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María Alejandra Amado Garfias*

* UCLA.

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Abstract

This document to evaluates the effectiveness, in terms of macroeconomic stability, of monetary policy rules and instruments of prudential supervision. Specifically, it seeks to distinguish between the gains of including in the standard monetary policy rule indicators of financial stress, such as credit growth -augmented rule-; and the gains of applying, in parallel to this augmented rule, a macroprudential instrument that allows a supervisory authority to affect credit interest rates directly. This analysis is performed using a dynamic stochastic general equilibrium model for a small open economy with financial rigidities, and is evaluated in the context of four shocks: financial, productivity, foreign demand and foreign interest rate. The model is calibrated in order to reflect the stylized facts of the Peruvian economy. The results obtained suggest that the effectiveness of the rules depends on the nature of the shock affecting the economy.

Resumen

Este documento tiene como objetivo evaluar la efectividad, en términos de estabilidad macroeconómica, de reglas de política monetaria e instrumentos de supervisión macroprudencial. De manera específica, se pretende distinguir entre las ganancias de incluir en la regla de política monetaria estándar indicadores de *stress* financiero, como el crecimiento de los créditos -regla aumentada-; y las ganancias de incluir, en paralelo a esta regla aumentada, un instrumento macroprudencial que le permita a la autoridad supervisora afectar las tasas de interés de préstamos directamente. Este análisis se realiza usando un modelo de equilibrio general dinámico y estocástico para una economía pequeña y abierta con rigideces financieras, y es evaluado en el contexto de cuatro choques: financiero, productividad, demanda externa y tasa de interés externa. El modelo es calibrado para reflejar los hechos estilizados de la economía peruana. Los resultados sugieren que la efectividad de las reglas depende de la naturaleza del choque que afecte la economía.

JEL Codes: E52, E61

Keywords: macroprudential, monetary policy, small open economy, DSGE model

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1. Introduction

In recent decades, the evolution of the financial system has played an important role in determining economic cycles. This relationship between the financial sector and the real sector has generally led to excessive volatility of the cycle, amplifying its expansionary effects and exacerbating downturns. Furthermore, empirical evidence argues that this procyclicality in the behavior of the financial sector may be the origin of strong instability once the expansionary phase of the cycle is reversed (Borio et al., 2001).

Empirical evidence in the case of emerging economies is consistent with the above. According to Mendoza and Terrones (2008), periods of economic growth tend to be associated with significant increases of the credit growth rate, and recessions, with sharp reductions of credit[1]. Indeed, such authors point that even though not every credit boom is associated with financial crises, most of these crises, in emerging markets, have been preceded by credit booms.

Thus, the behavior of variables such as credit growth may be an important indicator of financial vulnerability, which materializes in the contractionary phase of the cycle. Authors such as Borio et al. (2001) point that the reasons behind this procyclicality in the behavior of credit are in line with the presence of financial frictions, but mostly, with an inadequate perception of risk by financial institutions and regulations aimed at mitigating risk of individual institutions (micro prudential regulation), ignoring the risk of the financial system as a whole.

As a result of the recent financial crises, not only the weaknesses of micro-regulation have been exposed leading to regulatory proposals such as macroprudential tools[2], but questions about the way in which monetary policy should be implemented have been raised. In particular, there has been strong interest in answering the following questions: Is it enough to have a monetary policy rule that reacts to the traditional variables, such as output and inflation, to contain financial volatility?, to what extent is it beneficial for the monetary

[1]Mendoza and Terrones (2008) show evidence for 49 emerging countries, including Peru, of the existence of a systematic relationship between credit booms and the business cycle.

[2]Macroprudential policy is defined as *'the use of prudential tools with the explicit objective of promoting the stability of the financial system as a whole, not necessarily of individual institutions within it'* (Clement, 2010). These prudential tools can be understood as pro-cyclical capital requirements, pro-cyclical provisions, among others.

authority to include in its rule, indicators of financial volatility and vulnerability such as the credit growth rate? And finally, is the monetary policy, by itself, sufficient to address the procyclicality of the financial system, or does it require the participation of a financial stability supervisory agent?

There is a wide branch of literature that helps to answer these questions. This literature focuses specially on the debate about whether central banks should react directly to indicators of financial volatility. Bernanke and Gertler (2001) conclude that there is no role for asset prices as an indicator of financial vulnerability in monetary policy rules analyzed for the economies of United States and Japan. On the contrary, Cecchetti et al. (2000), using a neo-Keynesian model with financial frictions, concludes that central banks should react to changes in asset prices. Meanwhile, Gray et al. (2009) found a role for an indicator of financial stability in the monetary policy rule for Chile. Finally, Rabanal (2009), using a neo-Keynesian model with financial frictions for a closed economy, concludes that including in the monetary policy rule indicators of financial stress, such as credit growth, generates gains in terms of macroeconomic stability, if the economy is affected by a shock of financial nature.

This research contributes to the current debate by evaluating the effectiveness, in terms of macroeconomic stability, of monetary policy rules and instruments of prudential supervision in the context of a small open economy. Specifically, it seeks to distinguish between the gains from including indicators of financial stress, such as the credit growth, in the standard monetary policy rule, and the benefits that result from applying, in parallel to this augmented monetary policy rule, a macroprudential tool that allows the supervisory authority to affect credit interest rates to mitigate its volatility.

Therefore, this research does not only evaluate if it is effective for the monetary authority to react to signs of overheating in the dynamics of credits but, to what extent the simultaneous action of a monetary authority and a supervisory body is beneficial. This is done using a neo-Keynesian general equilibrium model, for a small open economy with financial frictions, and calibrated in such a way that it reflects the stylized facts of the Peruvian economy. Also, the rules are evaluated in the context of four types of shocks: financial shock, productivity shock, foreign demand and foreign interest rate shocks.

The results obtained suggest that the effectiveness of the rules depends strongly on the nature of the shock affecting the economy. In particular, under a financial shock that generates an easing of credit conditions, rules that react more aggressively to credit growth will be more effective in stabilizing the economy. Thus, the augmented Taylor rule in parallel to a macroprudential tool will generate higher stability than the two other rules: the simple Taylor rule and the augmented Taylor rule. Nevertheless, when the shock does not directly affect credit conditions using rules that react to credit growth increase the volatility of the economy. Therefore, under a productivity shock, external demand and foreign interest rate shocks, the most effective rule, in terms of stability, is the simple Taylor rule.

The paper is structured as follows: In Section 2, the microfoundations of the model are explored. Section 3 describes the calibration used. In Section 4 the results obtained under the three rules are described, while in Section 5, policy recommendations are put forward and conclusions are presented.

2. The Model

The model analyzed represents a small open economy with financial frictions. These frictions generate a spread between credit and savings interest rates, which depends on the level of leverage of domestic households relative to the value of their capital stock. Households capital stock consists of durable goods, which are used as collateral for accessing loans. When the price of these goods rises, the value of collateral rises as well, generating a lower leverage ratio and thus, lower credit rates for the same amount of debt. Or equivalently, the same level of credit rates for higher amounts of debt.

The model also incorporates an instrument of macroprudential regulation that directly affects the interest rate spread, in line with the contributions of Kannan, Rabanal and Scott (2009). This instrument can be understood as bank capital requirements or provision expenses, which are increased in line with credit growth. Thus, higher credit growth will be associated with higher costs for financial intermediaries, which will be transferred to lending rates, slowing down credit growth.

The basic model considers a two-country economy with indices, H: domestic and F:

foreign. Then, in order to obtain a domestic small open economy, it is assumed that the size of the domestic economy tends to zero in the limit, so that it has no effects on the foreign economy.

The model includes a domestic financial sector, comprising financial intermediaries and the central bank. Also, domestic families, firms producing non-durable final goods, firms producing non-durable intermediate goods and firms producing durable final goods. The durable good can be understood as a residential property or real estate and the non-durable good as any perishable consumption good that does not generate future utility. Finally, external agents are also included in the model. They have the possibility of investing in debt instrument issued by domestic financial intermediaries.

Financial intermediaries give credit to domestic families. This credit is financed through the issue of risk free bonds that are acquired by foreign savers. These intermediaries pay an interest rate R to foreign savers, and charge a rate R^L to domestic families for the credit granted. The resulting interest rate spread is a function of a financial shock, a function of domestic households net worth in line with the idea of the financial accelerator of Bernanke et al. (1998) and Aoki et al. (2004)-; and a function of a macroprudential tool that responds to credit growth rate. It is worth noting that the bonds issued by financial intermediaries are denominated in local currency, thus exchange rate risk is assumed entirely by foreign families.

The presence of price stickiness la Calvo in the model, allows monetary policy to have real effects and therefore, that the presence of a **central bank** -that sets the nominal interest rate R-, becomes relevant.

The existence of financial frictions allows policy makers (eg, a regulatory agent), to affect the interest rate spread, by imposing capital requirements, additional provisions, and in general, a macroprudential tool. Therefore, the model is adequate to assess different monetary policy rules and the effectiveness of a macroprudential instrument. Specifically, the relative effectiveness of three policy regimes will be evaluated: a **standard monetary policy rule**, that reacts to output growth and inflation, an **augmented monetary policy rule**, that reacts additionally, to credit growth rate, and an **augmented monetary policy rule simultaneously with a macroprudential instrument**.

Domestic households are characterized by being more impatient than foreign households, thus, in equilibrium they will be net debtors, and foreign households, net borrowers. Also, they consume the two types of goods available in the economy durable and non-durable-. Non-durable goods are tradable and are produced domestically or imported while durable goods are not tradable.

In turn, these families receive income from three sources: as a result of their work in firms producing intermediate goods in the non-durable sector, as a result of their share in the profits of those firms; and finally, as a result of their share in the profits of financial intermediaries.

Three types of firms operate in the domestic economy: a) producers of non-durable final goods, b) producers of non-durable intermediate goods, c) producers of durable final goods. The **non-durable final goods firms** operate under perfect competition and use a continuum of differentiated intermediate goods to produce the final good. The **non-durable intermediate goods firms** operate under monopolistic competition and produce differentiated goods through a technology that uses labor as a single production factor. Also, these firms face nominal rigidities la Calvo (1983)[3] , which means that they cannot set prices with discretion, and their ability to change prices depends on an exogenous probability. Finally **durable final goods firms** operate under perfect competition and flexible prices.

The sources of uncertainty in the model are determined by four shocks: a financial shock (to the interest rate spread), a domestic productivity shock, an external demand shock and a foreign interest rate shock.

2.1 Domestic Families

2.1.1 Preferences

The world economy is populated by a continuum of individuals of density 1. A fraction n live in the domestic economy and the difference, $1-n$, lives in the rest of the world. Each resident j in the domestic economy receives utility from consuming a bundle of non-durable goods, C_t^j, a bundle of durable goods, D_t^j, and receives disutility from hours worked, L_t^j.

[3]This assumption is standard in the literature and enables the aggregation of individual prices (see equation(48))

Thus, individuals preferences are represented by the following utility function.

$$U_t^j = E_t \left\{ \sum_{s=0}^{\infty} \beta^{t+s} U[C_{t+s}^j, C_{t+s-1}, D_{t+s}^j, L_{t+s}^j] \right\} \tag{1}$$

Where E_t represents the conditional expectation on the set of information of period t, β is the intertemporal subjective discount factor which lies between 0 and 1. Furthermore, consumption preferences have external habits as in Smets and Wouters (2003) and Iacoviello and Neri (2000)[4], which implies that the household does not only perceives utility from consumption, C_{t+s}^j, but from their consumption relative to the aggregate consumption of the previous period C_{t+s-1}. In other words, people enjoy greater utility in so far as their consumption levels rise relative to their habits . The functional form of utility is defined in Section 3.1, where the parameters and functional forms of the model will be detailed.

