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Abstract

Financial intermediation and bank spreads are important elements in the analysis of business cycle transmission and monetary policy. We present a simple framework that introduces lending relationships, a relevant feature of financial intermediation that has been so far neglected in the monetary economics literature, into a dynamic stochastic general equilibrium model with staggered prices and cost channels. Our main findings are: (i) banking spreads move countercyclically generating amplified output responses, (ii) spread movements are important for monetary policy making even when a standard Taylor Rule is employed (iii) modifying the policy rule to include a banking spread adjustment improves stabilization of shocks and increases welfare when compared to rules that only respond to output gap and inflation, and finally (iv) the presence of strong lending relationships in the banking sector can lead to indeterminacy of equilibrium forcing the central bank to react to spread movements.

JEL Codes: E44, E52, G21
Keyword: Endogenous Banking Spread, Credit Markets, Cost Channel of Monetary Transmission, Lending Relationships

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1. Introduction

Currently, there is a revived interest in the impact of imperfect credit markets on business cycles and monetary policy analysis. There are three main approaches in the existing literature. The first approach focuses on the inclusion of a banking sector that produces loans and deposits, following Goodfriend and McCallum (2007). The second approach focuses on the costly state verification of Bernanke, Gertler, and Gilchrist (1999) and Carlstrom and Fuerst (1997). The third approach, the closest to ours, looks at introducing imperfect competition in the banking sector, either building on the Salop circular model (Andres and Arce (2009) and Andres, Arce, and Thomas (2010)) or exploring entry and exit into niche markets (Mandelman (2010)). To the best of our knowledge, monetary policy implications of the market power in financial intermediation that takes the form of relationship lending has received only limited attention.

Lending relationships are directly aimed at resolving problems of asymmetric information as identified by Diamond (1984). In order to obtain better borrowing terms a firm might find optimal to reveal to its bank proprietary information that is not available to the financial market at large. Banks will have the incentive to invest in acquiring information about a borrower in order to build a lasting and profitable association. That way, the information flow between banks and firms improve, increasing the added value of a lending relationship (see amongst others, Boot (2000) and Petersen and Rajan (1994)). On the other hand, as pointed by Rajan (1992), such relationships also have a (hold-up) cost. After a relationship is formed banks gain an information monopoly that increases their bargaining power over firms. Santos and Winton (2008), using data from the US credit market, show that banking spreads can increase up to 95 basis points in a recession due to the fact that banks exploit this informational advantage after relationships are formed. Hence, banking spread movements driven by the existence of these relationships are significant and add to the "bank channel" effect of business cycle transmission and monetary policy. Figure 1 shows the loan spread to federal fund rate in the US. It is clear that spreads tend to increase sharply during recessions (1991, 2001 and 2007). Although the loan spreads in the survey includes both banking and credit spreads, by using the same dataset, Aliaga-Diaz and Olivero (2011) show that the evidence of countercyclical banking spreads remains when credit spread changes are controlled for.

[**Insert Figure 1 about here**]

The hold-up or locked-in problem is also emphasized by the European Commission report on the banking sector (European Commission (2007)). They conclude that competition problems within the industry are exacerbated as a result of information asymmetries between banks and their customers, which contribute to increasing switching costs. Furthermore, studies based on micro data point to a strong presence of lending relationships. For instance, Kim, Kliger, and Vale (2003) report that the duration of a lending relationship in Norway is about 13.5 years; Angelini, Di Salvo, and Ferri (1998), focusing on Italy, find an average duration of 14 years; Petersen and Rajan (1994) estimate an average duration of 11 years for the US, and Degryse and Van Cayseele (2000) obtain an average duration of 7.8 years for Belgium. See also Degryse and Ongena (2008) and references therein for a survey of further empirical evidence of the positive link between lending relationships and banking spreads and profits.[1]

The primary objective of the present paper is to understand the implications of lending relationships on credit market outcomes, economic activity and particularly on monetary policy making. We therefore develop a parsimonious model that captures this key credit market channel in an otherwise standard New Keynesian model with investment. We introduce endogenous banking spreads determined by the banks' profit margin which in turn is determined by the strength of lending relationships. Firms must borrow to pay for the capital input and salaries, thus they are subject to cost channels of monetary transmission. Therefore, our model incorporates a bank channel or cost channel as in Ravenna and Walsh (2006) and Christiano, Eichenbaum, and Evans (2005), however, these models assume perfect competition and hence, the bank interest rate is equal to the Central Bank base rate. We assume that each firm selects a set of banks to acquire loans with an inherent preference to continue borrowing from those banks that issued loans in the previous period. This preference introduces an implicit switching cost, reflecting informational asymmetries with other lenders/borrowers. We do not explicitly formalize the hold-up problem. We model lending relationships by adopting Ravn, Schmitt-Grohe, and Uribe's (2006) "deep habits". Lending relationships, thus, imply that a fraction of loan demand is inelastic and determined by the previous loan share of banks. Note that,

[1] Note that we use the terms 'banking spread' and 'banking mark-up' interchangeably throughout the paper.

in a parallel research to ours, Aliaga-Diaz and Olivero (2010) study a real business cycle model and incorporate lending relationships based on deep habits similar to the one presented here. They establish that countercyclical bank profit margins amplify the impact of productivity shocks. In the current paper, however, we study implications of lending relationships for the analysis of the monetary policy, focusing particularly on the impact of endogenous markup on interest rate setting, Taylor Rules and the indeterminacy properties of the augmented New Keynesian model.

In line with the empirical evidence presented by Santos and Winton (2008), Aliaga-Diaz and Olivero (2011) and Mandelman (2006), our model generates countercyclical banking spreads due to the existence of lending relationships. When output and loan demand are high, banks are willing to decrease the banking spread to form as many relationships as possible. That reflects the fact that banks recognize that higher current demand leads to higher future loan demand. However, as output decreases, banks exploit the relationships already formed by increasing the profit margin, therefore increasing banking spreads. We show that the cyclical properties of banking spreads lead to three main results.

First, given an initial shock that reduces output, banking spreads tend to increase. Loan interest rates, which are part of the firm's current marginal and capital investment costs, also increase. As a result, investment and total production decrease further leading to an amplification of the output response. This result is similar in nature to the financial accelerator proposed by Bernanke, Gertler, and Gilchrist (1999). In our model, the amplification arises due to lending relationships, particularly via investment finance, while in Bernanke, Gertler, and Gilchrist (1999) this arises due to movements in firms' net worth.

Second, our analysis sheds light on the effects of endogenous banking spreads on monetary policymaking. We initially assume that the Central Bank base rate only responds to inflation and output, employing a standard Taylor Rule. Although not directly, the base rate responds to spread changes given its impact on output and inflation. To show this, we compare the propagation of different shocks in our model with respect to a case with a constant spread. For instance, we find that, in the case of an inflation shock, the spread increases by around 100 basis points. Here, the base rate response is about 50 basis points lower compared to the model with constant spreads. The policymaker, being aware of potential movements in the banking spread, will react to the shock with a

subdued response, as spread movements reinforce the effects of monetary policy. Therefore, our results are in line with the literature on banking and monetary policy (see Goodfriend and McCallum (2007)). We hence conclude that ignoring the effects of banking sector characteristics on monetary policy could lead to sub-optimal policy responses. Following Taylor (2008) we verify whether a spread-adjusted monetary policy improves stabilization. We find that responding directly to spread movements may curb the output amplification observed in the presence of lending relationships without increasing inflationary pressures. We also show that when banking spreads are endogenous, the policymaker's response to spread movements leads to an improvement in welfare.

Third, the stronger the lending relationships, the higher the banking spread response will be to an initial shock in output and loan demand. Higher banking spreads further dampen loan demand, leading to a new round of banking spread adjustments. If banking spreads are volatile enough, the economy does not have a unique local rational expectations equilibrium. This feature is directly related to the fact banks react not only to current but also to expected future evolution of the loan demand. We argue that self fulfilling prophecies are possible since interest rates in the economy are affected by the future evolution of loan demand. However, the Central Bank could avoid the indeterminacy problem by implementing a spread-adjusted Taylor Rule to offset the destabilizing effects of endogenous banking spread. In other words, if sharp banking spread changes are matched by base rate cuts, the final loan interest rate does not increase as much and the output-banking spread spiral that leads to indeterminacy does not occur. This result indicates that not only stabilization but also determinacy should be a concern for monetary policy in economies where competition in the banking sector is imperfect and lending relationships are present.

As mentioned earlier, there is a recently growing literature on novel ways of introducing imperfect competition in the banking sector into a standard New Keynesian framework. A recent interesting paper by Andres and Arce (2009), for instance, develops a model with monopoly power in the loans market in the spirit of the Salop circular model. They are able to replicate countercyclical spreads, although their main focus is on the effect of banking competition on collateral and house prices. Another interesting paper is the one by Mandelman (2010). He develops a DSGE model with entry and exit in the banking sector that allows for sustainable collusive loan rate increases (decreases) during recessions (booms). This collusive behavior magnifies the financial accelerator impact

of shocks next to balance sheet channels. The mechanism, however, relies on entry and exit, which although relevant in emerging markets, might not be as significant in more stable banking markets where sizeable market shares are held by larger financial institutions. Finally, Hulsewig, Mayer, and Wollmershuser (2007) and Teranishi (2008) also focus on the characteristics of the banking sector on a model of cost channel similar to ours. However, their main assumption is that loan contracts are changed in a staggered fashion. Without further complications this type of models are not able to generate countercyclical banking mark-ups.

The paper's outline is as follows. Section 2 presents the model. In section 3 we begin by presenting the equilibrium conditions and then focus on the linearized system of equations and the parameters used in the numerical analysis. Section 4 presents the model's main dynamic properties and the results of our policy experiments. Section 5 considers the determinacy properties of our model economy. Finally, Section 6 concludes.

2. Model

The economy consists of a representative household, a representative final good firm, a continuum of intermediate good firms $i \in [0,1]$, a continuum of banks $j \in [0,1]$ and a Central Bank.

2.1 Households

The household maximizes the discounted lifetime utility given by

$$\max_{C_t, M_{t+1}, D_t, H_t,} E_t \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \chi \frac{H_t^{1+\eta}}{1+\eta} \right), \quad \beta \in (0,1) \quad \sigma,\ \eta > 0 \tag{1}$$

where C_t denotes the household's total consumption and H_t denotes hours worked. The curvature parameters σ, η are strictly positive. β is the discount factor. The household faces the following budget and cash in advance constraints

$$C_t + \frac{D_t}{P_t} + \frac{M_{t+1}^d}{P_t} \leqslant \frac{W_t H_t}{P_t} + \frac{R_{t,CB} D_t}{P_t} + \frac{M_t}{P_t} + \frac{\int_0^1 \Pi_{i,t} di}{P_t} + \frac{\int_0^1 \Pi_{t,j}^B dj}{P_t} \tag{2}$$

$$C_t + \frac{D_t}{P_t} \leqslant \frac{M_t}{P_t} + \frac{W_t}{P_t} H_t \tag{3}$$

where M^d_{t+1} are money holdings carried over to period $t+1$, $\int_0^1 \Pi_{i,t} di$ represents dividends accrued from the intermediate producers to households, $\int_0^1 \Pi^B_{t,j} di$ represents profits of the banks accrued to the household, and finally $R_{t,CB}$ is the rate of return on deposits D_t. We assume the Central Bank sets $R_{t,CB}$ directly according to a monetary policy rule to be specified. Although not modeled here, this is equivalent to allowing households to buy government assets, which pay a return rate equal to $R_{t,CB}$, as well as making bank deposits. Assuming no arbitrage conditions, the deposit rate would be equal to $R_{t,CB}$.

