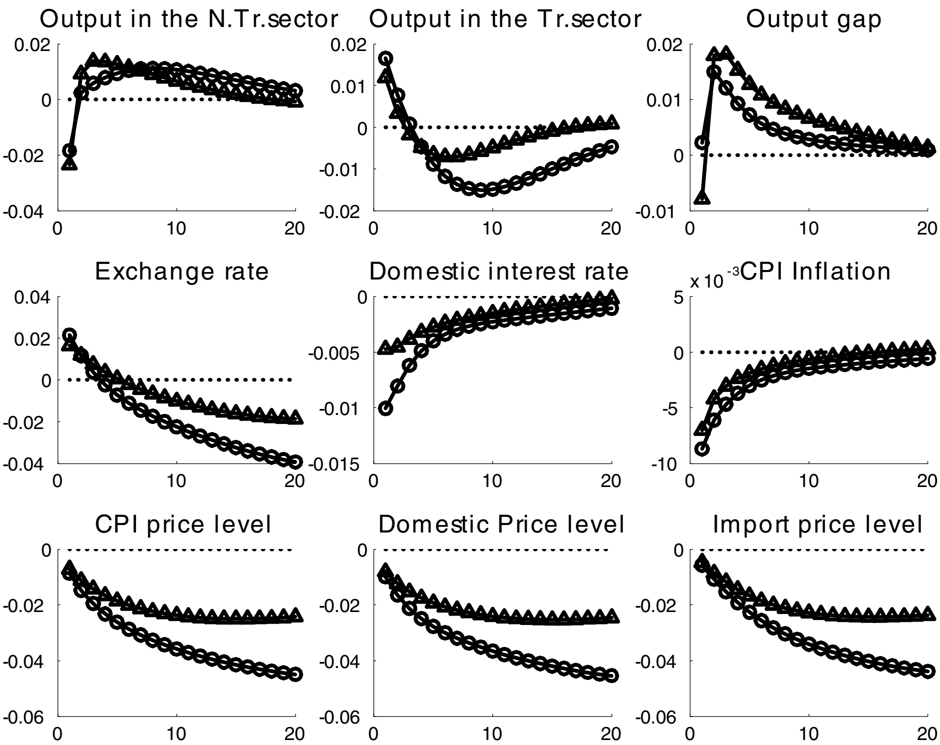


Figure 13: IRFs, optimal rule – price mark-up shock

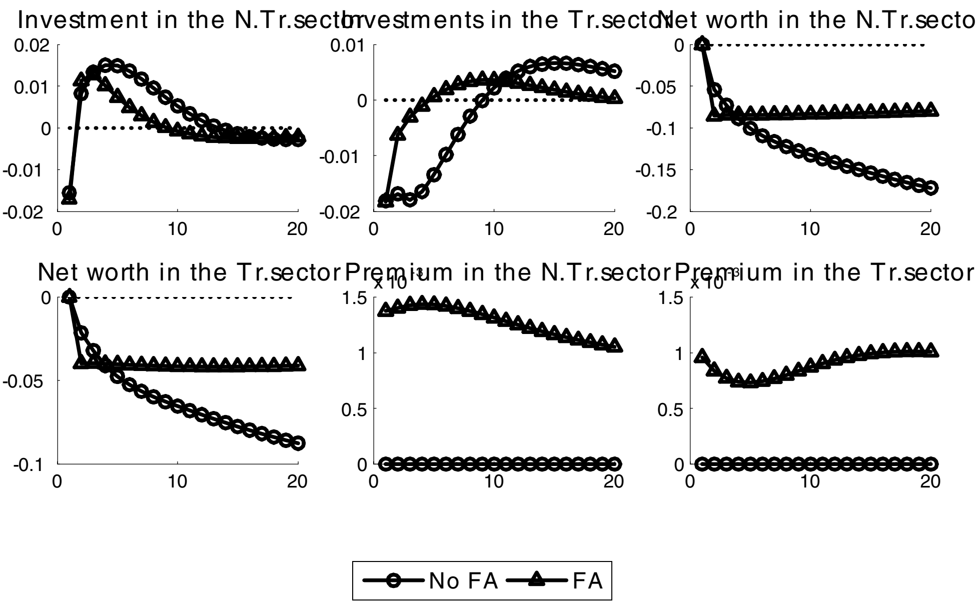


Figure 14: IRFs, optimal rule – price mark-up shock *bis*

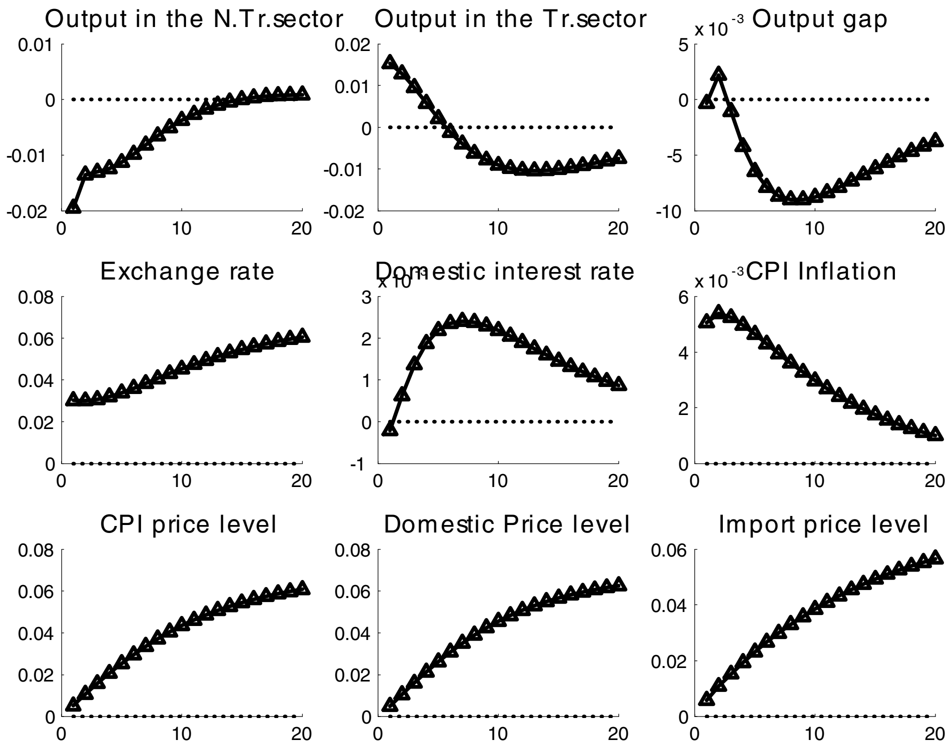


Figure 15: IRFs, optimal rule – financial shock

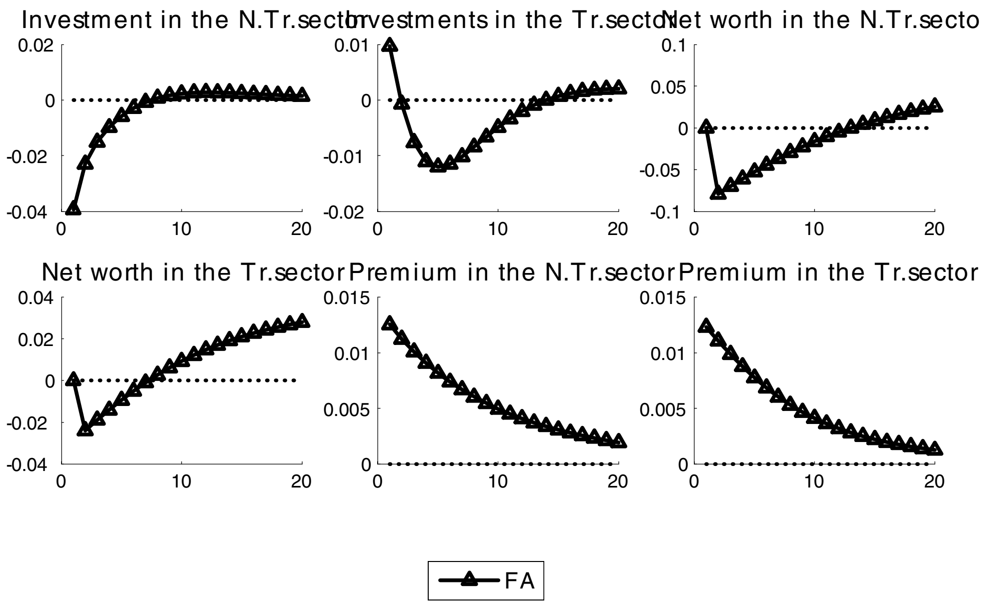


Figure 16: IRFs, optimal rule – financial shock *bis*

| Parameters | IT rule | Augmented Taylor rule | IT *cum* exchange rate | PLT rule | IT rule-No FA |
|---|---|---|---|---|---|
| $\rho_\pi$ | 0.000 | 0.263 | 0.000 | - | 1.238 |
| $\rho_P$ | - | - | - | 0.001 | - |
| $\rho_{RN}$ | 3.227 | 1.678 | 3.228 | 1.547 | 0.620 |
| $\rho_S$ | - | - | 0.000 | - | - |
| $\rho_y$ | 0.589 | 0.252 | 0.589 | 0.095 | 0.385 |
| $\rho_{PR}$ | - | 0.488 | - | - | - |
| $\sigma_\pi$ | 0.00072 | 0.00069 | 0.00072 | 0.00041 | 0,00018 |
| $\sigma_{RN}$ | 0.00056 | 0.00056 | 0.00056 | 0.00020 | 0.00031 |
| $\sigma_y$ | 0.00808 | 0.00826 | 0.00808 | 0.00535 | 0.00061 |
| Loss | 0.2002 | 0.19842 | 0.2002 | 0.01212 | 0.00377 |

Table 1: Optimal monetary policy, all shocks

| Parameters | IT rule | IT *cum* exchange rate stabilization | PLT rule |
|---|---|---|---|
| $\rho_\pi$ | 0.302 | 0.346 | - |
| $\rho_P$ | - | - | 0.644 |
| $\rho_{RN}$ | 1.848 | 2.080 | 0.000 |
| $\rho_S$ | - | 0.051 | - |
| $\rho_y$ | 0.255 | 0.326 | 0.391 |
| $\sigma_\pi$ | 0.00016 | 0.00016 | 0.00005 |
| $\sigma_{RN}$ | 0.00016 | 0.00016 | 0.00002 |
| $\sigma_y$ | 0.00324 | 0.00323 | 0.00062 |
| Loss | 0.00591 | 0.00591 | 0.00764 |

Table 2: Optimal monetary policy without the financial shock

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