Also, the consumption bundle of non-durable goods is composed by domestic goods and imported goods, which are added using the following index of consumption:

$$C_t \equiv \left[(1-\gamma^H)^{1/\theta_H} C_{H,t}{}^{\frac{\theta_H - 1}{\theta_H}} + (\gamma^H)^{1/\theta_H} C_{F,t}{}^{\frac{\theta_H - 1}{\theta_H}} \right]^{\frac{\theta_H}{\theta_H - 1}} \tag{2}$$

Where $\theta_H > 0$ represents the substitution elasticity between domestically produced non-durable goods intended for consumption, $C_{H,t}$, and imported non-durable goods intended for consumption, $C_{F,t}$; and $1-\gamma^H$ represents the share of domestically produced non-durable goods in the total bundle of non-durable consumption goods.

At the same time, $C_{H,t}$ and $C_{F,t}$ are indices of a continuum of differentiated goods of type z intended for consumption and produced domestically and abroad, respectively. These consumption indices are defined as follows[5]:

$$C_{H,t} \equiv \left[\left(\frac{1}{n} \right)^{1/\sigma_c} \int_0^n C_{H,t}(z)^{\frac{\sigma_c - 1}{\sigma_c}} dz \right]^{\frac{\sigma_c}{\sigma_c - 1}} \tag{3}$$

[4]The inclusion of consumer habits in New-Keynesian models allows the replication of the stylized facts associated with variables such as consumption and output in response to a monetary shock, by adding persistence to real variables.

[5]Note that these indices are aggregations of n goods of type z in the domestic economy and $1-n$ goods of type z in the foreign economy. Thus, n not only represents the continuum of individuals that populates the domestic economy, but also the number of goods of type z in the domestic economy

$$C_{F,t} \equiv \left[\left(\frac{1}{1-n} \right)^{1/\sigma_c} \int_n^1 C_{F,t}(z)^{\frac{\sigma_c - 1}{\sigma_c}} dz \right]^{\frac{\sigma_c}{\sigma_c - 1}} \tag{4}$$

Where $\sigma_c > 1$ represents the elasticity of substitution between types of non-durable goods produced domestically, $C_{H,t}(z)$, and also, between types of non-durable goods produced abroad, $C_{F,t}(z)$. The optimal consumption demands for each type z of domestic and foreign non durable goods are given by:

$$C_{H,t}(z) = \frac{1}{n}(1-\gamma^H) \left(\frac{P_{H,t}(z)}{P_{H,t}} \right)^{-\sigma_c} \left(\frac{P_{H,t}}{P_t^c} \right)^{-\theta_H} C_t \tag{5}$$

$$C_{F,t}(z) = \frac{1}{1-n}\gamma^H \left(\frac{P_{F,t}(z)}{P_{F,t}} \right)^{-\sigma_c} \left(\frac{P_{F,t}}{P_t^c} \right)^{-\theta_H} C_t \tag{6}$$

These demands are obtained from the minimization of total expenditure on non-durable goods intended for consumption, $P_t^c C_t$, where P_t^c is the consumer price index. It is worth noting that the demand for each type of good is an increasing function of aggregate consumption of non-durable goods and a decreasing function of their respective relative price.

On the other hand, it can be shown, under the assumption of preferences described above, that the consumer price index is determined by:[6]

$$P_t^C \equiv \left[(1-\gamma^H)(P_{H,t})^{1-\theta_H} + \gamma^H (P_{F,t})^{1-\theta_H} \right]^{\frac{1}{1-\theta_H}} \tag{7}$$

Where $P_{H,t}$ and $P_{F,t}$ are the price levels of domestically produced non-durable goods and imported non-durable goods, respectively. These prices, in turn, are defined as follows:

$$P_{H,t} \equiv \left[\left(\frac{1}{n} \right) \int_0^n P_{H,t}(z)^{1-\sigma_c} dz \right]^{\frac{1}{1-\sigma_c}} \tag{8}$$

$$P_{F,t} \equiv \left[\left(\frac{1}{1-n} \right) \int_n^1 P_{F,t}(z)^{1-\sigma_c} dz \right]^{\frac{1}{1-\sigma_c}} \tag{9}$$

Where $P_{H,t}(z)$ and $P_{F,t}(z)$ represent the prices of the variety z expressed in local currency, for domestic and externally produced non-durable goods.

On the other hand, the durable goods stock evolves as follows:

[6] See Appendix D2 for details about the derivation.

$$D_t^j = (1-\delta)D_{t-1}^j + g_t^D \tag{10}$$

This equation reflects the dynamics of the stock of durable goods, where δ denotes the depreciation rate and g_t^D reflects the spending intended to increase such stock. If we assume that the durable good is, for example, a residential property, the variable g_t^D can be understood as an expense in repair services, such as the spending on building an additional floor to the house or building, or acquiring additional housing.

2.1.2 Asset Structure

In the asset market there is only one financial asset, one period nominal bonds denominated in domestic currency. These bonds are risk free and are issued by financial intermediaries and purchased by foreign savers. They are issued for funding the credit granted to domestic households. Thus, the budget constraint of the representative household, j, expressed in local currency is defined as:

$$P_t^C C_t^j + P_t^D g_t^{D,j} + R_{t-1}^L B_{t-1}^j \leq B_t^j + W_t L_t^j + \Pi_t^j \tag{11}$$

Where P_t^D is the price of the durable good, B_{t-1}^j represents the amount of credit granted to individual j in period $t-1$ and R_{t-1}^L is the cost of that debt, that is, the active interest rate that the financial intermediary charges in period $t-1$. It should be noted that this interest rate R_t^L depends on the degree of leverage of the whole economy. In particular, if the total debt of the economy increases, the interest rate will also increase[7]. However, when the individual agent determines his optimal level of consumption and therefore, his level of debt, he does not internalize this fact. That is, the lending rate is taken as an exogenous variable in the individual optimization process, which constitutes an externality. This externality is crucial in the model, its implications are detailed in Section 2.2.

On the other hand, W_t, represents the nominal wage for hours worked and L_t^j, hours of work offered by the individual j. Finally, Π_t^j reflects the nominal benefits that individuals residing in the domestic economy receive for being owners of financial intermediaries and

[7]The determinants of the lending rate will be detailed in Section 2.2 (financial intermediaries).

firms producing intermediate non-durable goods. It is assumed that each individual owns a fraction $\frac{1}{n}$ of both firms and financial intermediaries throughout the economy, and also that there is no market for equity shares of firms or financial intermediaries. This assumption is useful since it allows working with the aggregate economy as a representative agent model, otherwise each individuals wealth would need to be tracked.

To determine the optimal dynamics of consumption of durable and non-durable goods, the individual maximizes (1) subject to (10) and (11):

2.1.3 Consumption/saving and work supply decisions

The first order conditions that determine the optimal path of consumption of durable goods are given by the following three equations:

$$U_{c,t} = \lambda_t P_t^C \tag{12}$$

$$U_{D,t} = \mu_t - \beta(1-\delta)\mu_{t+1} \tag{13}$$

$$\lambda_t P_t^D = \mu_t \tag{14}$$

Where μ_t is the Lagrangian multiplier associated with the restriction (10) and λ_t is the Lagrangian multiplier associated with the budget constraint (11). The first equation is the first order condition associated with the consumption of non-durable goods. This condition equals the marginal utility of non-durable consumption to the shadow price of an additional unit of consumption of non-durable good.

The third condition is the first order condition associated with the expenditure in increasing the stock of durable good, $g_t^{D,j}$. This equation equals the shadow price of an additional unit of consumption of durable good, to the shadow price of an additional unit of consumption of non-durable good.

The three first order conditions can be reduced to the following equation:

$$\frac{P_t^D}{P_t^C} = \frac{U_{D,t}}{U_{C,t}} + \beta(1-\delta)\frac{U_{C,t+1}}{U_{C,t}}\frac{P_{t+1}^D}{P_{t+1}^C} \tag{15}$$

Equation (16) is the Euler equation and reflects the optimal path of consumption of non-durable goods by equating marginal costs and marginal benefits of saving or dissaving. The index j is dropped because of the representative agent assumption.

$$U_{C,t} = \beta R_t^L E_t \left[\frac{P_t^C}{P_{t+1}^C} U_{C,t+1} \right] \tag{16}$$

This equation implies that an increase in the lending interest rate, R_t^L, raises the marginal costs of borrowing to consume the non-durable good. Also, the equation (15) implies that under an increase of the marginal utility of consumption of the non-durable good, the marginal utility of the durable good must increase in order to maintain the equality. This implies that the consumption of the durable good must also be reduced under an increase in the lending interest rate.

On the other hand, the first order condition that determines work supply is given by:

$$U_{L,t} = U_{C,t} \frac{W_t}{P_t^C} \tag{17}$$

Where the term on the left reflects the marginal disutility per hour worked, and the term on the right reflects the perceived real wage per hour worked multiplied by the marginal utility of consumption. That is, this condition equals the marginal cost of working with the marginal utility of consumption that the hour of work generates. Also, this condition implies that labor supply is an increasing function of real wage and a decreasing function of consumption[8].

2.2 Financial Intermediaries

The presence of financial intermediaries responds to the assumption that foreign agents -savers- cannot finance domestic agents directly. Thus, these intermediaries provide credit to domestic households, which is financed by issuing bonds. These bonds are purchased by foreign savers and pay a risk-free rate, R_t. Besides, the existence of an agency problem between the financial intermediary and domestic borrowers, translates into a lending interest rate, R_t^L, higher than the cost of funding for intermediaries, R_t, resulting in an interest rate spread. It is worth noting that bonds are denominated in domestic currency, therefore the

[8]This is because the marginal disutility of working is an increasing function of hours worked.

exchange rate risk is entirely assumed by foreign savers.

The interest rate spread is a function of a financial shock, a function of domestic households net worth -in line with the idea of the financial accelerator of Bernanke et al. (1998) and Aoki et al. (2004)-; and a function of a macroprudential tool following Kannan, Rabanal and Scott (2009). Thus, the lending rate R_t^L is defined as[9]:

$$R_t^L = v_t R_t F(B_t / P_t^D D_t) \tau_t \tag{18}$$

Where v_t is a financial shock that can be understood as changes in the perception of credit risk by financial institutions, or changes in the level of competition in the financial system. In particular, a reduction (increase) in the perception of risk and increases (reductions) in the level of competition in the financial system result in lower (higher) spreads.

On the other hand, F is a function of the leverage ratio of domestic households, $\frac{B_t}{P_t^D D_t}$, where B_t is the aggregate amount of credit of the domestic economy. Furthermore, this function satisfies the following properties: $F^{'}() > 0$,
$F^{''}() > 0$. Which implies that the lending rate is a decreasing function of the aggregate financial position or an increasing function of the leverage ratio.

Finally, τ_t is a macroprudential tool that allows the regulator or supervisory authority to directly affect the lending rate without affecting the monetary policy rate as long as credit grows above its steady state value. This instrument can be understood as a measure of banking regulation, whether capital requirements or loan provisions. As long as credit grows, this instrument will operate as an increase in the minimum capital requirement, or as an increase of the loan regulatory provision rate, which will result in higher costs for the financial intermediary that will be transferred to the lending rate, thus reducing credit growth.

The presence of this instrument becomes relevant given the existence of a key externality in the model: domestic individuals do not internalize the fact that increases in their demand for loans contribute to increases in the lending rate, due to the increase of the aggregate

[9]It is important to note that for the objectives pursued in this research, it is not necessary to deepen in the microfoundations that determine the shape of the spread. For more details about them see Schmitt-Grohé and Uribe, (2003): ‘Closing small open economy models’.

level of debt. This creates incentives for the individuals to have levels of debt higher than sustainable levels associated with the actual payment capacity of domestic agents.