The cash-in-advance constraint imposes the condition that the household needs to allocate money balances and labour earnings for consumption net of the deposits it has decided to allocate to the financial intermediary. This specification implies that the labour supply is not affected by real balances (see Christiano and Eichenbaum (1992)). Another important assumption regards the timing of deposits, which affects the evolution of consumption. We assume deposits are paid back in the same period (intra-period deposits) in order to avoid real balance frictions related to consumption in the money market.

2.2 Firms

The final good representative firm produces goods combining a continuum of intermediate goods $i \in [0,1]$ with the following production function

$$Y_t = \left[\int_0^1 y_{i,t}^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}. \tag{4}$$

As standard this implies a demand function given by

$$y_{i,t} = \left(\frac{P_{it}}{P_t} \right)^{-\varepsilon} Y_t, \tag{5}$$

where the aggregate price level is

$$P_t = \left[\int_0^1 P_{i,t}^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}. \tag{6}$$

The intermediate sector is composed of a continuum of firms $i \in [0,1]$ producing differentiated goods with the following constant returns to scale production function

$$y_{i,t} = K_{i,t}^{\alpha} H_{i,t}^{1-\alpha}, \tag{7}$$

where K_i is the capital stock and H_i is the labour used in production. Each firm hires labour and invests in capital. It is assumed that the firm must borrow money to pay for these expenses.

To characterize the problem of intermediate firms, we split their decision into a pricing decision given their real marginal cost, the production decision to minimize costs and a financial decision of allocation of bank loans.

Following the standard Calvo pricing scheme, firm i, when allowed, sets prices $P_{i,t}$ according to

$$\max_{P_{i,t}} E_t \left\{ \sum_{s=0}^{\infty} P_{t+s} Q_{t,t+s} \omega^s y_{i,t+s} \left[\frac{P_{i,t}}{P_{t+s}} - \Lambda_{t+s,i} \right] \right\}, \tag{8}$$

subject to the demand function (5), where $Q_{t,t+s}$ is the economy's stochastic discount factor, defined in the next section and $\Lambda_{t+s,i}$ is the firm's i real marginal cost at time $t+s$. To obtain the real marginal cost, we need to solve the firm's intertemporal cost minimization problem. That is

$$\min_{K_{i,t+1}, H_{i,t}} E_t \left\{ \sum_{t=0}^{\infty} Q_{0,t} \left(R_{t,i} W_t H_{i,t} + R_{t,i} P_t I_{i,t} \right) \right\}, \tag{9}$$

subject to the production function (7) and investment equation $I_{i,t} = K_{i,t+1} - (1 - \delta) K_{i,t}$; where W_t is the nominal wage, and $R_{i,t}$ the index of rates charged by the banks in the economy for the loan made by firm i in period t, to be paid in $t+1$. Finally, $P_t \Lambda_{t,i}$ is the multiplier of the constraint (7).

Expression $R_{t,i} W_t H_{i,t} + R_{t,i} P_t I_{i,t}$ in the cost minimization problem characterizes the costs of firms given that they need to borrow to finance wage and investment payments[2]. The model incorporates the cost channel of labour and investment: marginal costs of the firms are affected by the banks interest rate. Although cost channels are not a basic feature of New Keynesian models, the labour cost channel has been introduced by, amongst others, Christiano, Eichenbaum, and Evans (2005) and Ravenna and Walsh (2006), while all costly state verification models, e.g. Bernanke, Gertler, and Gilchrist (1999), assume cost channel on investment. Ravenna and Walsh (2006) and Barth and Ramey (2001) present corroborating econometric evidence for the direct (costly) influence of monetary policy on the U.S. inflation adjustment equation. Furthermore, Mayer and

[2] In Aksoy, Basso, and Coto-Martinez (2011), we considered a NKM to study the transmission of the monetary policy through the labour and capital cost channel, our results are robust to altering the intensity of one or both transmission channels.

Sussman (2004) report empirical evidence that US firms rely on debt relative to equity in financing investment implying the presence of investment cost channel in monetary transmission.

The firm takes loans to pay for production costs, thus the loan payment clearing condition is given by

$$\int_0^1 R_{t,i,j} L_{t,i,j} dj = R_{t,i} W_t H_{i,t} + R_{t,i} P_t I_{i,t}. \tag{10}$$

The financial department of the firm decides how to raise the total funds needed to pay the production costs from the continuum of banks $j \in [0,1]$[3]. We assume the firm establishes relationships with the banks that have issued loans to the firm in the previous period. Although we do not explicitly model the benefits of a relationship, a simple way of motivating them is the potential reduction in the cost of providing information for bank credit ratings (see Boot (2000))[4]. In order to formally incorporate this relationship that translates into a bank switching cost in a simple way, we follow Ravn, Schmitt-Grohe, and Uribe (2006) and assume the financial part of the firm cares about a measure $X_{t,i}$ of loans given by[5]

$$X_{t,i} = \left[\int_0^1 \left(L_{t,i,j} - \theta L_{t-1,j} \right)^{1-\frac{1}{\varrho}} dj \right]^{\frac{1}{1-\frac{1}{\varrho}}}. \qquad 0 < \theta < 1$$

The problem of the financial department of the firm is

$$\begin{aligned} \min_{L_{t,i,j}} \quad & \int_0^1 R_{t,i,j} L_{t,i,j} dj \\ s.t. \quad & \left[\int_0^1 \left(L_{t,i,j} - \theta L_{t-1,j} \right)^{1-\frac{1}{\varrho}} dj \right]^{\frac{1}{1-\frac{1}{\varrho}}} = X_{t,i}. \end{aligned}$$

As standard the interest rate index of the loans made by the firm across all banks j

[3]Note that we could assume that each firm i borrows from a fraction $[\xi_i, \vartheta_i]$ of banks. Results would remain the same given that there are infinite firms and banks in the continuum $[0,1]$.

[4]Here, we follow rich evidence provided by Detragiache, Garella, and Guiso (2000) and references therein, that show that there is strong evidence of multiple lending relationships.

[5]Note that an alternative and perhaps more intuitive measure would be to consider $X_{t,i} = \left[\int_0^1 \left(L_{t,i,j} - \theta L_{t-1,i,j} \right)^{1-\frac{1}{\varrho}} dj \right]^{\frac{1}{1-\frac{1}{\varrho}}}$. In that case equation (11) becomes $L_{t,i,j} = \left(\frac{\sum_{K=0}^{\infty} \theta^k E_t [Q_{t,t+k} R_{t+k,i,j}]}{\left[\int_0^1 \left(\sum_{K=0}^{\infty} \theta^k E_t [Q_{t,t+k} R_{t+k,i,j}] \right)^{1-\varrho} \right]^{1/(1-\varrho)}} \right)^{-\varrho} X_{t,i} + \theta L_{t-1,i,j}$. That would imply the bank problem, to be explained next, is not recursive, thus the loan interest rate decision would not be time consistent (see Ravn, Schmitt-Grohe, and Uribe (2006) for more details). We present the solution for both the discretionary and the full commitment cases in the a technical appendix available from the authors upon request.

is given by $R_{t,i} = \left[\int_0^1 (R_{t,i,j})^{1-\varrho}\, dj\right]^{\frac{1}{1-\varrho}}$. Using this definition we have that the demand for loans from firm i to bank j is given by

$$L_{t,i,j} = \left(\frac{R_{t,i,j}}{R_{t,i}}\right)^{-\varrho} X_{t,i} + \theta L_{t-1,j}. \tag{11}$$

Similar in nature to Ravn, Schmitt-Grohe, and Uribe (2006), the parameter θ determines how relevant the previous level of loans are to determine the current demand of loans for each bank j, altering the interest rate elasticity of credit demand[6]. Under a standard switching cost framework, loan demand is interest rate insensitive as long as the increase in cost does not trigger a switch, or the interest rate move is within a threshold. From equation (11) we observe that a higher θ implies that a higher portion of the demand is interest rate insensitive, independent of the interest rate move, thus reproducing a case of greater switching costs (a wider threshold). Note that the condition above also implies that $R_{t,i}X_{t,i} = \int_0^1 R_{t,i,j}\left(L_{t,i,j} - \theta L_{t-1,j}\right) dj$. Rearranging and using the loan payment clearing condition we have that

$$\int_0^1 \frac{R_{t,i,j}}{R_{t,i}} L_{t,i,j} = X_{t,i} + \theta \int_0^1 \frac{R_{t,i,j}}{R_{t,i}} L_{t-1,j} dj = W_t H_{i,t} + P_t I_{i,t}. \tag{12}$$

2.3 Banking Sector

Each bank $j \in [0,1]$ gets deposits from the household and lends money to the each firm i in the form of loans $(L_{t,i,j})$. The rate on deposits is the short term rate set by the Central Bank $R_{t,CB}$. Bank j nominal profits, which are part of the household budget constraint, are given by

$$\Pi^B_{t,j} = R_{t,j} L_{t,j} - R_{t,CB} D_{t,j},$$

where $R_{t,j} = R_{t,i,j}$, $L_{t,j} = \int_0^1 (L_{t,i,j})\, di$.

The balance sheet clearing condition implies $L_{t,j} = D_{t,j}$. Let the bank's j spread be

[6] As a referee pointed out the assumption of monopolistic competition may be unrealistic, as this requires a large number of banks. For reasons of parsimony, we don't consider strategic effects that may arise when the number of banks in the economy is small. (See for instance evidence presented in Farinha and Santos (2002) who show that about 70 percent of firms have only one lending relationship and 96 percent have relationships with no more than three banks in Portugal. Petersen and Rajan (1994) report similar results for the US.) Although these strategic effects may be important, and we aim at incorporating them in future research, the simple framework here under monopolistic competition allows us to study the impact of the hold-up cost on the macroeconomy. As discussed by Degryse and Ongena (2008) this cost is a key consequence of lending relationships.

given by $\mu_{t,j} = \frac{R_{t,j}}{R_{t,CB}}$, and let the average spread of the banking sector be $\mu_t = \frac{R_t}{R_{t,CB}}$, where $R_t = \int_0^1 (R_{t,i})\, di$. Profits then become

$$\Pi^B_{t,j} = (R_{t,j} - R_{t,CB})\, L_{t,j} = (\mu_{t,j} - 1)\, L_{t,j} R_{t,CB} = \frac{(\mu_{t,j} - 1)}{\mu_t} L_{t,j} R_t.$$

Bank's j problem, therefore, is to maximize profits subject to the demand constraint, which, considering all firms are equal, is given by $L_{t,j} = \left(\frac{R_{t,j}}{R_t}\right)^{-\varrho} X_t + \theta L_{t-1,j}$. We also assume that banks and households discount the future in the same way. Formally,

$$\max_{\mu_{t,j}, L_{t,i,j}} \Pi^B_{t,j} = E_t \sum_{t=0}^{\infty} Q_{0,t} \left\{ \frac{(\mu_{t,j} - 1)}{\mu_t} L_{t,j} R_t + \nu_t \left[\left(\frac{\mu_{t,j}}{\mu_t} \right)^{-\varrho} X_t + \theta L_{t-1,j} - L_{t,j} \right] \right\}.$$

3. Equilibrium

The equilibrium of the economy is defined as the vector of Lagrange multipliers $\{\nu_t, \Lambda_t\}$, the allocation set $\{C_t, H_t, K_{t+1}, L_t, M_{t+1}, Y_t, D_t\}$, and the vector of prices $\{P_{i,t},\ P_t,\ W_t,\ \mu_{t,j}\}$ such that the household, the final good firm, intermediate firms and banks maximization problems are solved, and the market clearing conditions hold.