2.3 Producers of durable goods

Producers of durable goods use non-durable goods produced domestically or abroad as inputs. In line with the example of the residential property, construction companies can use as production inputs non-durable goods such as cement or paint.

Thus, the function of durable goods production is specified as follows, following Bernanke et al. (1999):

$$Y_t^D = \left[\phi\left(\frac{I_t^D}{D_{t-1}}\right)\right] D_{t-1} \tag{19}$$

Where $\phi'(.) > 0$ and $\phi''(.) < 0$. Thus, to produce one unit of durable good, it takes more investment each time, which is equivalent to an increasing function of marginal costs.

The pricing of durable goods is the result of the maximization of firms profits in an environment of perfect competition and flexible prices. The problem of the firm producing durable goods is as follows:

$$max_{I_t^D} P_t^D \left[\phi\left(\frac{I_t^D}{D_{t-1}}\right)\right] D_{t-1} - P_t^C I_t^D.$$

From the first order condition it is obtained the price set by firms, given by:

$$P_t^D = P_t^C \left[\phi'\left(\frac{I_t^D}{D_{t-1}}\right)\right]^{-1} \tag{20}$$

That is, the price of durable goods is an increasing function of the ratio $\frac{I_t^D}{D_{t-1}}$ as in the theory of Tobins q. This is because the price of durable goods in a competitive market is equivalent to the marginal cost of producing, which is increasing in the level of investment.

2.4 Foreign economy

Similarly to the case of domestic households, external families maximize their utility function given by:

$$U_t^{*j} = E_t \left\{ \sum_{s=0}^{\infty} \beta^{t+s} U[C_{t+s}^{*j}, C_{t+s-1}^{*}, D_{t+s}^{*j}, L_{t+s}^{*j}] \right\} \tag{21}$$

Subject to the following restrictions:

$$P_t^{*C} C_t^{*j} + P_t^{*D} g_t^{*D,j} + \frac{B_t^j}{e_t} + B_t^{*j} \leq R_{t-1} \frac{B_{t-1}^j}{e_t} + R_{t-1}^* B_{t-1}^{*j} + W_t^* L_t^{*j} + \Pi_t^{*j} \tag{22}$$

$$D_t^{*j} = (1-\delta) D_{t-1}^{*j} + g_t^{*D} \tag{23}$$

Where e_t is the nominal exchange rate and R_t^* is the foreign nominal interest rate. Unlike domestic households, foreign families can decide between investing in foreign bonds, B_t^{*j}. receiving an interest rate R_t^* and investing in bonds of the domestic economy, B_t^j, obtaining a risk free rate, R_t, set by the domestic central bank. Thus, the first order conditions associated to B_t^{*j} and B_t^j are given by:

$$\frac{\lambda_t^*}{\lambda_{t+1}^*} = \beta R_t^* \tag{24}$$

$$\frac{\lambda_t^*}{\lambda_{t+1}^*} = \beta \frac{e_t R_t}{E_t(e_{t+1})} \tag{25}$$

Where λ_t^* is the Lagrangian associated with the budget constraint. By combining both equations a non-linear version of the *uncovered interest parity* (UIP) relation is obtained. This relation relates the expected depreciation of the nominal exchange rate with the nominal spread of interest rates. It also determines the dynamics of the nominal exchange rate in the model.

$$R_t = R_t^* \frac{E_t(e_{t+1})}{e_t} \tag{26}$$

On the other hand, the consumption bundle of the external economy has a similar structure to the consumption bundle of the domestic economy, and it is given by:

$$C_t^* \equiv \left[(1-\gamma^F)^{1/\theta_H} C_{H,t}^{*\frac{\theta_H - 1}{\theta_H}} + (\gamma^F)^{1/\theta_H} C_{F,t}^{*\frac{\theta_H - 1}{\theta_H}} \right]^{\frac{\theta_H}{\theta_H - 1}} \tag{27}$$

Where $\theta_H > 0$ is the elasticity of substitution between domestically produced goods intended for consumption, $C^*_{H,t}$, and goods produced in the external economy and intended for consumption, $C^*_{F,t}$. Also, $1-\gamma^F$ represents the fraction of domestically produced goods in the whole consumption bundle of the external economy.

At the same time, $C^*_{H,t}$ and $C^*_{F,t}$ are indices of a continuum of differentiated goods intended for consumption and produced domestically and abroad, respectively. These consumption indices are similar to $C_{H,t}$ and $C_{F,t}$, defined in equations (3) and (4). Thus, the consumer demand for each type of good is defined as follows:

$$C^*_{H,t}(z) = \frac{1}{n}(1-\gamma^F)\left(\frac{P^*_{H,t}(z)}{P^*_{H,t}}\right)^{-\sigma_c}\left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\theta_H} C^*_t \tag{28}$$

$$C^*_{F,t}(z) = \frac{1}{1-n}\gamma^F\left(\frac{P^*_{F,t}(z)}{P^*_{F,t}}\right)^{-\sigma_c}\left(\frac{P^*_{F,t}}{P^*_t}\right)^{-\theta_H} C^*_t \tag{29}$$

Where $P^*_{H,t}$ represents the price of exports of the domestic economy, $P^*_{F,t}$ is the price of goods produced in the foreign economy and P^*_t is the consumer price index of the external economy, defined as:

$$P^*_t \equiv \left[(1-\gamma^F)(P^*_{H,t})^{1-\theta_H} + \gamma^F(P^*_{F,t})^{1-\theta_H}\right]^{\frac{1}{1-\theta_H}} \tag{30}$$

2.4.1 The small open economy assumption

In line with Sutherland (2005), it is assumed that the parameter that determines the preference for imported goods, γ^H, depends on the relative size of the external economy, $1-n$, and the degree of openness of the domestic economy, γ. Where $\gamma^H = (1-n)\gamma$. Similarly, for the foreign economy it is assumed that the external consumer preferences for domestic goods, $(1-\gamma^F)$, depend on the relative size of the domestic economy, n, and the degree of openness of the external economy γ^*. Where $(1-\gamma^F) = n\gamma^*$.

The previous parametrization implies that when the openness of the economy if higher, the fraction of imported goods in the consumption bundle is higher. Also, when the economy becomes larger in relative terms, this fraction falls. Obtaining the small open economy is achieved by making the size of the economy tend to zero, $n \to 0$. This implies that $\gamma^H \to \gamma$

and that $1-\gamma^F \to 0$. That is, in the limit, the external economy does not use domestic goods in its consumption bundle, and the consumption demand for domestic goods conditions can be written as follows:

$$C_{H,t} = (1-\gamma)\left(\frac{P_{H,t}}{P_t^C}\right)^{-\theta_H} C_t \tag{31}$$

$$C_{F,t} = \gamma\left(\frac{P_{F,t}}{P_t^C}\right)^{-\theta_H} C_t \tag{32}$$

$$C_{H,t}^* = \gamma^*\left(\frac{P_{H,t}^*}{P_t^*}\right)^{-\theta_H} C_t^* \tag{33}$$

Similarly, in the limit, the domestic and foreign consumer price indices acquire the following form:

$$P_t^C \equiv \left[(1-\gamma)(P_{H,t})^{1-\theta_H} + \gamma(P_{F,t})^{1-\theta_H}\right]^{\frac{1}{1-\theta_H}} \tag{34}$$

$$P_t^* = P_{F,t}^* \tag{35}$$

As detailed in Section 2.3, firms producing durable goods use as production inputs non-durable goods, both domestically produced and imported. Demand for non-durable goods by such investment firms is called investment in durable goods, I_t^D. The domestic and external bundle of investment in durable goods take the same functional form as the consumption bundles described in (2) and (27). This assumption allows the aggregation of both components of expenditure (consumption and investment) and getting the demand for domestically produced goods intended for domestic market; the demand for imported goods and the demand for exports:

$$Y_{H,t} = (1-\gamma)\left(\frac{P_{H,t}}{P_t^C}\right)^{-\theta_H} (C_t + I_t^D) \tag{36}$$

$$Y_{F,t} = \gamma\left(\frac{P_{F,t}}{P_t^C}\right)^{-\theta_H} (C_t + I_t^D) \tag{37}$$

$$Y^*_{H,t} = \gamma^* \left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\theta_H} Y^*_t \tag{38}$$

Where Y^*_t denotes the external product[10] . From the above, we obtain the demand for each type of domestically produced goods and intended for domestic market, the demand for each type of imported good and the demand for each type of exported good:

$$Y_{H,t}(z) = (1-\gamma) \left(\frac{P_{H,t}(z)}{P_{H,t}}\right)^{-\sigma_c} \left(\frac{P_{H,t}}{P^C_t}\right)^{-\theta_H} (C_t + I^D_t) \tag{39}$$

$$Y_{F,t}(z) = \gamma \left(\frac{P_{F,t}(z)}{P_{F,t}}\right)^{-\sigma_c} \left(\frac{P_{F,t}}{P^C_t}\right)^{-\theta_H} (C_t + I^D_t) \tag{40}$$

$$Y^*_{H,t}(z) = \gamma^* \left(\frac{P^*_{H,t}(z)}{P^*_{H,t}}\right)^{-\sigma_c} \left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\theta_H} Y^*_t \tag{41}$$

It is easy to show that the total demand for the type z good produced domestically is given by[11] :

$$Y_t(z) = Y_{H,t}(z) + Y^*_{H,t}(z) = \left(\frac{P_{H,t}(z)}{P_{H,t}}\right)^{-\sigma_c} \left(\frac{P_{H,t}}{P^C_t}\right)^{-\theta_H} \left[(1-\gamma)(C_t + I_t) + \gamma Q^{\theta_H} Y^*_t\right] \tag{42}$$

If we define:

$$Y_t = \left(\frac{P_{H,t}}{P^C_t}\right)^{-\theta_H} \left[(1-\gamma)(C_t + I_t) + \gamma Q^{\theta_H} Y^*_t\right], (43)$$

the demand for the type z good produced domestically can be expressed as:

$$Y_t(z) = \left(\frac{P_{H,t}(z)}{P_{H,t}}\right)^{-\sigma_c} Y_t, \tag{44}$$

Where Y_t is the aggregate output. Finally, given the assumption of a small economy, the external variables that affect the dynamics of the domestic economy are the external product, Y^*_t, the foreign interest rate, R^*_t, and the foreign inflation, π^*_t. It is assumed, for simplicity, that the evolution of these variables follows an autoregressive process in loga-

[10]It is worth noting that in the limit, where $n \to 0$, the foreign economy operates as a closed economy, whose total output is given by the sum of its consumption and investment demands.

[11]See appendix D.2.3 for derivation details.

rithms, whose order is determined by its data generating process according to the results of Castillo, Montoro y Tuesta (2009)[12] .

2.5 Producers of nondurable intermediate goods

There is a continuum of firms producing nondurable intermediate goods indexed by z. Each z firm works in a monopolistic competition environment, where they face a downward sloping demand, specified in equation (44). It is also assumed that in each period t intermediate goods producers face an exogenous probability of changing prices, $(1-\omega)$. According to Calvo (1983), it is assumed that this probability is independent of the price level chosen by the firm in the previous period and the time elapsed since the last time the firm changed its prices.

Intermediate goods in nondurable sector are produced using labor as the only production input. The production function is the following:

$$Y_t(z) = A_t L_t(z), \forall z \in [0,1] \tag{45}$$

Where A_t represents a productivity shock which follows an AR(2) process in logarithms according to Castillo, Montoro and Tuesta (2009) estimations.

Cost minimization by firms leads to the following function of real marginal cost:

$$CM_{H,t} = CM_{H,t}(z) = \frac{W_t}{A_t P_{H,t}} \tag{46}$$

Also, the maximization problem faced by firms producing intermediate goods is the following:

$$max_{P_{H,t}(z)} E_t \left[\sum_{k=0}^{\infty} (\beta\omega)^k \Lambda_{t+k} \left(\left(\frac{P^o_{H,t}(z)}{P_{H,t}} F_{H,t+k} - CM_{H,t}(z) \right) Y_{t+k}(z) \right) \right]$$

Where:

$$Y_{t+k}(z) = \left(\frac{P^o_{H,t}(z)}{P_{H,t}} F_{H,t+k} \right)^{-\sigma_c} Y_{t+k}$$

[12]See section 3.1, for calibration and functional forms.

and

$$F_{H,t+k} = \frac{P_{H,t}}{P_{H,t+k}}$$

The first order condition that solves this problem is given by:

$$E_t \left[\sum_{k=0}^{\infty} (\beta\omega)^k \Lambda_{t+k} \left(\left(\frac{P^o_{H,t}(z)}{P_{H,t}} F_{H,t+k} - \frac{\sigma_c}{\sigma_c - 1} CM_{H,t+k}(z) \right) \right) F^{-\sigma_c}_{H,t+k} Y_{t+k} \right] = 0 \tag{47}$$

After simplifying the expression above, the optimal price charged by the firm is:

$$\left(\frac{P^o_{H,t}(z)}{P_{H,t}} \right) = \frac{\sigma_c}{\sigma_c - 1} \frac{E_t \left[\sum_{k=0}^{\infty} (\beta\omega)^k \Lambda_{t+k} CM_{H,t+k}(z) F^{-\sigma_c}_{H,t+k} Y_{t+k} \right]}{E_t \left[\sum_{k=0}^{\infty} (\beta\omega)^k \Lambda_{t+k} F^{1-\sigma_c}_{H,t+k} Y_{t+k} \right]} = \frac{V^N_t}{V^D_t} \tag{48}$$

Where the aggregate price is the weighted average of the prices set by firms that can change prices, $(1-\omega)$, and of the firms who can't, ω (see equation (49)). Since firms that can change prices are chosen randomly, the price of these firms appears to be the aggregate price of the previous period:

$$P_{H,t} = \left((1-\omega) {P^o_{H,t}}^{1-\sigma_c} + \omega P^{1-\sigma_c}_{H,t-1} \right)^{\frac{1}{1-\sigma_c}} \tag{49}$$

Alternatively, this condition can be written as:

$$\omega \pi^{\sigma_c - 1}_{H,t} = 1 - (1-\omega) \left(\frac{V^N_t}{V^D_t} \right)^{1-\sigma_c} \tag{50}$$

Where $\pi_{H,t} = \frac{P_{H,t}}{P_{H,t-1}}$, V^N_t and V^D_t are defined as:

$$V^N_t = \frac{\sigma_c}{\sigma_c - 1} CM_{H,t} Y_t + \beta\omega E_t [\pi^{\sigma_c}_{H,t+1} V^N_{t+1}] \tag{51}$$

$$V^D_t = Y_t + \beta\omega E_t [\pi^{\sigma_c - 1}_{H,t+1} V^D_{t+1}] \tag{52}$$

These last three equations define what is known as the Phillips curve.

2.6 Policy Regimes

The presence of rigidities in non-durable goods prices and financial frictions enables the existence of two types of policy interventions. First, monetary policy can have an effect on real variables through changes in the nominal interest rate and secondly, it is possible that policy makers affect lending rates by imposing capital requirements or loan provisions when credit level rises above its steady state level.

On this basis, three policy regimes are modeled. The first one is a simple Taylor rule that allows monetary authority to react to output growth and inflation:

$$R_t = \left[\bar{R} \left(\frac{P^C_{t-1}/P^C_{t-2}}{\bar{\pi}^C} \right)^{\gamma_\pi} \left(\frac{Y_{t-1}}{Y_{t-2}} \right)^{\gamma_y} \right]^{1-\gamma_R} R^{\gamma_R}_{t-1} \tag{53}$$

Where $\bar{\pi}^C$ is the level of steady-state inflation for the price of non-durable consumption goods. It also includes the first lag of the policy rate to add persistence to the central bank response. This rule is the reference policy regime. On the basis of this regime, the effectiveness of the rest of the rules will be evaluated[13] .

The second policy regime enables the evaluation of the gains obtained by incorporating information from financial vulnerability indicators. In particular, it adds to the simple Taylor rule, the nominal credit growth rate. This augmented Taylor rule takes the following form:

$$R_t = \left[\bar{R} \left(\frac{P^C_{t-1}/P^C_{t-2}}{\bar{\pi}^C} \right)^{\gamma_\pi} \left(\frac{Y_{t-1}}{Y_{t-2}} \right)^{\gamma_y} \left(\frac{B_{t-1}}{B_{t-2}} \right)^{\gamma_B} \right]^{1-\gamma_R} R^{\gamma_R}_{t-1} \tag{54}$$

The third regime evaluated is the combination of the augmented Taylor rule with a macroprudential instrument. This latter reacts to the nominal credit growth rate and is defined as:

$$\tau_t = \tau \left(\frac{B_{t-1}}{B_{t-2}} \right) \tag{55}$$

This macroprudential instrument allows affecting, directly, the market interest rate with-

[13] Following Kannan, Rabanal and Scott (2009) both, output growth and inflation are introduced with a lag because in practice, the monetary authority has this information with a lag. Meanwhile, information about credit growth is obtained with greater anticipation. However, including contemporaneous credit could bias the results by increasing the relative importance of credit as an indicator. Thus, credit is also included with a lag.

out affecting the monetary policy interest rate. By being a positive function of credit growth rate, it has the capacity to offset the effect that changes in the value of borrowers collateral or a financial shock have on the lending interest rate.

For example, if credit shows high growth rates exacerbating the demand for durable goods -and hence, their price-, borrowers collateral will revaluate and downward pressures to the lending rate will be generated. This latter effect will exacerbate credit growth rate even more.

Implementing a macroprudential rule will mitigate this effect through its positive effect on the lending rate. Similarly, a financial shock that affects positively the interest rate and generates negative credit growth pressures will be offset by a macroprudential instrument that decreases the lending rate.

3. Model Solution

The model is solved approximating the equations log-linerarly with respect to the deterministic steady state detailed in appendix D.1. Furthermore, the set of log-linearized equations which determine the solution of the model, are presented in appendix C. Finally, to perform the simulation exercises that will be presented in the following sections, we use the platform offered by DYNARE[14] .

3.1 Calibration and functional forms

The model is calibrated using data from Peru for a quarterly basis, according to the estimates obtained by Castillo, Montoro and Tuesta (2009). The utility function in the model is:

$$U[C^j_{t+s}, C_{t+s-1}, D^j_{t+s}, L^j_{t+s}] = \left[\psi \log\left(C^j_{t+s} - \varepsilon C_{t-1-s}\right) + (1-\psi)log(D^j_{t+s}) - \frac{(L^j_t)^{1+\varphi}}{1+\varphi}\right] \quad (56)$$

The parameter β , which represents the subjective discount factor, is calibrated at 0.9975, which is associated with a real interest rate of 1 percent in steady state, Castillo et al. (2009).

[14]See http://www.cepremap.cnrs.fr/dynare/.

On the other hand, the parameter ε , which is the coefficient associated with habit formation, takes a value of 0.75[15] according to Castillo et al. (2009).

The inverse of the labor supply elasticity, φ, is set at 2, which implies a very inelastic supply[16] . The parameter γ, which reflects the share of imported non-durable goods in the consumer price index is calibrated with a value of 0.15[17] . Also, in line with Rabanal and Tuesta (2006), the value of the substitution elasticity between domestic and imported goods, θ_H, is calibrated with a relatively low value of, 0.8[18] . The parameter ψ reflecting the share of non durable goods consumption in individual $j's$ utility, is a free parameter calibrated at 0.5 so as to obtain, at the steady state, a value of investment to GDP ratio of approximately 20 percent, the same value as the average of this ratio for the period 2000-2010[19] . In turn, the level of depreciation, δ, is calibrated at 0.025 which is equivalent to an annual depreciation rate of 10 percent, an standard value in the literature.

The substitution elasticity between types of non durable goods, σ_c, is set at 6, which is in line with a margin of 15 percent on marginal costs for firms producing intermediate goods in the non durable sector, Castillo et al. (2009). On the other hand, the parameter κ, which reflects the elasticity of the lending rate to changes in the leverage ratio[20] , is set *ad-hoc* in a value of 0.1.

The parameter that reflects the degree of price rigidity faced by producers of intermediate goods, ω, is calibrated at 0.75, implying that firms keep their prices fixed, on average, four trimesters, Castillo et al. (2009).

Regarding the parameters associated with the policy rules, we have used standard values used in the literature for the simple Taylor rule. The weight of the output growth rate, γ_y, is calibrated in 0.1, the inflation rate weight, γ_π, in 1.5 and the weight of the persistence of the policy rate, γ_R, in 0.7 (Kannan et al., 2009). The weight of the nominal credit growth

[15]Castillo, Montoro and Tuesta find values between 0.62 and 0.79 for these parameters.

[16]This is consistent with Céspedes and Rendon (2012). They estimate the Frisch elasticity of a labor market with a high degree of informality and with high job turnover, using Peruvian Data. They obtain an elasticity of around 0.38 (an inverse elasticity of 2.6).

[17]Winkelried (2003) estimates a value near to 0.15 for this parameter.

[18]It is standard in the literature for general equilibrium models in open economies using values between 0.8 and 1.5 for this parameter.

[19]Central Reserve Bank of Peru, economic statistics.

[20]The parameter κ represents the interest rate elasticity of the leverage ratio in the linear version of the model, which is detailed in appendix C.

rate in the augmented Taylor rule, γ_B , and the weight of the macroprudential instrument, τ, has been calibrated with *ad-hoc* values of 0.5 and 0.4 respectively.

Finally, shocks have been introduced in the model as autoregressive processes of first and second order, according to the estimations of Castillo et al. for the Peruvian economy[21] . The values of the persistence and standard deviations of these shocks are shown in Table 1:

Table 1: Persistence and standard deviation of the shocks

Shock	Standard Deviation	Persistence AR(1)	Persistence AR(2)
Financial	0.01	0.99	N.A
Productivity	0.009969	0.868892	-0.189623
Foreign demand	0.0042904	1.047492	-0.23630
External interest rate	0.0027867	1.562675	-0.688752

[21] The persistence of the financial shock is set *ad-hoc* in a value of 0.99.

4. Incorporation of Policy Rules

This section evaluates the dynamics of key macroeconomic variables under a simple Taylor rule, in comparison with the results obtained by incorporating two types of rules: the first one consists in an augmented Taylor rule, which allows the monetary authority to react to credit growth rate. The second one is a macroprudential rule, described in Section 2.6, in parallel with an augmented Taylor rule. The results will be evaluated in face of each of the following shocks: a financial shock, a productivity shock, an external demand shock and an external interest rate shock.