The consumer problem is represented by the following first order conditions

$$\beta E_t \left(\frac{R_{t,CB} C_{t+1}^{-\sigma}}{\pi_{t+1}} \right) = C_t^{-\sigma} \tag{13}$$

$$\frac{\chi H_t^{\eta}}{C_t^{-\sigma}} = \frac{W_t}{P_t}. \tag{14}$$

Where $\pi_{t+1} = P_{t+1}/P_t$. The goods market clearing condition is given by

$$Y_t = C_t + I_t. \tag{15}$$

The capital and labour market clearing condition are given by

$$K_t = \int_0^1 K_{i,t} di \text{ and } H_t = \int_0^1 H_{i,t} di. \tag{16}$$

Using the conditions above, investment evolves according to

$$I_t = K_{t+1} - (1 - \delta) K_t. \tag{17}$$

Since the households own the firms and banks and receive their profits/dividends we use the consumption Euler equation and set the nominal discount factor (or the pricing kernel) to be the ratio of the marginal utilities adjusted to inflation (the real discount factor to firms and banks is therefore equal to the ratio of marginal utilities). Therefore, we can write

$$Q_{t,t+1} = \beta E_t \left(\frac{C_{t+1}^{-\sigma}}{\pi_{t+1} C_t^{-\sigma}} \right) = \frac{1}{R_{CB,t}}.$$

Given that the purpose of our analysis is not to look at the effects of firm-specific capital, we assume that there exist capital markets within firms. As firms must borrow to invest in newly produced capital, the price of capital in this market is $R_t P_t$. That way all firms will have the same labour-capital ratio and $\Lambda_{t,i} = \Lambda_t$ for all i, as in the case where a capital rental market is available. The net aggregate investment in (new) capital is then acquired from the final good producer. Note that, as shown by Woodford (2005) and Sveen and Weinke (2007), the relevant difference of considering firm-specific capital is that the parameter κ in the Phillips curve (equation (26d)) would be lower, increasing price stickiness. Our results are not qualitatively affected by this change[7].

Based on that, the price setting equation is given by solving (8), substituting for the stochastic discount factor and using $\Lambda_{t+s,i} = \Lambda_{t+s}$. That gives

$$p_{i,t} = \frac{\varepsilon}{\varepsilon - 1} \frac{E_t \left\{ \sum_{s=0}^{\infty} \frac{C_{t+s}^{-\sigma}}{C_t^{-\sigma}} (\omega\beta)^s \Lambda_{t+s} Y_{t+s} \left(\prod_{k=1}^{s} \pi_{t+k} \right)^{\varepsilon} \right\}}{E_t \left\{ \sum_{s=0}^{\infty} \frac{C_{t+s}^{-\sigma}}{C_t^{-\sigma}} (\omega\beta)^s Y_{t+s} \left(\prod_{k=1}^{s} \pi_{t+k} \right)^{\varepsilon - 1} \right\}}, \tag{18}$$

where, $p_{i,t} = P_{i,t}/P_t$ and

$$1 = (1 - \omega) p_{i,t}^{1-\varepsilon} + \omega \pi_t^{\varepsilon - 1}. \tag{19}$$

From the firm cost minimization problem, we obtain the demand for capital and labour. After rearranging the first order conditions and substituting for the stochastic discount factor $Q_{t,t+1}$, we obtain the following equilibrium conditions[8]

[7] The derivation and simulation results are presented in a separate note available from the authors upon request.

[8] Once again we have used the fact that marginal costs are the same across firms.

$$\Lambda_t = \frac{R_t W_t H_t}{P_t Y_t (1-\alpha)} \tag{20}$$

$$R_t = E_t \left\{ \frac{\pi_{t+1}}{R_{CB,t}} \left[\Lambda_{t+1} \frac{\alpha Y_{t+1}}{K_{t+1}} + (1-\delta) R_{t+1} \right] \right\} . \tag{21}$$

As conditions (20) and (21) reveal, when both cost channels of labour and investment are present, the real marginal costs of the firm will be a function of both current and future expected short term rates.

The bank spread is determined by profit margin, using the banks first order conditions and credit market conditions at the symmetric equilibrium, and letting $l_t = L_t/P_t$ we obtain

$$l_t R_t = \varrho \nu_t (l_t - \theta \frac{l_{t-1}}{\pi_t}), \tag{22}$$

$$\nu_t = \frac{(\mu_t - 1)}{\mu_t} R_t + E_t \left[\frac{\theta \nu_{t+1}}{R_{t,CB}} \right], \tag{23}$$

$$l_t = \frac{W_t H_t}{P_t} + I_t. \tag{24}$$

Equation (23) exhibits the effects of lending relationships onto the loan interest rate decision. The Lagrange multiplier on the loan demand equation, ν_t, is equal to the bank's marginal gain to an extra unit of loan demand. Given that $\theta > 0$, then an extra unit of demand today increases profits due to the current period gain (first term) and the discounted future period gains from the additional relationships formed today (second term). Using equations (23) and (22), we obtain an expression for profit margins

$$\frac{R_t - R_{t,CB}}{R_{t,CB}} = \frac{(\mu_t - 1)}{\mu_t} = \frac{l_t}{\varrho \left(l_t - \theta \frac{l_{t-1}}{\pi_t} \right)} - \frac{1}{R_t} E_t \left[\frac{\theta \nu_{t+1}}{R_{t,CB}} \right]. \tag{25}$$

Therefore, the profit margin of the banks is determined by two forces, one being the elasticity of the current loan demand and the other being the dynamic effect arising due to expected leading relationships. The first part of expression (25) describes the effects of existing lending relationships on the profit margin. The elasticity of demand is determined by ϱ (the elasticity of substitution across lenders) and the evolution of demand for loans given by $\frac{l_t}{(l_t - \theta \frac{l_{t-1}}{\pi_t})}$. If the past demand for credit was high, the bank can exploit those existing relationships to increase profit margins, that is, the demand

becomes highly inelastic. The second part of expression (25), $\frac{1}{R_t} E_t \left[\frac{\theta \nu_{t+1}}{R_{t,CB}} \right]$, describes dynamic effects due to expected profits from forming new lending relationships. The bank will increase the banking spread when its effect on the current marginal gain (positive) is greater than the effect on the future marginal gain (negative, due to the decrease in the number of future relationships), and decrease it otherwise. Although the introduction of banking relationships in our model is done in a reduced form, this trade-off faced by the bank highlights the main characteristics of relationship lending. On the one hand, banks will decrease rates to attract more firms, thus firms have a benefit by entering in a long-term agreement. On the other hand, firms might face higher spreads in the future due to the hold up costs when the bank's incentive to form relationships diminishes. In the Appendix we present a simple asymmetric information model that delivers equivalent expressions for profit margins, emphasizing that asymmetric information in loan markets is able to generate forward looking behavior in bank mark-ups. We stress that the forward looking behavior in mark-ups has nontrivial implications not only for macroeconomic outcomes but also for economic stability.

3.1 The Linearized Model

The linear model for the set of variables $\left\{ \widehat{c}_t, \widehat{r}_t, \widehat{\Lambda}_t, \widehat{y}_t, \widehat{\pi}_t, \widehat{i}_t, \widehat{k}_{t+1}, \widehat{h}_t, \widehat{l}_t, \widehat{\nu}_t, \widehat{r}_{CB,t}, \widehat{\mu}_t \right\}$ is summarized as follows

$$\widehat{c}_t = E_t\left(\widehat{c}_{t+1}\right) - \frac{1}{\sigma} E_t\left[\widehat{r}_{t,CB} - \widehat{\pi}_{t+1}\right] \tag{26a}$$

$$\widehat{r}_t = -\widehat{r}_{t,CB} + \widehat{\pi}_{t+1} \tag{26b}$$

$$+(1-\beta(1-\delta))E_t\left[\widehat{y}_{t+1} + \widehat{\Lambda}_{t+1} - \widehat{k}_{t+1}\right] + \beta\left(1-\delta\right)E_t\left(\widehat{r}_{t+1}\right)$$

$$\widehat{\Lambda}_t = \widehat{r}_t + (1+\eta)\,\widehat{h}_t + \sigma\widehat{c}_t - y_t \tag{26c}$$

$$\widehat{\pi}_t = \beta E_t\left(\widehat{\pi}_{t+1}\right) + \kappa\widehat{\Lambda}_t \tag{26d}$$

$$\widehat{y}_t = s_c\widehat{c}_t + s_I\widehat{i}_t \tag{26e}$$

$$\widehat{k}_{t+1} = (1-\delta)\widehat{k}_t + \delta\widehat{i}_t \tag{26f}$$

$$\widehat{y}_t = \alpha\widehat{k}_t + (1-\alpha)\widehat{h}_t \tag{26g}$$

$$\widehat{\Lambda}_t = \frac{s_L}{(s_L - s_I)}\widehat{l}_t - \frac{s_I}{(s_L - s_I)}\widehat{i}_t - \widehat{y}_t + \widehat{r}_t \tag{26h}$$

$$\widehat{l}_t + \widehat{r}_t - \widehat{\nu}_t = \frac{1}{(1-\theta)}\left[\widehat{l}_t - \theta\widehat{l}_{t-1} + \theta\widehat{\pi}_t\right] \tag{26i}$$

$$\frac{\overline{\mu}}{(\overline{\mu}-1)}\widehat{r}_t - \frac{1}{(\overline{\mu}-1)}\widehat{r}_{CB,t} = \frac{1}{(1-\beta\theta)}E_t\left[\widehat{\nu}_t - \beta\theta\widehat{\nu}_{t+1} + \beta\theta\widehat{r}_{CB,t}\right] \tag{26j}$$

$$\widehat{\mu}_t = \widehat{r}_t - \widehat{r}_{CB,t} \tag{26k}$$

where $\kappa = (1-\omega)(1-\omega\beta)/\omega$, $s_c = C/Y$, $s_I = I/Y$ and $s_L = l/Y$. $\overline{\mu}$ is the banking spread at steady state and $\overline{r} = \overline{\mu}/\beta$ the steady state loan rate.

We close the model by assuming the Central Bank sets the reference rate according to

$$\widehat{r}_{t,CB} = \epsilon_y\widehat{y}_t + \epsilon_\pi\widehat{\pi}_t + \epsilon_r\widehat{r}_{t-1,CB}.$$

It has been extensively argued that such monetary policy rules, where the monetary authority reacts to inflation and output gap, are remarkably successful for stabilization purposes. Hence, section 5 of the paper focuses on the implications of strengthening lending relationships to the determinacy properties of the model economy given different monetary policy rules. Apart from the parameter that govern the lending relationships (θ) and the monetary rule parameters (ϵ_y, ϵ_π, ϵ_r) the benchmark model has nine free parameters: σ, δ, η, s_c, s_I, α, β, ω and $\overline{\mu}$.