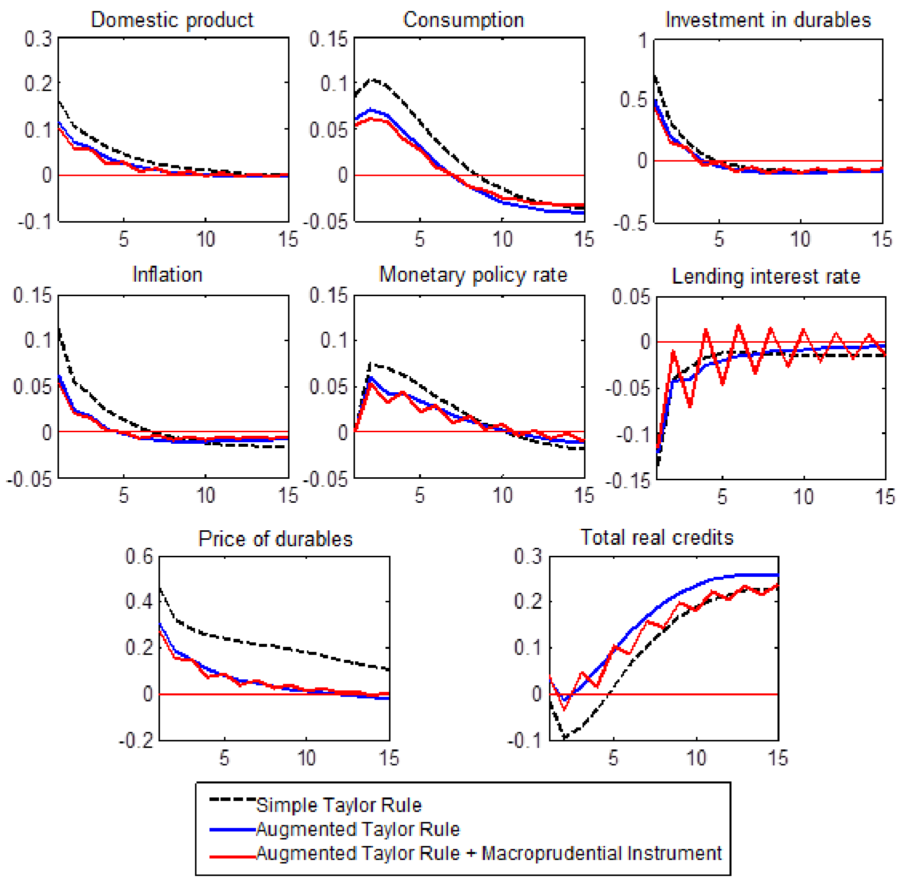
4.1 Performance of policy rules under a financial shock

The basic model includes a simple Taylor rule that reacts only to the output growth rate and inflation. The financial shock is modeled as an easing of lending standards, i.e. a reduction of the lending interest rate, as shown in Figure 1. The immediate effect of a reduction in the lending rate is an increase in credit demand, resulting in an increase of consumption of both durable and nondurable goods. The increase in durable goods demand translates into an increase of durable goods prices. It is this effect which activates the financial accelerator mechanism: by increasing the collateral value of borrowers, these face an even lower lending rate, exacerbating, again, credit demand, consumption, price of durable goods, and once again, the value of collateral. It is this 'first round' effect which generates an overheating of the economy. Figure 1 shows an initial jump of GDP, consumption and investment in durables. Also, there is an increase in inflation in the consumption bundle of nondurable goods (IPC), and a sustained increase in credits.

In this context, the Central Bank, operating through a simple Taylor rule, will increase its policy rate in response to inflationary pressures. This should dampen the increase in output, inflation, consumption, investment and credit growth until they stabilize.

On this basis we consider the effect of an augmented monetary policy rule to react to the growth rate of nominal credit. To perform this exercise, it has been assumed that the weight given to credit growth in the rule is 0.5 (see section 3.1). The incorporation of this rule increases the stability of the main macroeconomic variables in the presence of a financial

Figure 1: Policy rules under a financial shock



shock. It can be seen in Figure 1 that the volatility of the product is considerably lower. Similarly, consumption, investment and inflation become much more stable. It is important to highlight the fact that despite we are assessing a more aggressive monetary policy rule; the volatility of the policy rate is much lower with an augmented Taylor rule than with the simple Taylor rule. The reason is that we are working with rational agents that incorporate in their expectations a more aggressive reaction of the central bank. Thus, monetary policy works through the commitment of an aggressive reaction, without necessarily having to make such increase or decrease of its rates.

Under the incorporation of a macroprudential instrument to the augmented Taylor rule, the results, in terms of stability, are much better. It is not only attacking credits, whose accelerator effect is one of the main sources of volatility of the business cycle, but this is done affecting directly the lending rate, without affecting the monetary policy rate. In this way, the burden on the policy rate whose volatility also affects the volatility of external variables such as the exchange rate and hence the volatility of the economy as a whole- is reduced. To perform this simulation, a weight of 0.4 is assigned to credit in the macroprudential rule, keeping all the other weights previously used. Table 2 shows the standard deviations of output and inflation of consumption under each of the three rules. It is observed that with the augmented Taylor rule, the standard deviation of both, product and inflation, are lower than when using the simple Taylor rule. And also, if the macroprudential rule is used, the volatility of output and inflation are even lower than under the augmented Taylor rule.

The last row of the table shows the simple average of product and inflation volatilities. In aggregate terms, there is a gain of stability when using the augmented Taylor rule, relative to the simple Taylor rule. And even a greater gain if the macroprudential rule is used.

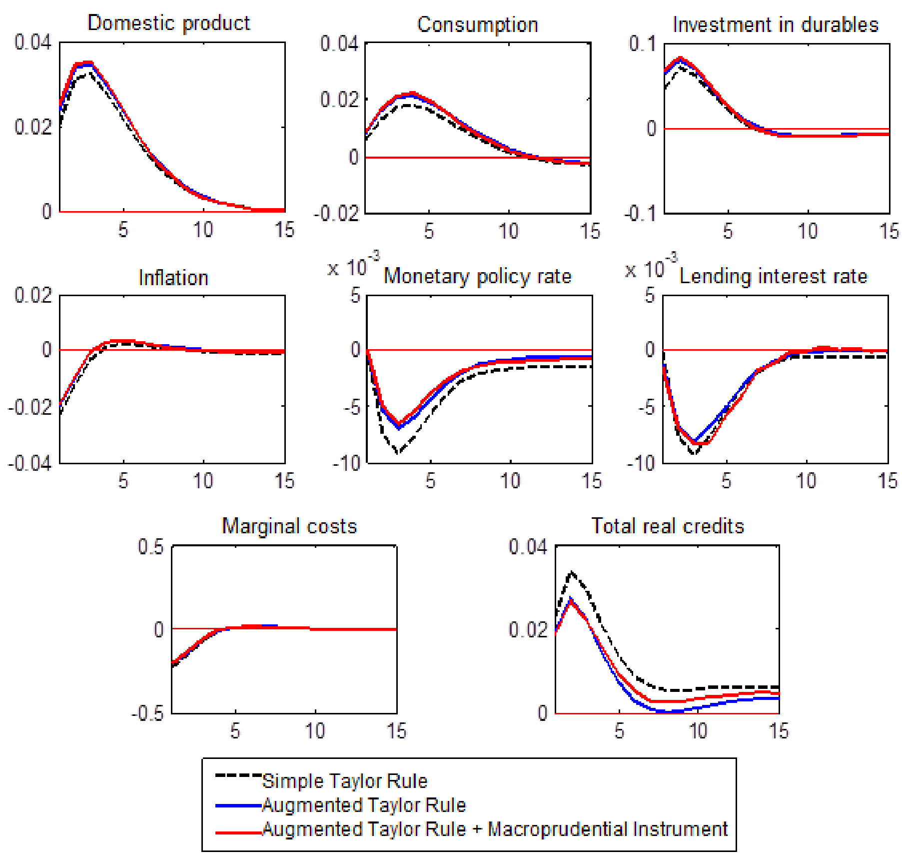
Table 2: Performance of policy rules under a financial shock

	Standard Deviation		
Variable	Simple Taylor	Augmented Taylor	Augmented Taylor + Macroprudential
Product	0.1276	0.0981	0.0883
Inflation	0.0708	0.0438	0.0388
Average	**0.0992**	**0.0709**	**0.0635**
Ranking	**3**	**2**	**1**

4.2 Performance of policy rules under a productivity shock

The productivity shock is modeled as a positive, persistent and unanticipated shock to the productivity in the non-durable goods sector. The immediate effect of this shock is reflected in the reduction of marginal costs incurred by firms. This is understood as a positive wealth effect, which expands the possibilities of present and future consumption of agents. Thus, it is observed in figure 2, an increase in both consumption and investment, with a simultaneous reduction in inflation associated with the reduction of marginal costs.

Figure 2: Policy rules under a productivity shock



This reduction of inflation generates that agents anticipate lower policy rates and therefore, more flexible credit conditions. This, coupled with the positive wealth effect, generates an increase of credit demand, which creates additional pressures on consumption and total product.

In this context of productivity gains, what monetary policy should do is to accommodate the shock as much as possible, reducing its policy rate and generating gains in terms of product without the risk of inducing inflationary pressures. Thus, under a simple Taylor rule, which reacts to a greater extent to inflation, the central bank reduces its policy rate. This reduction will end up returning inflation to its initial levels. However, if more aggressive policy rules are applied, such as an augmented Taylor rule, the reduction of the policy rate is not as substantial as it should be. This is because the increase of credits, a financial vulnerability indicator, generates pressures to an increase in the policy rate. Also, a macroprudential regime will put upward pressure on credit costs, offsetting the effects of a lower policy rate.

Table 3 shows that the volatility of inflation is lower under the augmented Taylor rule and even lower under macroprudential rule. However, this comes at the cost of greater volatility in terms of product. Therefore, in the aggregate, the volatility of the economy (output and inflation) turns out to be lower under the simple Taylor rule, and higher under the augmented Taylor rule and the augmented Taylor rule with the macroprudential instrument. This means that, to the extent that the rule is more aggressive (giving credit growth a larger participation), gains in terms of stability will be lower under a productivity shock.

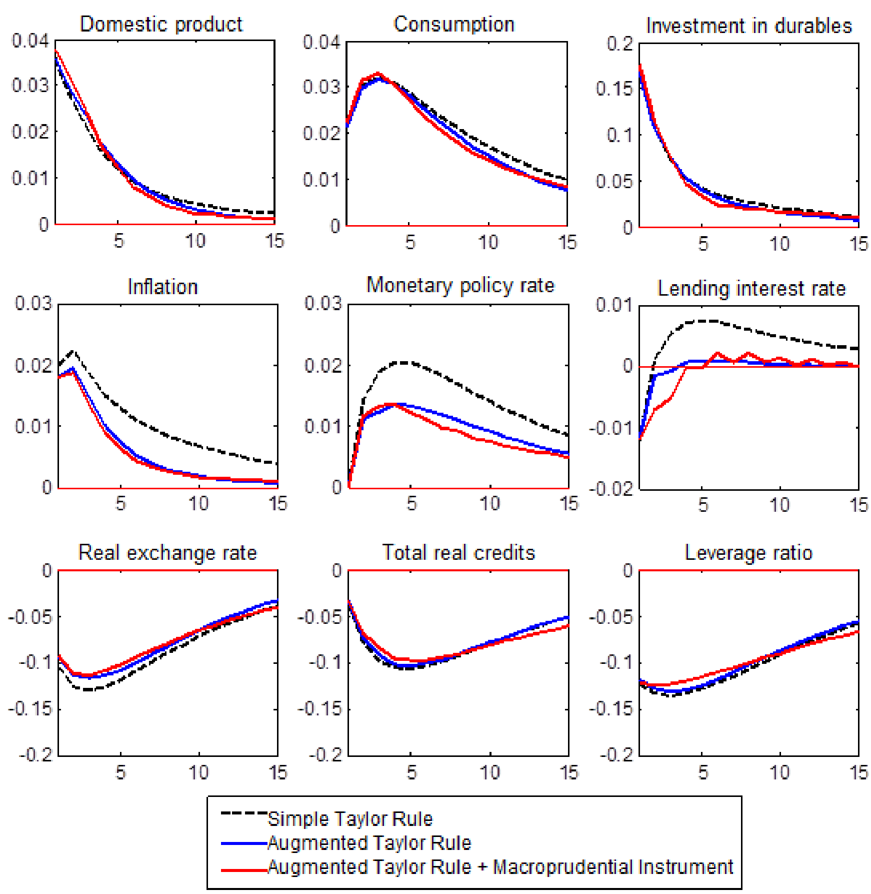
Table 3: Performance of policy rules under a productivity shock