We set the parameter of intertemporal elasticity of substitution $\sigma = 1$ and the parameter of intertemporal elasticity of labour supply $\eta = 1.03$. The discount factor, β, is

calibrated to be 0.99, which is equivalent to an annual steady state real interest rate of 4 percent. Following Goodfriend and McCallum (2007) we set the annual banking spread at steady state to 2 percentage points or $\overline{\mu} = 1.005$. The depreciation rate, δ, is set equal to 0.05 per quarter. We set $\alpha = 0.36$ which roughly implies a steady state share of labour income in total output of 65%. The share of steady state consumption (s_c) is set equal to 0.725, while the share of steady state investment (s_I) is set equal to 0.275. Using the credit market clearing condition one can establish the relationship between the share of loans and investment at the steady state. Finally, we set the value of the Calvo parameter ω (fraction of firms which do not adjust their prices) as equal to 0.66 consistent with the findings reported in Gali and Gertler (1999).

4. Banking Spread and the Propagation of Shocks

In our model the strength of the lending relationship is represented by the size of the variable θ. High θ implies that a firm is more attached to the set of banks that have offered them loans in the past, making the demand for loans less interest rate elastic. This in turn increases the market power of banks. Given that very little empirical research has been done on banking spreads movements, bank relationships and macroeconomic fluctuations we guide our parameter choice to match the initial response in banking spread after a negative inflation shock to be around 100 basis points (yearly) following the empirical evidence presented by Santos and Winton (2008). In view of that, we set $\theta = 0.65$[9].

In order to facilitate the comparison of our impulse response analysis to those in the literature (e.g. Woodford (2003) and Curdia and Woodford (2008)), we set the benchmark Taylor Rule parameters as follows: $\epsilon_\pi = 2$, $\epsilon_y = 0.5$ and $\epsilon_r = 0$. We first look at the economy's response to four standard types of shocks: a taste shock directly associated with the consumption Euler equation, an investment shock that reflects an unexpected boost in investment, an inflation (or supply) shock associated with the New Keynesian Phillips Curve and finally a policy shock to the Taylor Rule. The vector of shocks is defined as $\xi_t = [\varepsilon_{c,t}, \varepsilon_{I,t}, \varepsilon_{\pi,t}, \varepsilon_{r,t}]'$. All four shock processes are assumed to have an autocorrelation coefficient equal to 0.75; their standard deviations are set equal to 1%. Given that our model explicitly includes a banking sector we can also consider a financial

[9]Note that θ has important implications for model stability. We study the stability properties of our model in detail in the next section.

sector shock that can be interpreted as a banking capital shock or temporary change to bank regulation that affects the bank loan rate decision. We start the analysis by looking at the cyclical properties of banking spreads.

4.1 Cyclical Properties of Banking Spreads

Aliaga-Diaz and Olivero (2011) find evidence in support of the countercyclical banking spreads (or as they refer to, price-cost margins) using data on the United States banking sector for the period 1984-2005. Bernanke, Gertler, and Gilchrist (1999) rationalize the impact of variations of banking spreads influencing the real economy with the use of costly state verification. However, as that empirical result holds after controlling for credit risk, monetary policy and the term structure of interest rates, there should be further factors driving the cyclical properties of spreads. Aliaga-Diaz and Olivero (2010) consider a real business cycle model with deep habits and flexible prices and show that productivity shocks indeed can yield countercyclical banking spreads. Here, we investigate whether lending relationships in the presence of an active monetary policymaker can also rationalize countercyclical banking spreads.[10]

[**Insert Figure 2 about here**]

Figure 2 shows the output and banking spread responses to our four main shocks. After a demand shock (investment shock), output increases, while the banking spread decreases. This is consistent to the view that banks take advantage of periods of relatively high output to build relationships, decreasing mark-ups to attract firms, since they recognize that the current rate decision affects future loan demand.

On the other hand, after an inflation (cost-push) shock, output decreases and interest rate margins increase. When output decreases, banks take advantage of the lending relationships. They have an incentive to increase the banking spread. This bank practice of exploiting lending relationships is verified empirically by Schenone (2009) and Santos and Winton (2008). The latter, using firm level data in the United States, find that firms without access to corporate bond market face banking spread increases of up to 95 basis points in a recession, while for firms with bond market access, the spread can increase up to 28 basis points. In Europe, where lending relationships are more common these

[10]For the sake of brevity we do not report correlations and standard deviations. These are available upon request.

numbers could be even greater.

In our simulations, after an inflation shock, spreads increase annually by roughly 100 basis points. We also confirm countercyclical spreads after both a taste shock and a contractionary monetary policy (Taylor Rule) shock. In both cases, output decreases and banks once again exploit credit relationships by increasing the spread.

In order to gain more understanding on how spreads move one can combine (26i) and (26j) to obtain the solution for the spread deviation $\widehat{\mu}_t$, which is given by

$$\delta_1 \widehat{\mu}_t = \delta_2 \widehat{r}_{CB,t} + \frac{1}{1-\beta\theta}\left[\frac{\theta}{1-\theta}(\beta\theta\Delta\widehat{l}_{t+1} - \Delta\widehat{l}_t) + \frac{\theta}{1-\theta}(\beta\theta\widehat{\pi}_{t+1} - \widehat{\pi}_t) - \beta\theta(\widehat{\mu}_{t+1} + \widehat{r}_{CB,t+1})\right] \tag{27}$$

where $\delta_1 = \frac{\overline{\mu}}{(\overline{\mu}-1)} - \frac{1}{1-\beta\theta}, \delta_2 = \frac{1+\beta\theta}{1-\beta\theta}$ are positive. The reason as to why spreads move strongly when the shock hits the economy and even overshoots the initial move generating opposite spread deviations, is due to the assumption that relationships last only one quarter. After a negative inflation shock banks initially exploit already formed relationships by increasing spreads. In the subsequent periods, given that relationships are formed after the shock first occurred, they no longer affect the interest setting decision for $\tau > t+1$. In those periods, spreads are only determined by the expected evolution of the loan demand. In Section 4.6. we consider an extension of the model with persistent lending relationships that last for four periods.

4.2 Endogenous Spreads, Output and Monetary Policy

In order to identify the impact of lending relationships, and the endogenous spread movements it generates, onto the main variables of the economy we compare the impulse responses of a model with constant spread, setting $\theta = 0$, and our benchmark model with $\theta = 0.65$. We firstly look at output responses. Spread movements amplify output responses to all shocks (Figure 3). Under a model with constant banking spread, output decreases after a standard cost-push shock. However, if banks try to exploit existing lending relationships by increasing spreads, output will decrease even further. Higher loan rates imply a direct increase on the cost of hiring labour and investing in capital. This will be followed by further decreases in investment and labour demand leading to lower output levels.

[**Insert Figure 3 about here**]

The opposite holds true for an investment shock, which leads to an initial rise in credit demand and output. An increase in credit demand gives banks an incentive to form new relationships by decreasing spreads. Decreasing spreads imply lower labour and investment costs and hence boosts production.

After a contractionary monetary shock, output will be lower in the case of lending relationships relative to the case of constant spreads for a number of periods. Spread movements are more persistent in this case, leading to a further deterioration of output. In the case of investment, inflation and taste shocks, however, spreads converge to their steady-state value and output responses are similar in both scenarios with and without lending relationships.

Existence of lending relationships contributes significantly towards output amplification. In our simulations the amplification effects are in the order of 10% with respect to the baseline case without lending relationships. In our model, loan rates directly influence the firm's costs of production. As a result, as banks use their market power by moving spreads countercyclically to maximize profits, they reinforce the variations in production costs after the shock, leading to greater output responses. The amplification of output occurs at the time the shock impacts the economy. Once again, amplification occurs because we model lending relationships to last only one quarter. Hence, spreads deviate from their steady state level only during this first period. In Section 4.6 we will allow relationships to affect lending for up to four quarters.

[**Insert Figure 4 about here**]

Figure 4 (a) shows the banking loan rate movement after the shocks in the constant spread case ($\theta = 0$) and lending relationship case ($\theta = 0.65$). As expected, when banking spreads move, so do the loan rates. However, spread deviations are always greater than the actual difference between the loan rates when comparing the $\theta = 0$ and 0.65 cases. Under the existence of lending relationships, spreads increase by roughly 25 basis points (in a quarter) after an inflation shock; the net difference between loan rate and the Central Bank is by about 12/13 basis points. The policymaker, knowing that the banks will exploit the existing relationships after an adverse inflation shock, avoids an excessively

tight monetary policy due to its output concerns.

This observation becomes clear in Figure 4 (b) that shows how the Central Bank base rate responds to the four main shocks. As loan rates increase after the shock, the Central Bank moves the base rate offsetting some of this increase and thereby dampens the potential effect of endogenous banking spreads on the real economy. Nonetheless, as we have seen, output responses are still amplified. While monetary policy actively tries to offset spread movements, it can not do so completely. An increase in loan rates leads to more volatile output responses. Inflation, however, does not change as much, following a similar path in both constant spread and lending relationships cases. The change in monetary policy does not generate increasing inflationary pressures. The Taylor Rule endogenously accommodates movements in spread without having to target the evolution of spreads.

Two important aspects of this result should be highlighted. First, the base interest rate (or monetary policy stance), responds quite differently to shocks depending on whether lending relationships are in place or not. Thus, if the Central Bank is uncertain whether these relationships are strong or not, it may set an incorrect interest rate path, therefore failing to stabilize output gap and inflation. De Fiore and Tristani (2008) obtain a similar conclusion while looking at a monetary policy that tracks the natural rate in a model with and without credit frictions. Their model incorporates the financial accelerator into a standard New Keynesian model. They find that credit frictions imply different natural rate dynamics and different monetary policy responses. Once again, their results are similar to the ones presented here, though the channel is different. While spreads in our model evolve due to lending relationships, in De Fiore and Tristani (2008) spreads move due to changes in the firm's net worth.

Second, we find that even though a standard Taylor Rule implies an endogenous reaction of the monetary policy towards variations in the spread, this is not sufficient to fully deal with the impact of the loan rate changes. In other words, standard Taylor rules can not fully offset the amplification effects of spread movements that are generated by the presence of lending relationships. Therefore, in the following section we look into two alternative policy rules, augmenting the original Taylor Rule with banking spreads and with credit aggregates.[11]

[11] An issue that is important to consider in future research is the presence of the zero bound problem. When the economy is operating at the zero bound of policy rates, a negative macroeconomic shock may be further amplified by the movements of the bank mark-ups as the policymaker cannot off-set the profit

4.3 Alternative Monetary Policy Rules

Taylor (2008) advocates that the Central Bank base rate should respond not only to output gap and inflation deviations but also to changes in the banking spread. Such framework allows the Central Bank to accommodate changes in the banking/financial sector conditions. This adjusted Taylor Rule takes into consideration the movements in the base rate that impacts the consumption through the Euler equation and the loan rate, which impact production and investment costs. The spread-adjusted Taylor Rule is given by

$$\widehat{r}_{t,CB} = \epsilon_y \widehat{y}_t + \epsilon_\pi \widehat{\pi}_t + \epsilon_r \widehat{r}_{t-1,CB} - \epsilon_\mu \widehat{\mu}_t,$$

For $0 < \epsilon_\mu < 1$, the Central Bank targets a hybrid rate that is a weighted average of the loan rate and the Central Bank base rate. If $\epsilon_\mu = 1$, then the Central Bank in fact targets the loan rate instead of the base rate in the economy. We present the results for $\epsilon_\mu = 0.5$ and $\epsilon_\mu = 1$, while keeping the other Taylor Rule parameters unchanged ($\epsilon_\pi = 2$, $\epsilon_y = 0.5$ and $\epsilon_r = 0$). Figure 5 shows impulse responses after an exogenous inflation and an exogenous investment shock.