	Standard Deviation		
Variable	Simple Taylor	Augmented Taylor	Augmented Taylor + Macroprudential
Product	0.0468	0.0507	0.0522
Inflation	0.0256	0.0223	0.0215
Average	**0.0362**	**0.0368**	**0.03685**
Ranking	**1**	**2**	**3**

4.3 Performance of policy rules under a foreign demand shock

The foreign demand shock is modeled as an increase in external product. This means an increase in foreign demand for domestically produced goods (increase in exports) that generates appreciation pressures on the real and nominal exchange rate and an increase in domestic product (see figure 3). Also, the appreciation of the exchange rate generates a cheapening of imports which generates additional upward pressures on investment, output and inflation. In this context, agents expect an increase of the policy rate to reduce inflationary pressures. These expectations of tighter credit conditions coupled with the positive wealth effect, encourages domestic agents to reduce their leverage and thus their demand for credit. This improvement in the balance sheets of individuals is what generates the initial reduction of credit interest rate. Given the inflationary pressures, monetary authority, acting under a

Figure 3: Policy rules under a foreign demand shock



simple Taylor rule, will increase its policy rate, which will stabilize consumption, investment, inflation and output. Also, the cost of credit will increase, as anticipated, generating even more downward pressures on credit demand.

Under a shock of this type, in which credit growth does not move in the same direction as inflation, increasingly aggressive rules are not effective to mitigate the volatility of the economy. In particular, an augmented Taylor rule will suggest a smaller increase in the policy rate than under the simple Taylor rule, because of the decrease in credits. And a macroprudential regime, which also responds affecting the cost of credit in the same direction of its growth, will offset the increase in the policy rate with a reduction of the lending rate.

Table 4 shows that, similarly to the productivity shock, volatility of inflation is lower under the augmented Taylor rule and even lower under the macroprudential rule. Again, this comes at the cost of a sharp increase in output volatility. Thus, in aggregate, the volatility of the economy (output and inflation) turns out to be lower under the simple Taylor rule, and higher under the augmented Taylor rule and the augmented Taylor rule with the macroprudential instrument.

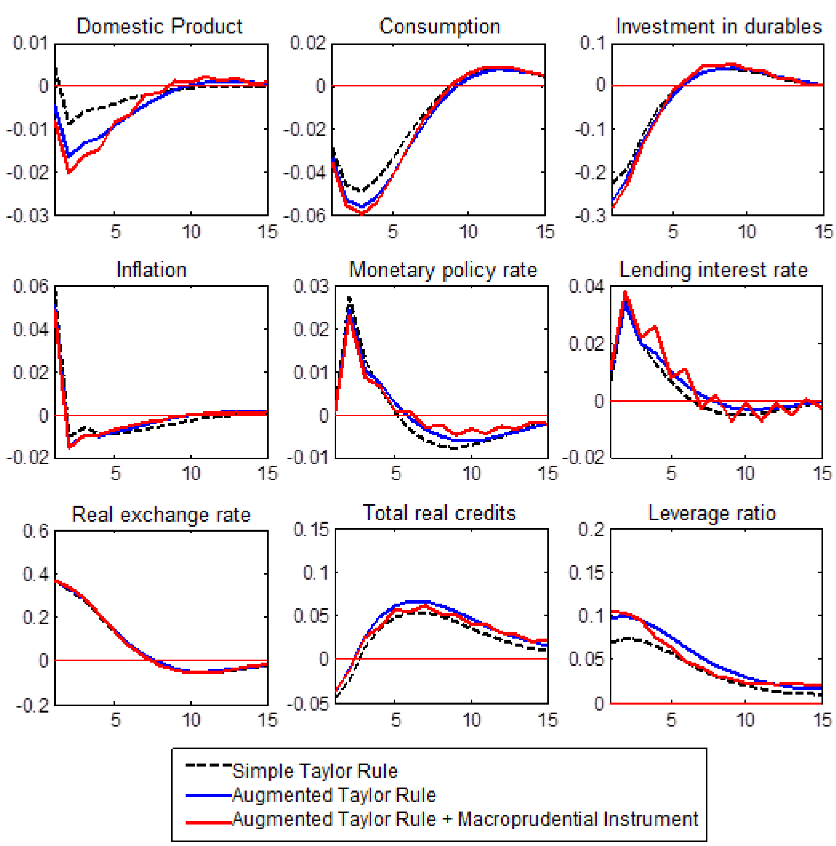
Table 4: Performance of policy rules under a foreign demand shock

	Standard Deviation		
Variable	Simple Taylor	Augmented Taylor	Augmented Taylor + Macroprudential
Product	0.0407	0.0440	0.0470
Inflation	0.0285	0.0254	0.0246
Average	**0.0346**	**0.0347**	**0.0358**
Ranking	**1**	**2**	**3**

4.4 Performance of policy rules under a external interest rate shock

The external interest rate shock is modeled as an increase in the international interest rate. The immediate effect of this shock is reflected in the nominal exchange rate, which suffers a sharp depreciation that is transmitted to imported inflation increasing total inflation (see figure 4). The increase in imports price is a negative wealth effect that translates into a reduction of both consumption and investment. Although product increases slightly as a result of the positive effect of depreciation on exports, this shrinks rapidly as a result of the decrease of domestic demand. Despite tighter credit conditions, as a result of a lower value of individuals collateral, the leverage ratio of the economy increases, and with it, the demand for credit. This is because individuals seek to smooth consumption, to the extent possible.

Figure 4: Policy rules under a external interest rate shock



Given the increase in imported inflation, the monetary authority, acting under a simple Taylor rule, increases its policy rate. With so inflation is rapidly reduced, partly because of the reduction in domestic demand which press down prices, even below their initial level. Thus, subsequent to the deflationary pressures, the central bank reduces its policy rate, stabilizing inflation, activating credit, consumption and product even more.

If the monetary authority used an augmented Taylor rule that reacts to the credit growth rate, it would have incentives to increase the policy rate to mitigate credit growth, but would also have incentives to decrease it to reduce deflationary pressures. Thus, policy rate reduces, but by less extent than the reduction associated with a simple Taylor rule. Therefore, under an augmented Taylor rule, the recovery of the economy is slower than under a simple Taylor rule. Similarly, under a macroprudential rule, the reduction of the policy rate is smaller than under a simple Taylor rule, given the incentives to slow down credit growth. And yet, the effects of this reduction in the policy rate are offset by an increase in the credit interest rate, further slowing the process of economic recovery. Table 4 shows the performance, in terms of stability, of the three rules. As with the two previous shocks, while a macroprudential rule and an augmented Taylor rule generate less volatile responses of inflation; the costs in terms of product stability are high enough so that, in aggregate, the simple Taylor rule is the most effective.

Table 5: Performance of policy rules under a external interest rate shock

	Standard Deviation		
Variable	Simple Taylor	Augmented Taylor	Augmented Taylor + Macroprudential
Product	0.0121	0.0217	0.0271
Inflation	0.0623	0.056	0.0539
Average	**0.0372**	**0.03885**	**0.0405**
Ranking	**1**	**2**	**3**

5. Conclusions and recommendations

The results of this work show that the response by the monetary authority and by a supervisory agent, to the credit growth as an indicator of financial vulnerability, does not necessarily translate into gains in terms of macroeconomic stability. The optimal response of these agents depends strongly on the nature of the shock affecting the economy.

A financial shock can be understood as an improvement in the perception of risk by financial institutions or as higher levels of competition in the financial system. The greater optimism or the need to capture more customers translates into lax credit conditions and therefore, an increase in credit supply which, usually, is not consistent with actual improvements in the payment capacity of debtors. In this context, the credit growth does constitute an important source of vulnerability to macroeconomic stability, since it may generate an artificial dynamism of the economy. That is why, under a shock of this nature, there are significant stability gains when using an augmented Taylor rule instead of a simple Taylor rule. The results also show even greater gains in terms of stability if there is a simultaneous action by the monetary authority and by a supervisory agent (macroprudential rule). The presence of the supervisory agent enables affecting credit interest rates directly, avoiding distortions associated with a more volatile monetary policy rate.

However, credit growth is not always of the same nature. In particular, when this is encouraged by demand factors, the accelerating effect of credit is not as important, since credit conditions do not vary substantially, as they do under a financial shock.

Productivity and external interest rate shocks lead to a greater credit demand. In the first case, due to real improvements in households payment capacity and in the second case, due to the need of smooth a negative wealth effect. In both cases, lax credit conditions are not behind the increase in credit demand. Therefore, credit growth does not constitute an accurate indicator of the volatility generated by the shock, and thus, reacting to this indicator may result in policy errors that lead to greater macroeconomic volatility. Simulations show that for these two shocks, a simple Taylor rule is the most effective to achieve stability.

In the case of a positive shock to foreign demand, the reduction in credit growth is not associated, once again, to supply factors, but to a lower need of indebtedness due to the positive wealth effect generated by the shock, and an anticipation of tighter credit conditions. Thus, the reduction of credit is not associated to a slowdown in domestic demand, but to the contrary. That is why policy rules that respond to credit growth will do nothing but hinder output and inflation stabilization. Simulation results show that the simple Taylor rule is the best alternative in face of a shock of this nature.

We can conclude, then, that committing to follow a rule rigidly, regardless of the nature of the shock affecting the economy and the dynamics of credit, can lead to costly policy mistakes in terms of stability. It will be necessary that policymakers react discretionarily and properly identify the source of vulnerability, which is not always the credit growth.

It is worth noting that even though the model used has been calibrated to replicate the stylized facts of an economy like the Peruvian, an important empirical factor has been omitted. In reality, the economy is affected by multiple shocks simultaneously, many of which are correlated. Therefore, analyzing the effectiveness of policy rules in the context of individual and isolated shocks provide reference results that can be improved. Further research can be oriented to include the relative importance of financial shocks, to other external and internal shocks. Also, in the model presented, we are not including the possibility that the value of individuals assets differ from their fundamental value, generating financial bubbles. Future work could be oriented to model them endogenously.

Additionally, the macroprudential instrument used in this research is fairly simple and referential. Future research may focus on analyzing the most appropriate practical way in which this instrument should be implemented.

Finally, it should be noted that the implementation of certain discretionary policy response to a particular shock may not work if the monetary authority does not adequately communicate its long-term objectives, and the extent to which policy decisions are consistent with those objectives. Furthermore, the effectiveness of a macroprudential regime may depend on the coordination between the monetary authority and the supervisory agent, and to what extent their objectives are aligned.

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APPENDICES

Appendix A: Basic identities

From the definition of the real exchange rate:

$$Q_t = \frac{P_t^* e_t}{P_t^C} \tag{A.1}$$

and from equation (35) on the main text, we obtain the following equation:

$$Q_t = \frac{P_{F,t}^* e_t}{P_t^C} \tag{A.2}$$

Using the no-arbitrage condition in the goods market given by:

$$P_{H,t} = P_{H,t}^* e_t \tag{A.3}$$

and

$$P_{F,t} = P_{F,t}^* e_t \tag{A.4}$$

Where e_t is the nominal exchange rate, we get:

$$Q_t = \frac{P_{F,t}}{P_t^C} = \frac{P_{F,t}}{P_{H,t}} \frac{P_{H,t}}{P_t^C} \tag{A.5}$$

Replacing the definition of terms of trade, given by:

$$TI_t = \frac{P_{H,t}}{P_{F,t}} \tag{A.6}$$

In (A5), we obtain the first relevant identity in the model:

$$Q_t = TI_t^{-1} \frac{P_{H,t}}{P_t^C} \tag{A.7}$$

The second identity is derived from the definition of the consumer price index, equation (7) of the main text:

$$P_t^C \equiv \left[(1-\gamma^H)(P_{H,t})^{1-\theta_H} + \gamma^H (P_{F,t})^{1-\theta_H}\right]^{\frac{1}{1-\theta_H}} \tag{A.8}$$

If both terms of the identity are divided by $P_{H,t}$, we obtain the following identity:

$$\left(\frac{P_t^C}{P_{H,t}}\right)^{1-\theta_H} \equiv (1-\gamma) + \gamma TI_t^{\theta_H - 1} \tag{A.9}$$

Again, from equation (7) of the main text and dividing both terms by P_{t-1}^C , it is easy to obtain the following identity:

$$\left(\pi_t^C\right)^{1-\theta_H} \equiv \left[(1-\gamma) + \gamma TI_t^{\theta_H - 1}\right]\left[\pi_{H,t}\left(\frac{P_{H,t-1}}{P_{t-1}^C}\right)\right]^{1-\theta_H} \tag{A.10}$$

Finally, from the no-arbitrage condition in the goods market and the definition of terms of trade, we get the last relevant identity:

$$TI_t \equiv TI_{t-1}\frac{\pi_{H,t}}{\pi_{F,t}^*\left(\frac{e_t}{e_{t-1}}\right)} \tag{A.11}$$

Appendix B: Market equilibrium conditions

As a result of aggregating the budget constraint of the domestic economy -equation (11) of the main text- we obtain:

$$P_t^C C_t + P_t^D g_t^D + R_{t-1}^L B_{t-1} \leq B_t + W_t L_t + \Pi_t \tag{B.1}$$

Where Π_t are the aggregated benefits of the producers of non-durable intermediate goods and of the financial intermediaries, defined as:

$$\Pi_t = P_{H,t}(z)\int_0^n \left(\frac{P_{H,t}(z)}{P_{H,t}}\right)^{-\sigma_c} Y_t dz - W_t L_t + (R_t^L - R)B_t \tag{B.2}$$

Using the definition of $P_{H,t}$, given by equation (8) of the main text, the previous expression is simplified to:

$$\Pi_t = P_{H,t}Y_t - W_t L_t + (R_t^L - R)B_t \tag{B.3}$$

Replacing in the aggregate budget constraint, (B.1), we obtain:

$$\frac{P_{H,t}}{P_t^C}Y_t - C_t - \frac{P_t^D}{P_t^C}g_t^D = \frac{R_{t-1}^L B_{t-1}}{P_t^C} - \frac{B_t}{P_t^C} - \frac{(R_t^L - R)B_t}{P_t^C} \tag{B.4}$$

In equilibrium, the expenditure of domestic households in increasing the stock of durable goods is equal to the production of durable goods in period t .

$$g_t^D = Y_t^D \tag{B.5}$$

Replacing the previous condition in equation (B.4), we obtain:

$$\frac{P_{H,t}}{P_t^C}Y_t - C_t - \frac{P_t^D}{P_t^C}Y_t^D = \frac{R_{t-1}^L B_{t-1}}{P_t^C} - \frac{B_t}{P_t^C} - \frac{(R_t^L - R)B_t}{P_t^C} \tag{B.6}$$

Appendix C: Linear version of the model

The simulations and exercises presented in this document are made based on the linear version (log-linear approximation with respect to the steady state) of the model. To do this, we take a first order approximation of the efficiency conditions of consumer and firms problems around the steady state. The resulting set of equations has, as solution, a system of stochastic and in differences equations that link the endogenous variables of the model with the state variables. State variables can be shocks financial, productivity or external shocks- or lagged endogenous variables, such as the stock of durable goods of the previous period.

The model consists of 22 equations and 5 autoregressive processes that determine the evolution of the exogenous shocks[22] . Variables defined in lowercase correspond to the difference, in natural logarithms, between the variable in level with its steady state. That is: $x_t = lnX_t - ln\bar{X}$. Where variables with bars represent steady state variables.

The optimal consumption conditions of durable and non-durables, presented in equations (15) and (16) of the main text, take the following linear form:

[22] The 5 shocks included in the lineal model are: productivity shock, a_t, financial shock, v_t, external inflation shock, $\pi_{F,t}^*$, external demand shock, y_t^*, external interest rate shock, r_t^*.

$$p_t^D - p_t^C = \left(\frac{1-\psi}{\psi}\right)\left(\frac{\bar{C}-\varepsilon\bar{C}}{\frac{\bar{Y}^D}{\delta}}\right)\frac{\bar{P}^D}{\bar{P}^C}\left[\left(\frac{c_t-\varepsilon c_{t-1}}{1-\varepsilon}\right)-d_t\right]+\beta(1-\delta)\left[\frac{(c_t-\varepsilon c_{t-1})-E_t(c_{t+1}-\varepsilon c_t)}{1-\varepsilon}+E_t(p_{t+1}^D)-E_t(p_{t+1}^C)\right] \tag{C.1}$$

$$\varepsilon(c_t - c_{t-1}) = E_t(c_{t+1} - c_t) - (1-\varepsilon)\left(r_t^L - E_t(p_{t+1}^C - p_t^C)\right) \tag{C.2}$$

In turn, the optimal decision of labor supply defined in equation (17) of the main text, in linear terms is given by:

$$\varphi l_t = w_t - p_t^C - \left(\frac{c_t - \varepsilon c_{t-1}}{1-\varepsilon}\right) \tag{C.3}$$

From the production functions of non-durable and durable consumption goods, given by equations (45) and (19), we obtain the following linear versions:

$$y_t = a_t + l_t \tag{C.4}$$

$$y_t^D - d_{t-1} = \alpha(i_t - d_{t-1}) \tag{C.5}$$

On the other hand, as a result of the optimal decisions of production by non-durable goods firms, we obtain the following linear form of the Phillips curve described by the equations (50), (51) and (52):

$$\pi_{H,t} = \frac{(1-\omega)}{\omega}(v_t^n - v_t^d) \tag{C.6}$$

$$v_t^n = (1-\beta\omega)(cm_{H,t} + y_t) + \beta\omega\left(\sigma_c \pi_{H,t+1} + E_t(v_{t+1}^n)\right) \tag{C.7}$$

$$v_t^d = (1-\beta\omega)y_t + \beta\omega\left((\sigma_c - 1)\pi_{H,t+1} + E_t(v_{t+1}^d)\right) \tag{C.8}$$

Where the linear version of the definition of marginal costs in equation (46) is given by:

$$cm_{H,t} = w_t - p_{H,t} - a_t \tag{C.9}$$

Also, the linear version of the equation (20) of the main text, which determines the optimal price of firms producing durable goods, is given by:

$$p_t^D - p_t^C = \eta(i_t - d_{t-1}) \tag{C.10}$$

The identities presented in Appendix A in linear terms are:

$$q_t = -ti_t + p_{H,t} - p_t^C \tag{C.11}$$

$$p_{H,t} - p_t^C = \gamma \left(\frac{\bar{P}^C}{\bar{P}_H} \right)^{\theta_H - 1} ti_t \tag{C.12}$$

$$\pi_t^C = \pi_{H,t} + p_{H,t-1} - p_{t-1}^C - \gamma \left(\frac{\bar{P}^C \bar{T}\bar{I}}{\bar{P}_H} \right)^{\theta_H - 1} ti_t \tag{C.13}$$

$$ti_t^C = ti_{t-1} + \pi_{H,t} - \pi_{F,t}^* - e_t + e_{t-1} \tag{C.14}$$

The linear version of equation (43) that represents the aggregate output is given by:

$$y_t = -\theta_H[p_{H,t} - p_t^C] + \frac{(1-\gamma)[\bar{C}c_t + \bar{I}i_t] + \gamma \bar{Q}_H^{\theta} \bar{Y}^* (\theta_H q_t + y_t^*)}{(1-\gamma)(\bar{C} + \bar{I}) + \gamma \bar{Q}_H^{\theta} \bar{Y}^*} \tag{C.15}$$

The balance of payments (B.6) and the uncovered interest rate parity relation are expressed linearly as follows:

$$p_{H,t} - p_t^C + y_t = \frac{\bar{B}}{\bar{P}_H \bar{Y}} \left[\bar{R}^L (b_{t-1} + r_{t-1}^L - p_t^C) - b_t + p_t^C - \bar{R}^L (b_t + r_t^L - p_t^C) + \bar{R}(r_t + b_t - p_t^C) \right] + \frac{1}{\bar{P}_H \bar{Y}} \left[\bar{P}_C \bar{C} c_t + \bar{P}^D \bar{Y}^D (p_t^D - p_t^C + y_t^D) \right] \tag{C.16}$$

$$r_t = r_t^* + e_{t+1} - e_t \tag{C.17}$$

The linear version of the equation that defines the lending interest rate, equation (18) of the main text, is the following:

$$r_t^L = r_t + v_t + \kappa(b_t - p_t^D - d_t) + \tau_t \tag{C.18}$$

Where the macroprudential tool, equation (55) of the main text, in linear terms is:

$$\tau_t = (b_{t-1} - b_{t-2})\tau \tag{C.19}$$

The linear Taylor rule is:

$$r_t = \gamma^R r_{t-1} + (1-\gamma^R)\left[\gamma_\pi(p^C_{t-1} - p^C_{t-2}) + \gamma_y(y_{t-1} - y_{t-2}) + \gamma_B(b_{t-1} - b_{t-2})\right] \tag{C.20}$$

Where the value of the parameter γ_B will depend on the type of rule that is being evaluated.