[**Insert Figure 5 about here**]

When the monetary policy responds to banking spread changes, the previously observed output amplification is offset. After an inflation shock, the Central Bank base rate does not increase as much as when the original Taylor Rule is considered; in this way the reduction in output is actually smaller than when the Central Bank does not target the spread. Note that in the case of the inflation shock, the smaller output deviation is not "paid" by more inflationary pressures. Although inflation initially increases more, it is less persistent, falling down faster to its steady state level. After an investment shock, output does not increase as much as when a basic Taylor Rule is considered; so a monetary policy that adjusts to spread movements is able to offset the inflationary impact of lower banking spreads. The spread-adjusted Taylor Rule also delivers a lower initial inflation response, although now the inflation response is flatter. In other words, although under a standard Taylor Rule monetary policy implicitly responds to banking spread movements, adjusting the monetary rule to include the banking spread improves

margins.

economic stabilization.

Christiano, Motto, and Rostagno (2007) present a model that introduces nominal lending contracts. They argue that including a measure of broad money into a standard Taylor Rule results in less volatile output. Therefore, we analyze the case of an inflation and an investment shock, when monetary policy follows a credit-adjusted Taylor Rule that includes an additional term of real credit aggregates (l_t).

$$\widehat{r}_{t,CB} = \epsilon_y \widehat{y}_t + \epsilon_\pi \widehat{\pi}_t + \epsilon_r \widehat{r}_{t-1,CB} + \epsilon_l \widehat{l}_t,$$

As in the previous case, we set $\epsilon_y = 0.5$, $\epsilon_y = 2$ and $\epsilon_r = 0.5$.

[**Insert Figure 6 about here**]

Credit aggregates deviations are closely related to deviations in output, since the credit demand is determined by investment and labour finance requirements. Hence, increasing ϵ_l from zero to 0.4 would lead to similar monetary policy responses as if the Taylor Rule parameter on output has increased (see Figure 6). After an inflation shock, output does not decrease as much, but inflation increases substantially more than in the case of the standard Taylor Rule. After an investment shock, output does not increase as much, but inflation drops considerably more. Note that, as we increase ϵ_l, holding ϵ_y constant, indeterminacy obtains. In order to obtain a unique solution, we increase ϵ_r from zero to 0.5 (see Aksoy, Basso, and Coto-Martinez (2011) for a detailed discussion of indeterminacy due to the cost channel of monetary policy). We, therefore, conclude that credit-adjusted rule is less successful in terms of stabilization and is susceptible to indeterminacy issues.

4.4 Banking/Financial Shocks

Our model considers a type of financial sector friction generated by lending relationships. As we explicitly model the banking sector, we can consider an alternative shock, a banking spread shock, that we interpret as a banking capital shock or a temporary change in bank regulations that impact the bank's loan rate decision via a change in the marginal gain of an extra unit of loan demand (equation (26j)).

[**Insert Figure 7 about here**]

We present our results in Figure 7. A positive banking shock leads to an increase in the spread and a decrease in investment and output. At the same time, inflation increases slightly due to cost-push effects of the increased marginal costs. Therefore, modifying the monetary policy by a spread-adjusted Taylor Rule does not seem to generate improved stabilization as measured by output and inflation. If the shock is not persistent, responding to spreads reduces the output contraction at the cost of an inflationary pressure.

Targeting spread movements in this case is equivalent to a Central Bank more concerned with output than inflation. Given the forward looking nature of the inflationary process, initial drive to decrease the base rate as spread increases, leads to high inflationary pressures. Taking that into account actually means that, the base rate does not decrease as much as in the case when monetary policy is set based on the standard Taylor Rule. If shocks are very persistent, this forward looking element is very strong. Here, the Central Bank, that takes the banking spread into consideration to set policy, seems to deliver a high inflation rate but less output loss. Figure 7 shows the impulse responses for both cases, when shocks have a low persistence ($\rho = 0.3$) and a high persistence ($\rho = 0.75$). Note that a similar result obtains when a credit-adjusted Taylor Rule is considered.

4.5 Monetary Policy Rules and Welfare

While spread-adjusted Taylor Rules seem to perform better than standard Taylor Rules in stabilizing macroeconomic shocks, targeting credit aggregates is less successful. In view of that, we employ Schmitt-Grohe and Uribe (2004a) methodology to quantify the welfare costs of alternative policy rules and test whether spread-adjusted Taylor Rules improve welfare. To this end, we write the non-linear equilibrium conditions in the following format

$$E_t(y_{t+1}, y_t, x_{t+1}, x_t) = 0,$$

where y_t contains the non-predetermined variables of the model and x_t contains the endogenous predetermined variables (x_t^1) and the exogenous shocks (x_t^2). Given our interest in policy rules, we exclude the Taylor Rule shock and set $x_t^2 = [\varepsilon_{c,t}, \varepsilon_{I,t}, \varepsilon_{\pi,t}, \varepsilon_{b,t}]'$,

where the last term is the banking sector shock. Furthermore we assume that

$$x_{t+1}^2 = \Lambda x_t^2 + \widetilde{\kappa_e}\Theta z_t,$$

where Λ stands for the persistence of shocks and $\widetilde{\kappa_e}$ stands for the standard deviation of shocks[12]. Θ scales standard deviations and z_t is an *iid* shock. The economy's welfare is given by the household's conditional expectation of lifetime utility, V_0, given by

$$V_0 = E_t \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \chi \frac{H_t^{1+\eta}}{1+\eta} \right).$$

By including V_0 as one of the variables in the vector y_t, the solution to the system is given by $y_t = g(x_t, \Theta)$ and $x_{t+1} = h(x_t, \Theta) + \kappa_e \Theta z_t$. Finally, the non-stochastic steady state is given by $x_t = x$ and $\Theta = 0$.

As in Schmitt-Grohe and Uribe (2004a), we define the welfare cost of adopting an alternative policy regime a compared to a policy regime r (a pure inflation targeting regime) as a portion of consumption WC such that the household would be indifferent between these two policies. Formally,

$$V_r^a = E_t \sum_{t=0}^{\infty} \beta^t \left(\frac{(C_t^a)^{1-\sigma}}{1-\sigma} - \chi \frac{(H_t^a)^{1+\eta}}{1+\eta} \right) = E_t \sum_{t=0}^{\infty} \beta^t \left(\frac{((1-WC)C_t^r)^{1-\sigma}}{1-\sigma} - \chi \frac{(H_t^r)^{1+\eta}}{1+\eta} \right).$$

Then, using the fact that the first derivative of the policy function g with respect to Θ evaluated at the steady state ($x_t = x$ and $\Theta = 0$) is zero (see Schmitt-Grohe and Uribe (2004b)), the welfare cost can be approximated to

$$\text{Welfare Cost } = WC(x,0) = -(1-\beta) \left[\frac{\partial^2 V^a}{\partial\Theta\partial\Theta}\Big|_{(x,0)} - \frac{\partial^2 V^r}{\partial\Theta\partial\Theta}\Big|_{(x,0)} \right] \frac{\Theta^2}{2}.$$

We present a model with cost channels of monetary policy, in which, contrary to standard New Keynesian models, policymakers face a trade-off between stabilizing the inflation rate and stabilizing the output gap (see the discussion in Ravenna and Walsh (2006)). This creates a policy bias towards a more aggressive inflation stabilization. As our focus is on the welfare impact of including additional terms dependent on credit market measures, we fix the value of $\epsilon_\pi = 2$ and measure welfare changes by varying

[12] We kept persistence equal to 0.75 and standard deviation of 1% for all shocks.

other policy rule parameters[13], therefore

$$\widehat{r}_{t,CB} = 2\widehat{\pi}_t + \epsilon_y \widehat{y}_t + \epsilon_r \widehat{r}_{t-1,CB} - \epsilon_\mu \widehat{\mu}_t$$

$$\widehat{r}_{t,CB} = 2\widehat{\pi}_t + \epsilon_y \widehat{y}_t + \epsilon_r \widehat{r}_{t-1,CB} + \epsilon_l \widehat{l}_t.$$

Table 1: Monetary Policy Rule - Welfare Analysis

		$\epsilon_r = 0$			$\epsilon_r = 1$		
			ϵ_μ			ϵ_μ	
		0	0.5	1	0	0.5	1
ϵ_y	0	0.00%†	0.01%	0.02%	0.00%†	0.04%	0.06%
	0.1	0.00%	0.01%	0.02%*	0.03%	0.05%	0.07%
	0.2	-0.01%	0.00%	0.00%	0.05%	0.06%	0.07%*
	0.3	-0.06%	-0.05%	-0.04%	0.05%	0.06%	0.07%
	0.4	-0.17%	-0.16%	-0.15%	0.05%	0.05%	0.06%
	0.5	-0.45%	-0.43%	-0.42%	0.03%	0.04%	0.04%
			ϵ_l			ϵ_l	
		0	0.2	0.4	0	0.2	0.4
ϵ_y	0	0.000%†	-0.058%	-2.263%	0.000%†	0.068%*	-0.053%
	0.1	0.002%*	-0.195%	-26.087%	0.032%	0.051%	-0.125%
	0.2	-0.012%	-0.545%	-**	0.047%	0.025%	-0.229%
	0.3	-0.057%	-1.670%	-	0.052%	-0.015%	-0.389%
	0.4	-0.169%	-8.068%	-	0.046%	-0.074%	-0.642%
	0.5	-0.446%	-	-	0.030%	-0.163%	-1.072%

† Indicates the reference policy for that quadrant, thus deviation equals zero

* Indicates the best set of policy parameters for that quadrant

** A dash indicates there was no unique equilibrium for these policy parameters.

Table 1 shows welfare costs (WC) for different policy parameter combinations. We set the reference policy, for which $WC = 0$, to be the first entry in each quadrant, where $\epsilon_\mu = \epsilon_y = \epsilon_l = 0$. For each value of output coefficient (ϵ_y), increasing ϵ_μ (the response to banking spread changes) increases welfare. Note that, welfare costs are always increasing in each row for the two top quadrants. The welfare analysis presented here suggests that a welfare maximizing Central Bank should target the loan rate, by setting $\epsilon_\mu = 1$, rather than the Central Bank base rate ($\epsilon_\mu = 0$) or the average of the two rates ($\epsilon_\mu = 0.5$). This is because lending relationships introduce a dynamic distortion in credit markets, since they give incentives to banks to vary spreads and thereby move the economy further away from the steady state. When the base rate responds directly to spread movements, the Central Bank is able to partially offset this distortion, increasing welfare.

Table 1 also shows that targeting credit aggregates does not improve welfare. The

[13] We also run simulations for lower and higher values of ϵ_π. The conclusions of the welfare analysis remain the same.

only case where it is optimal to target credit aggregates is when the policy rule is set with inertia. In this case, targeting credit aggregates replaces targeting output as a more efficient way to maximize welfare.

4.6 Persistent Spread Movements

Until now, we assumed that lending relationships last only one period. The empirical evidence suggests that although relationships are occasionally broken, they usually last for longer periods (see Ongena and Smith (2001)). In view of that, we modify our model allowing relationships to lasts for up to 4 quarters. Here, we assume the financial part of the firm cares about a measure $X_{t,i}$ of loans given by

$$X_{t,i} = \left[\int_0^1 \left(L_{t,i,j} - \theta_1 L_{t-1,j} - \theta_2 L_{t-2,j} - \theta_3 L_{t-3,j} - \theta_4 L_{t-4,j} \right)^{1-\frac{1}{\varrho}} dj \right]^{\frac{1}{1-\frac{1}{\varrho}}} .$$

As a result, we obtain the demand for loans and the bank maximization conditions stated below.

$$\begin{aligned} L_{t,i,j} &= \left(\frac{R_{t,i,j}}{R_{t,i}} \right)^{-\varrho} X_{t,i} + \theta_1 L_{t-1,j} + \theta_2 L_{t-2,j} + \theta_3 L_{t-3,j} + \theta_4 L_{t-4,j} \\ \nu_t &= \frac{(\mu_t - 1)}{\mu_t} R_t + E_t \left[Q_{t,t+1}\theta_1 \nu_{t+1} + Q_{t,t+2}\theta_2 \nu_{t+2} + Q_{t,t+3}\theta_3 \nu_{t+3} + Q_{t,t+4}\theta_4 \nu_{t+4} \right] . \end{aligned}$$

The final set of equations are then modified such that (26i) includes all lagged loan deviations $\hat{l}_{t-k}$, for $k = 1, 2, 3$ and 4 and (26j) includes all forward looking shadow marginal profit measures $\hat{\nu}_{t+k}$. Therefore, we derive the expression for the spread deviation $\widehat{\mu}_t$, that is comparable to equation (27), and is given by[14]

$$\begin{aligned} \tilde{\delta}_1 \widehat{\mu}_t &= \tilde{\delta}_2 \widehat{r}_{CB,t} + \frac{1}{1-\theta \sum_{k=1}^{4} \beta^k} \Bigg(\frac{1}{1-4\theta} \Big(\theta^2 \textstyle\sum_{k=1}^{3} \sum_{z=1}^{k} \beta^k (4-(k-z+1))(\Delta \widehat{l}_{t+4-k} + \widehat{\pi}_{t+4-k}) \\ &\quad - [\textstyle\sum_{k=0}^{3} (4-k)\theta + \theta^2 \sum_{z=1}^{4-k-1} \beta^k (4-k-z)](\Delta \widehat{l}_{t-k} + \widehat{\pi}_{t-k}) \Big) - \theta \textstyle\sum_{k=1}^{4} \beta^k (\widehat{\mu}_{t+k} + \widehat{r}_{CB,t+k}) + \theta \sum_{k=2}^{4} \widehat{r}_{CB,t+k-1} \Bigg) \end{aligned} \tag{28}$$

[**Insert Figure 8 about here**]

Figure 8 shows impulse responses after an inflation shock of the modified model against

[14] Where $\tilde{\delta}_1 = \frac{\overline{\mu}}{(\overline{\mu}-1)} - \frac{1}{1-\theta \sum_{k=1}^{4} \beta^k}, \tilde{\delta}_2 = \frac{1+\theta \sum_{k=1}^{4} \beta^k}{1-\theta \sum_{k=1}^{4} \beta^k}$.

the case when no lending relationships are present[15]. For these simulations, we set $\theta_1 = \theta_2 = \theta_3 = \theta_4 = 0.175$. As it is clear, spread movements are more persistent, remaining positive for four quarters. As a result, there is a more pronounced hump-shaped response of the Central Bank base rate, offsetting the endogenous tightening caused by the spread movements. There is also more persistent amplification of output lasting for the periods for which the banking relationships are in effect. By comparing expression (28) with (27) we can see also the reason for the increased persistence in the behavior of macroeconomic variables. Under this scenario a decrease in loan demand, $\widehat{l}_t$, impacts positively the spread variation for consecutive four quarters; spread deviations are negative only after the fifth period.

5. (In)Determinacy Analysis

We now turn to the analysis of the implications of lending relationships for the determinacy properties of our model economy. As it is well known, the policymaker needs to select appropriate policy rule parameters to stabilize inflation and output gap to ensure local model stability. To provide a comprehensive discussion, we consider the standard Taylor Rule and the two rules discussed in the previous sections in which the Central Bank targets banking spreads or credit aggregates.

We show that the range of policy rules support three possible outcomes: *i*) a unique solution, *ii*) multiple equilibria (sun spots) and *iii*) no solution. Of course, our interest is to determine the policy rules that deliver a unique solution. We will first concentrate on the standard Taylor Rule, where the main policy parameters of interest are ϵ_π, ϵ_y and ϵ_r.

In Figures 9 and 10, we report determinacy areas for different combinations of values for ϵ_y and ϵ_r, and we vary ϵ_π from 0 to 2 and θ from 0 to 1. The dark grey shaded areas show the no solution cases, the light grey shows the region where the model has a unique solution and the white area shows the multiple equilibria cases. We report three positive results and a normative discussion on alternative policy rules.

[**Insert Figures 9 and 10 about here**]

First, in all four cases depicted in Figure 9, in the presence of strong lending rela-

[15] We do not present other shocks since the qualitative conclusions remain the same.

tionships, it is very difficult to design a Taylor Rule that ensures model stability. When the Central Bank cares about inflation deviations a value of θ greater than around 0.75 (sometimes lower) implies our economy does not have a unique equilibrium. The underlying intuition is quite simple. If lending relationships are strong (θ very large), banking spreads are more volatile. Assume agents become very pessimistic and reduce consumption/investment, then the economy could move into a recession; the initial reduction in consumption/investment becomes a "self-fulfilling prophecy". The remedy to self-fulfilling prophecies in standard NK models is a policy rule that prescribes an aggressive cut in interest rates to anchor inflation expectations. In our model, given the reduction in consumption and investment, banks anticipate a decline in the credit demand; they respond by increasing their mark-up from existing borrowers. Even if the base rate decreases, the sharp spread increase leads to a higher loan rates and higher firm marginal costs. As a consequence aggregate output contracts. Thus, if the Central Banks follows a standard Taylor Rule, it can not avoid the recession, since the reduction in the base interest rate is dominated by the increase in the banking spread. The standard mechanism that ensures determinacy is no longer in place, even if the base rate responds strongly to inflation deviations.

Second, Figures 9(c) and 9(d) show the cases where the Central Bank does not target output with and without interest rate smoothing. We show that the Central Bank needs to be very aggressive towards inflation to ensure determinacy. Targeting output reduces the area of stability. This is a consequence of the presence of the cost channels in the model. As discussed by Aksoy, Basso, and Coto-Martinez (2011) in a model with cost channels like ours, a contractionary policy change leads to a contraction of the economy but two opposing implications for inflation, one through aggregate demand and one through the cost channel. Thus, targeting output together with inflation requires the determinacy concerned policymaker to act in order to make sure the aggregate demand channel dominates the cost channel. Related to this result, introducing base rate smoothing generally helps to ensure stability. If we compare Figures 9 (a) and 9 (b), we observe that the elimination of the persistence parameter significantly reduces the area of stability. However, note that, although mildly, interest inertia worsens the impact of lending relationships; indeterminacy obtains for lower values of θ in Figure 9 (a) relative to 9 (b). This occurs because as banking spreads move, the base interest rate must move strongly in the opposite direction to curb the change on the final borrowing rate.

Given interest rate inertia this sharp base rate movement does not materialize leading more frequently to indeterminacy problems. Hence, interest inertia mildly reinforces the impact of lending relationships on indeterminacy but provides considerable more room for the policy maker to be less aggressive towards inflation relative to output.

Third, Figure 10 (a) shows the effects of the combinations of increasing θ and the steady state banking mark-up $\overline{\mu}$. We initially set $\overline{\mu} = 1.005$ implying an annual banking spread of 2 percentage points based on a model calibrated for the U.S. However, in some economies where competition in the banking sector is weaker this number can be considerably higher. Higher steady state spread levels imply that indeterminacy occurs for lower levels of θ. Thus, indeterminacy problems are worsened in economies with lending relationships associated with high average spread levels. When the profit margin is large and the lending relationships have strong influence in banking spreads (θ is large), the Central Bank has a very limited power over the final loan rates. As a result bank spread movements dominate base interest rate changes more easily.

On the normative side we find that to circumvent the indeterminacy problem related to strong lending relationships, the Central Bank could target the banking spread, in addition to inflation and output gap targeting. As we have shown the monetary rule in this case takes the following form

$$\widehat{r}_{t,CB} = \epsilon_y \widehat{y}_t + \epsilon_\pi \widehat{\pi}_t + \epsilon_r \widehat{r}_{t-1}^{CB} - \epsilon_\mu \widehat{\mu}.$$

This targeting rule may be particularly appealing under our set-up with bank distortions represented by the strength of lending relationships (θ). If the Central Bank base rate responds directly to spread changes, the final loan rates will not be dominated by spread deviations. As a result of that, the Central Bank can anchor inflation expectations and offsets self-fulfilling expectations. As Figure 10 (b) shows, targeting spread movement does indeed improve the performance of the model in terms of stability.

The other alternative monetary policy rule considered in the previous section includes a direct term based on credit aggregates. Figure 10 (c) shows that this modified policy rule does not ameliorate the indeterminacy problem. As discussed before targeting credit aggregates is very similar to increasing the importance of output movements relative to inflation. Excess output concern implies indeterminacy.

We conclude that active policymaking under lending relationships and endogenous

banking spreads significantly alters stability conditions as compared to basic three equation New Keynesian model. While interest rate smoothing is important for stability purposes, there is a much less clear-cut case for targeting output gap. One key result of Taylor-Woodford work is that in setting the short term rates the policymaker needs to respond more than one to inflation changes. Here we document that is not necessarily the case. Finally, the strength of lending relationships turns out to be crucial in the determinacy discussion. Strong lending relationships imply less stable economies forcing the Central Bank to change the policy rule; we show that policy rules that respond to bank spread are less prone to indeterminacy issues.

6. Conclusions

We present a simple New Keynesian model that incorporates a basic and relevant feature of financial intermediation, namely, lending relationships. While such relationships benefit firms through the reduction of information asymmetries, they also create hold-up costs; firms become locked to a bank, reducing their bargaining power over credit rates. We report four main findings.

First, we show that lending relationships can explain observed countercyclical pattern of bank spreads. This is because banks decrease spreads attempting to form as many relationships as possible during booms and increase spreads to sustain profitability during recessions, exploiting the firms locked into pre-existing relationships.

Second, lending relationships help to explain the amplification of output responses. Countercyclical mark-ups serve as a propagation mechanism of shocks hitting the economy. The Central Bank responds to banking spread changes by decreasing the base rate relative to its level under constant spreads. Therefore, confirming Goodfriend and McCallum's (2007) conclusions, monetary policy should take into account financial intermediation and different short-term interest rate dynamics in order to stabilize the economy in a stochastic environment. In our basic set-up the Central Bank base rate adjustment to spread movements occur indirectly, through the changes in output and inflation. One of the current monetary policy debates is whether the base rate should respond directly to spread movements. We show that including an additional term dependent on the banking spread improves stabilization of the economy. Targeting credit aggregates, however, does not improve stabilization performance.

Third, we show that from a welfare perspective the standard Taylor Rule is suboptimal under the alternative of bank-spread targeting. Results are less encouraging for policy rules that respond directly to credit aggregates. Welfare is not improved in this case.