Price inflation of the total consumption bundle is defined, linearly, as:

$$\pi^C_t = p^C_t - p^C_{t-1} \tag{C.21}$$

The dynamics of the stock of durable goods, equation (10) of the main text, takes the following linear form:

$$y^D_t = \frac{1}{\delta}(d_t - (1-\delta)d_{t-1}) \tag{C.22}$$

Finally, the 5 shocks affecting the economy, in linear terms, are:

$$a_t = \rho^1_a a_{t-1} + \rho^2_a a_{t-2} + \varepsilon^a_t \tag{C.23}$$

$$v_t = \rho^1_v v_{t-1} + \varepsilon^v_t \tag{C.24}$$

$$\pi^*_{F,t} = \rho^1_{\pi^*_F} \pi^*_{F,t-1} + \varepsilon^{\pi^*_F}_t \tag{C.25}$$

$$y^*_t = \rho^1_{y*} y^*_{t-1} + \rho^2_{y^*} y^*_{t-2} + \varepsilon^{y^*}_t \tag{C.26}$$

$$r^*_t = \rho^1_{r*} r^*_{t-1} + \rho^2_{r^*} r^*_{t-2} + \varepsilon^{r^*}_t \tag{C.27}$$

Appendix D: Model derivations

D.1 Steady State

From the Euler equation that defines the optimal dynamic of non-durable consumption by domestic households (equation (16) of the main text), we get the following steady-state value for the lending interest rate in the credit market:

$$\bar{R}^L = \frac{1}{\beta} \tag{D.1}$$

Similarly, from conditions (24) and (25) obtained from the optimization problem of foreign households, we obtain the following steady-state value of the monetary policy interest rate:

$$\bar{R} = \frac{1}{\beta} \tag{D.2}$$

On the other hand, assuming that terms of trade are equal to unity in steady state:

$$\bar{TI} = 1 \tag{D.3}$$

And therefore:

$$\bar{P}_H = \bar{P}_F \tag{D.4}$$

Using the identity (A.7) and the definition of the price index of non-durable goods, we obtain the following steady-state value for the real exchange rate:

$$\bar{Q} = 1 \tag{D.5}$$

Steady-state properties of the function $\phi(.)$ are the following:

$$\phi(\bar{I}^D/\bar{D}) = \bar{I}^D/\bar{D} \tag{D.6}$$

$$\phi'\left(\bar{I}^D/\bar{D}\right) = 1 \tag{D.7}$$

From these properties, using equation (19) that defines the production function of durables goods, we obtain:

$$\bar{Y}^D = \bar{I}^D \tag{D.8}$$

Using equation (10) which defines the dynamics of the stock of durable goods, we obtain:

$$\bar{I}^D = \delta \bar{D} \tag{D.9}$$

The condition that determines the optimal price of firms producing durable goods (20), in steady state implies:

$$\bar{P}^C = \bar{P}^D \tag{D.10}$$

From the definition of balance of payments and using the previous steady state relations, we obtain:

$$\frac{\bar{C} + \delta \bar{D}}{\bar{Y}} = 1 - \frac{\bar{B}}{\bar{P}^C \bar{Y}^H} \left(\frac{1-\beta}{\beta} \right) \tag{D.11}$$

Where the ratio of nominal credits to total product is calibrated at 0.6 in line with the empirical evidence for Peru, that is:

$$\frac{\bar{B}}{\bar{P}^C \bar{Y}^H} = 0.6 \tag{D.12}$$

From equation (15) of the main text we get the relationship between the stock of durable goods and the aggregate consumption of non-durables in steady state:

$$\bar{D} = \bar{C} \frac{(1-\psi)}{\psi} \frac{(1-\varepsilon)}{(1-\beta(1-\delta))} \tag{D.13}$$

Defining

$$\frac{\bar{C} + \delta \bar{D}}{\bar{Y}} = A \tag{D.14}$$

And replacing (D.14) in (D.13), we get:

$$\bar{C} = \bar{Y}A\left(1 + \frac{(1-\psi)}{\psi}\frac{(1-\varepsilon)\delta}{(1-\beta(1-\delta))}\right)^{-1} \tag{D.15}$$

In steady state, the technology shock is calibrated at one:

$$\bar{A} = 1 \tag{D.16}$$

Therefore, according to equation (45), the following is satisfied:

$$\bar{Y} = \bar{L} \tag{D.17}$$

From the definition of marginal cost (46) and from the optimal condition of labor supply, (17) we get:

$$Y^{-\varphi} = \frac{\psi}{\bar{C}(1-\varepsilon)}C\bar{M}_H \tag{D.18}$$

The three equations defining the Phillips curve (50), (51) and (52), derive in:

$$C\bar{M}_H = \frac{\sigma_c - 1}{\sigma_c} \tag{D.19}$$

Combining (D.15) with (D.18) and replacing the marginal cost in steady state (D.19), we obtain the value of total production in steady state:

$$Y = \left[\left(\frac{\psi}{1-\varepsilon}\right)\left(\frac{\sigma_c - 1}{\sigma_c}\right)\left(1 + \frac{(1-\psi)}{\psi}\frac{(1-\varepsilon)\delta}{(1-\beta(1-\delta))}\right)A^{-1}\right]^{\frac{1}{\varphi+1}} \tag{D.20}$$

Finally, from equation (43) evaluated at steady state, and from the relations obtained in this appendix, we get the steady state value of foreign product shock:

$$\bar{Y}^{*} = \bar{Y}\frac{(1-(1-\gamma)A)}{\gamma} \tag{D.21}$$

D.2 Derivation of the optimal consumption bundle

D.2.1 Derivation of $C_{H,t}$ and $C_{F,t}$ bundles

The consumer problem is to choose the consumption bundle $C_{H,t}$ and $C_{F,t}$ that minimize their expenditure, given the prices $P_{H,t}$ and $P_{F,t}$ and subject to the index of consumption C_t.

$$MinP_tC_t = P_{H,t}C_{H,t} + P_{F,t}C_{F,t} \tag{D.22}$$

Subject to:

$$C_t \equiv \left[(1-\gamma^H)^{1/\theta_H} C_{H,t}{}^{\frac{\theta_H-1}{\theta_H}} + (\gamma^H)^{1/\theta_H} C_{F,t}{}^{\frac{\theta_H-1}{\theta_H}}\right]^{\frac{\theta_H}{\theta_H-1}} \tag{D.23}$$

The Lagrangian associated with this problem is given by:

$$L = P_tC_t - \lambda_c \left\{ C_t - \left[(1-\gamma^H)^{1/\theta_H} C_{H,t}^{\frac{\theta_H-1}{\theta_H}} + \gamma^{H\frac{1}{\theta_H}} C_{F,t}^{\frac{\theta_H-1}{\theta_H}}\right]^{\frac{\theta_H}{\theta_H-1}} \right\} \tag{D.24}$$

Where λ_c is the Lagrange multiplier of this problem. The first order conditions with respect to $C_{H,t}$, $C_{F,t}$ and C_t are the following:

$$P_{H,t} = \lambda_c C_t{}^{\frac{1}{\theta_H}} (1-\gamma^H)^{\frac{1}{\theta_H}} C_{t,H}^{-\frac{1}{\theta_H}} \tag{D.25}$$

$$P_{F,t} = \lambda_c C_t{}^{\frac{1}{\theta_H}} (\gamma^H)^{\frac{1}{\theta_H}} C_{t,F}^{-\frac{1}{\theta_H}} \tag{D.26}$$

and

$$P_t = \lambda_c \tag{D.27}$$

Replacing λ_c and solving for $C_{H,t}$ and $C_{F,t}$ we get:

$$C_{H,t} = (1-\gamma^H)\left(\frac{P_{H,t}}{P_t^C}\right)^{-\theta_H} C_t \tag{D.28}$$

$$C_{F,t} = \gamma^H \left(\frac{P_{F,t}}{P_t^C} \right)^{-\theta_H} C_t \tag{D.29}$$

Demand functions are replaced in the index of consumption and we obtain the consumer price index:

$$P_t^C \equiv \left[(1-\gamma)(P_{H,t})^{1-\theta_H} + \gamma (P_{F,t})^{1-\theta_H} \right]^{\frac{1}{1-\theta_H}} \tag{D.30}$$

D.2.2 Derivation of $C_{H,t}(z)$ and $C_{F,t}(z)$ bundles

The consumer problem is to choose the consumption bundles $C_{H,t}(z)$ for $z \in [0, n]$ that minimizes expenditure, given the prices $P_{H,t}(z)$ and subject to the index of consumption $C_{H,t}$:

$$Min P_{H,t} C_{H,t} = \int_0^n P_{H,t}(z) C_{H,t}(z) dz \tag{D.31}$$

Subject to:

$$C_{H,t} \equiv \left[\left(\frac{1}{n} \right)^{\frac{1}{\sigma_c}} \int_0^n C_{H,t}(z)^{\frac{\sigma_c - 1}{\sigma_c}} dz \right]^{\frac{\sigma_c}{\sigma_c - 1}} \tag{D.32}$$

The Lagrangian of this problem is:

$$L = P_{H,t} C_{H,t} - \lambda_{C_H} \left\{ C_{H,t} - \left[\left(\frac{1}{n} \right)^{\frac{1}{\sigma_c}} \int_0^n C_{H,t}(z)^{\frac{\sigma_c - 1}{\sigma_c}} dz \right]^{\frac{\sigma_c}{\sigma_c - 1}} \right\} \tag{D.33}$$

Where λ_{C_H} is the Lagrange multiplier of this problem. The first order conditions with respect to each one of the goods $C_{H,t}(z)$ is:

$$P_{H,t}(z) = \lambda_{C_H} C_{H,t}^{\frac{1}{\sigma_c}} (1/n)^{\frac{1}{\sigma_c}} C_{H,t}(z)^{\frac{1}{\sigma_c}} \tag{D.34}$$

While the first order condition associated with the index of domestic consumption, $C_{H,t}$, is:

$$P_{H,t} = \lambda_{C_H} \tag{D.35}$$

Replacing this equation into (D.30) and solving for $C_{H,t}(z)$, we obtain:

$$C_{H,t}(z) = \frac{1}{n}\left(\frac{P_{H,t}(z)}{P_{H,t}}\right)^{-\sigma_c} C_{H,t} \tag{D.36}$$

This condition is replaced in the index of domestic consumption and we get the following index of domestic prices:

$$P_{H,t} \equiv \left[\frac{1}{n}\int_0^n P_{H,t}(z)^{1-\sigma_c} dz\right]^{\frac{1}{1-\sigma_c}} \tag{D.37}$$

Similarly, the problem is solved for $C_{F,t}(z)$, and we obtain the corresponding demand function:

$$C_{F,t}(z) = \frac{1}{1-n}\left(\frac{P_{F,t}(z)}{P_{F,t}}\right)^{-\sigma_c} C_{F,t} \tag{D.38}$$

And the index of import prices is:

$$P_{F,t} \equiv \left[\frac{1}{1-n}\int_n^1 P_{F,t}(z)^{1-\sigma_c} dz\right]^{\frac{1}{1-\sigma_c}} \tag{D.39}$$

Replacing equations (D.26) in (D.32) and (D.27) in (D.34), we get equations [5] and [6] of the main text:

$$C_{H,t}(z) = \frac{1}{n}(1-\gamma^H)\left(\frac{P_{H,t}(z)}{P_{H,t}}\right)^{-\sigma_c}\left(\frac{P_{H,t}}{P_t^c}\right)^{-\theta_H} C_t \tag{D.40}$$

$$C_{F,t}(z) = \frac{1}{1-n}\gamma^H\left(\frac{P_{F,t}(z)}{P_{F,t}}\right)^{-\sigma_c}\left(\frac{P_{F,t}}{P_t^c}\right)^{-\theta_H} C_t \tag{D.41}$$

D.2.3 Derivation of the demand for z, $Y_t(z)$

Using the no-arbitrage condition in the goods market, given by (A.3) and (A.4) and the definition of the real exchange rate, (A.1), equation (41) of the main text can be expressed as:

$$Y^*_{H,t}(z) = \gamma^* \left(\frac{P_{H,t}(z)}{P_{H,t}}\right)^{-\sigma_c} \left(\frac{P_{H,t}}{P^C_t}\right)^{-\theta_H} Q^\theta_H Y^*_t \tag{D.42}$$

Thus, total demand for type z good produced domestically is given by:

$$Y_t(z) = Y_{H,t}(z) + Y^*_{H,t}(z) = \left(\frac{P_{H,t}(z)}{P_{H,t}}\right)^{-\sigma_c} \left(\frac{P_{H,t}}{P^C_t}\right)^{-\theta_H} \left[(1-\gamma)(C_t + I_t) + \gamma Q^{\theta_H} Y^*_t\right] \tag{D.43}$$

If we define:

$$Y_t = \left(\frac{P_{H,t}}{P^C_t}\right)^{-\theta_H} [(1-\gamma)(C_t + I_t) + \gamma Q^\theta_H Y^*_t] \tag{D.44}$$

equation (44) of the main text is obtained:

$$Y_t(z) = \left(\frac{P_{H,t}(z)}{P_{H,t}}\right)^{-\sigma_c} Y_t \tag{D.45}$$