Fourth, our model indicates that strong lending relationships have important equilibrium determinacy implications through feedback effects between the financial intermediation and the real economy. An initial shock that decreases output will push banking spreads up, which further dampen output. If spread movements are significant the economy does not converge back to equilibrium. That implies monetary policy should also be vigilant, responding to banking spread movements, to guarantee equilibrium determinacy.

Our model matches two main empirical findings: countercyclical spreads and significant spread changes during downturns. Naturally, building up lending relationships from a fully fleshed out banking sector based on game theoretical foundations is an important issue that we intend to pursue in our future research. Nevertheless, we believe that the simple structure we provide here captures the essential elements of the effects of relationship banking on macroeconomic performance.

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Appendix

In the appendix we present a simple corporate finance model of asymmetric information based on Akerlof (1970) that features dynamic behavior of banking mark-ups, which is an essential element of lending relationships. We assume that every entrepreneur (firm) lives for two periods. A fraction $(1-\theta)$ are opportunistic and will default on the loan after one period. By the end of the first period, the lender (bank) that issues the loan will know the type of entrepreneur as a private information. That implies that the lender will not know whether those firms that are willing to switch lenders are willing to do so due to opportunistic or competitive price seeking behavior. In equilibrium there will also be a "market for lemons" leading to the collapse of this market. The outcome will be that "good" companies, that are competitive price-seekers, will prefer to stay with the existing lender. Given that "good companies" cannot switch, the lender can price loan demand monopolistically (R) and retains the surplus over the competitive price, that is R_{CB}.

We now present the profit of the banks. The demand for loans for each period is equal to $\left(\frac{R_{ti}}{Rj}\right)^{-\varrho} L_t$, L_t being the real volume of funds demanded to pay factor inputs. As in the main text, we assume monopolistic competition between banks. Expression $\left(\frac{R_{t,i,j}}{R_{t,i}}\right)^{-\varrho}$ represents the market share of the bank. After one period a fraction θ of entrepreneurs will not default and stay with the existing lender; $\theta(\frac{R_{ti}}{Rtj})^{-\varrho} L_{t+1}$ representing the demand for loans by good entrepreneurs. As in the paper, we also assume that the lender cannot discriminate between new and old costumers. Intertemporal bank profits, under discretion, are therefore given by

$$\begin{aligned}\Pi^B_{t,j} &= \sum_{t=0}^{\infty} Q_{0,t}\Bigg\{\theta_t R_{t,i,j}\left(\frac{R_{t,i,j}}{R_{t,i}}\right)^{-\varrho} L_t + R_{t,i,j}\theta_{t-1}\left(\frac{R_{t-1,i,j}}{R_{t-1,i}}\right)^{-\varrho} L_t \\ &\quad -R_{t,CB}\left[\left(\frac{R_{t,i,j}}{R_{t,i}}\right)^{-\varrho} L_t + \theta_{t-1}\left(\frac{R_{t-1,i,j}}{R_{t-1,i}}\right)^{-\varrho} L_t\right]\Bigg\}.\end{aligned}$$

Total demand for loans consists of demand for loans made by new entrepreneurs and demand due to existing lending relationships. Note that a fraction $(1-\theta)$ of entrepreneurs each period default on their loan, and hence bank profits are directly affected by opportunistic entrepreneurs. As in the main model, the marginal cost is given by $R_{t,CB}$. The profit margin at the symmetric equilibrium is given by

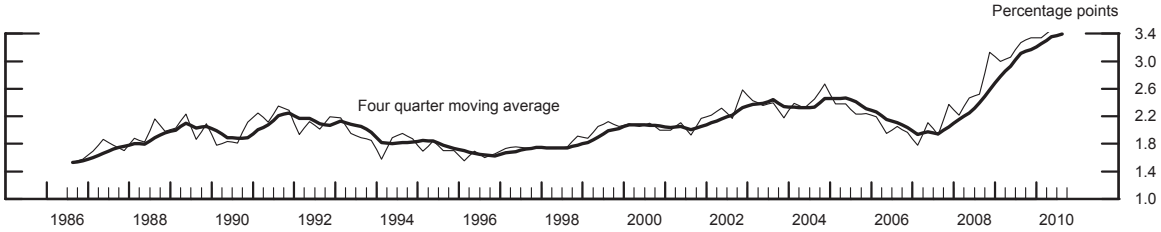
$$\frac{R_t - R_{t,CB}}{R_t} = \frac{\theta_t + \theta_{t-1}}{\varrho} + (1 - \theta_t) - Q_{0,t}\frac{R_{t+1}}{R_t}\left(\frac{R_{t+1} - R_{t+1,CB}}{R_{t+1}}\right)\theta_t \frac{L_{t+1}}{L_t}.$$

This expression is equivalent to the profit margin equation (25) under deep habits. The profit margin is determined by the same effects; i.e. ϱ represents the static banking mark-up, θ_{t-1} represents the fact that banks exploit existing lending relationships to increase monopoly profits and the expected future profits of forming new lending relationship are given by $Q_{0,t}\frac{R_{t+1}}{R_t}\left(\frac{R_{t+1}-R_{t+1,CB}}{R_{t+1}}\right)\theta_t \frac{L_{t+1}}{L_t}$, representing the forward looking behavior of profit margins. Deep habits in lending capture these dynamics in a parsimonious way.

This simple model shows that the time varying default probability $(1-\theta_t)$ affects the profit margins. (Even when lenders do not have market power, profit margins need to cover the default losses.) These also affect the expected profits of forming new lending relationships. We currently investigate a case where the default probabilities are endogenously determined by the value of the entrepreneurs' collateral. For instance, when the value of the collateral declines, the probability of default will increase, leading to a decrease in the expected future profits by forming new relationships, therefore lenders will increase their profit margins. The cyclical evolution of collateral would reinforce the movements in credit spreads.

Figures

Figure 1: Commercial and Industrial Loan Rates Spreads over Federal Funds Rate
(Actual and Four-Quarter Moving Average)



Source: Survey of Terms of Business Lending - Federal Reserve Bank

Figure 2: Cyclical Properties of Banking Spread - $\theta = 0.65$

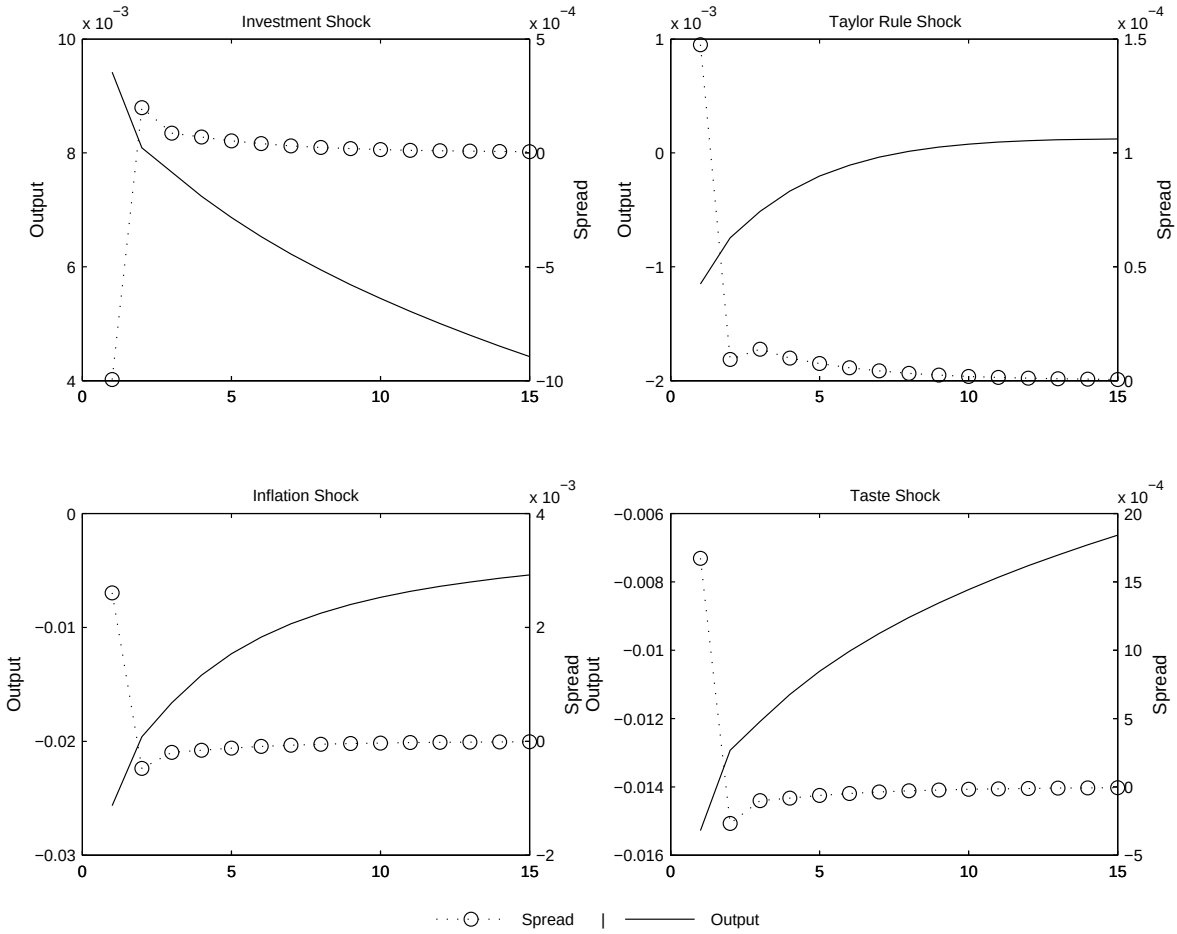


Figure 3: Endogenous Spread and Amplification of Output Responses

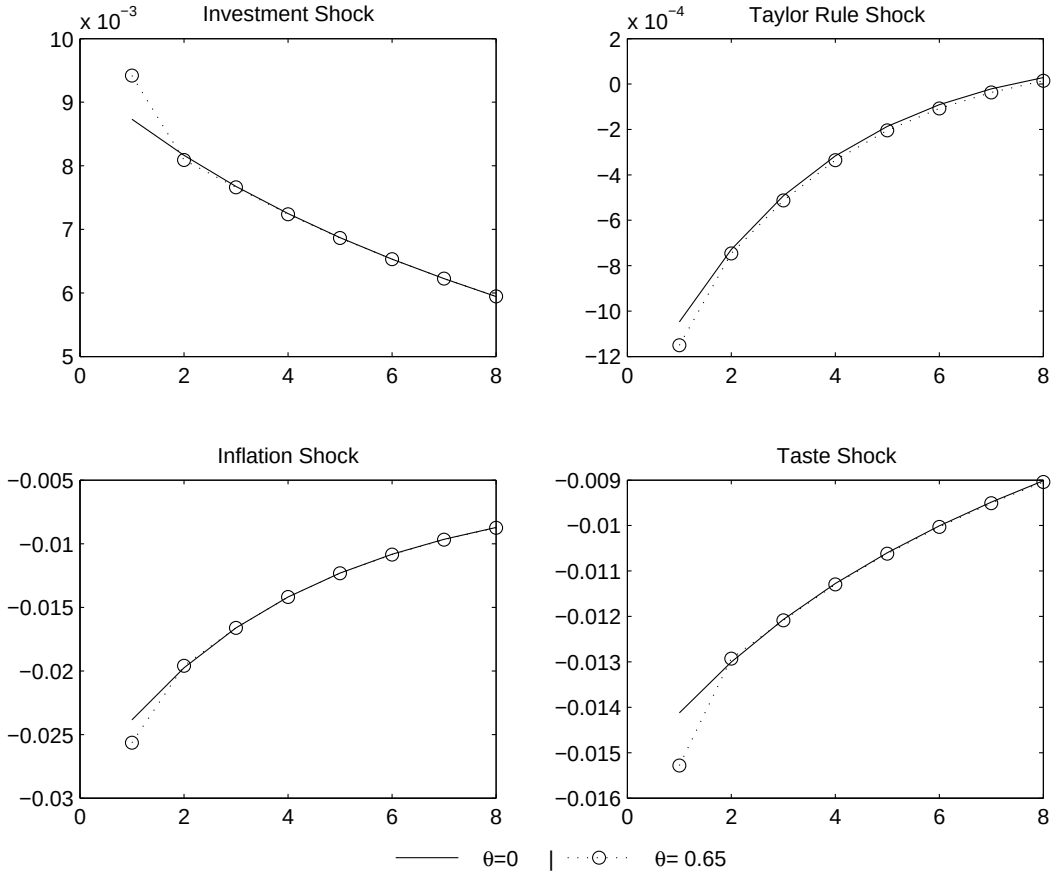
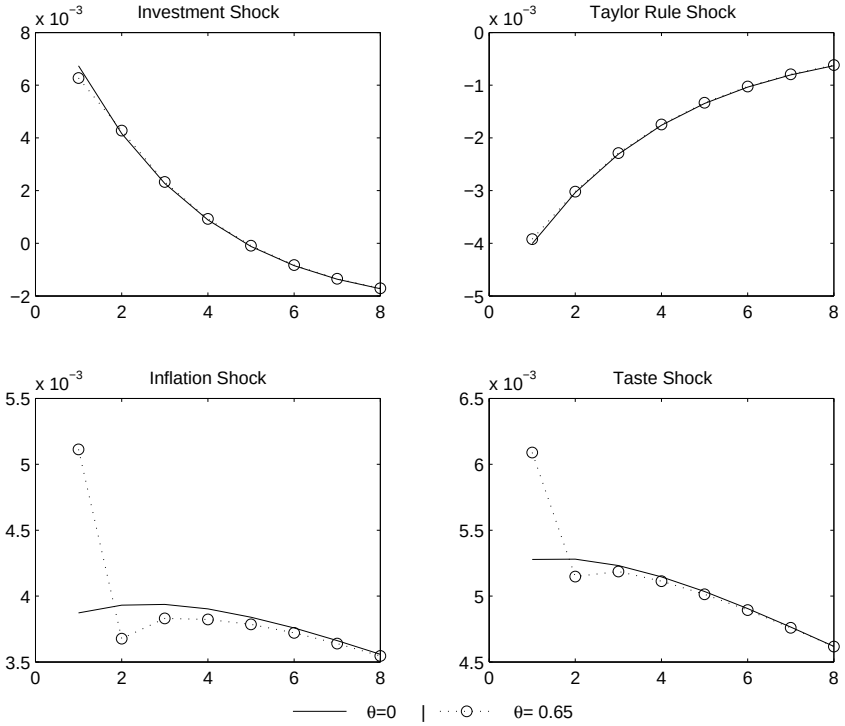
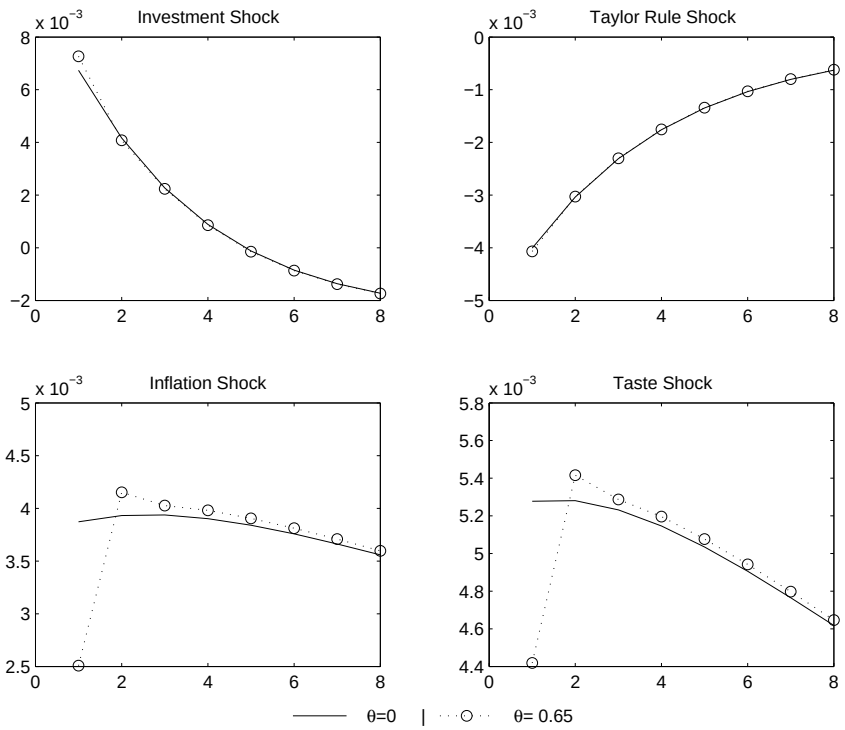


Figure 4: Endogenous Spread and Interest Rate Response

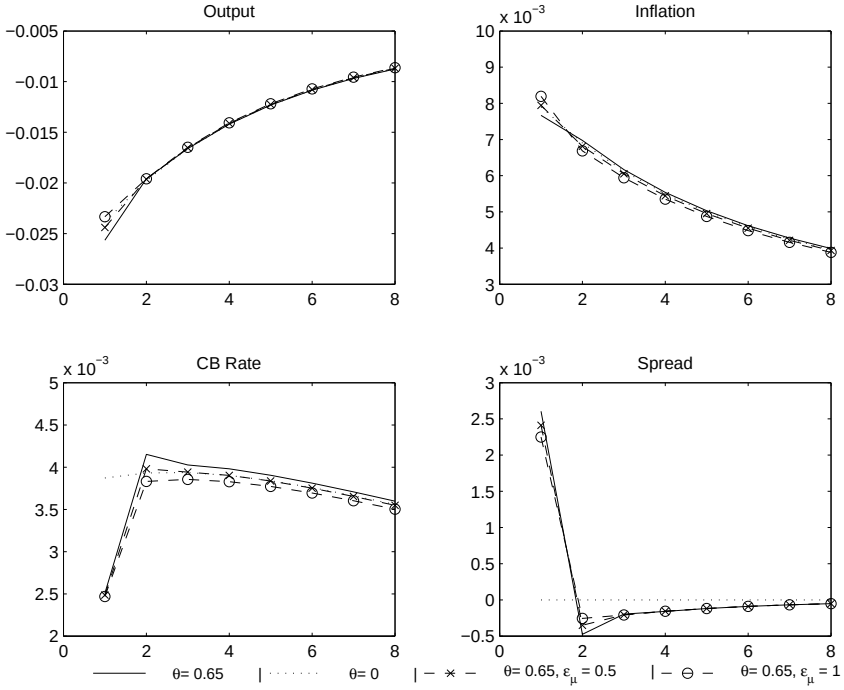


(a) Loan Rates

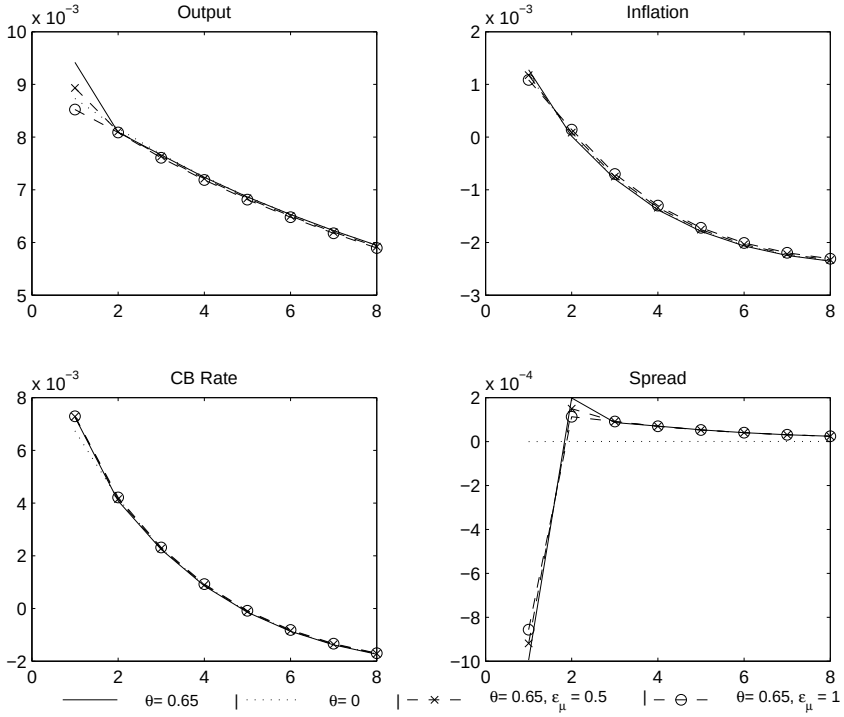


(b) Central Bank Rate

Figure 5: Spread-Adjusted Taylor Rule

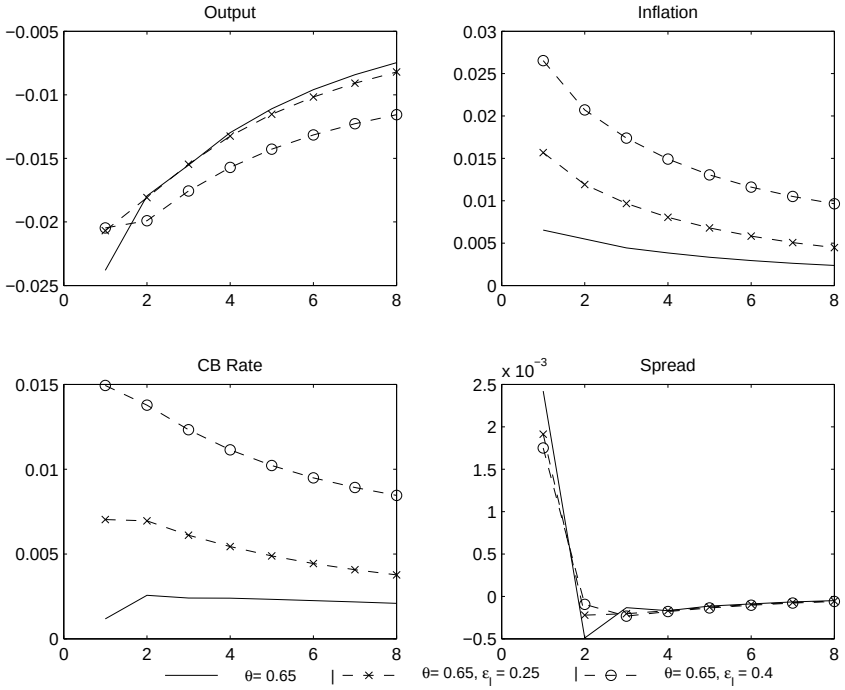


(a) Inflation Shock

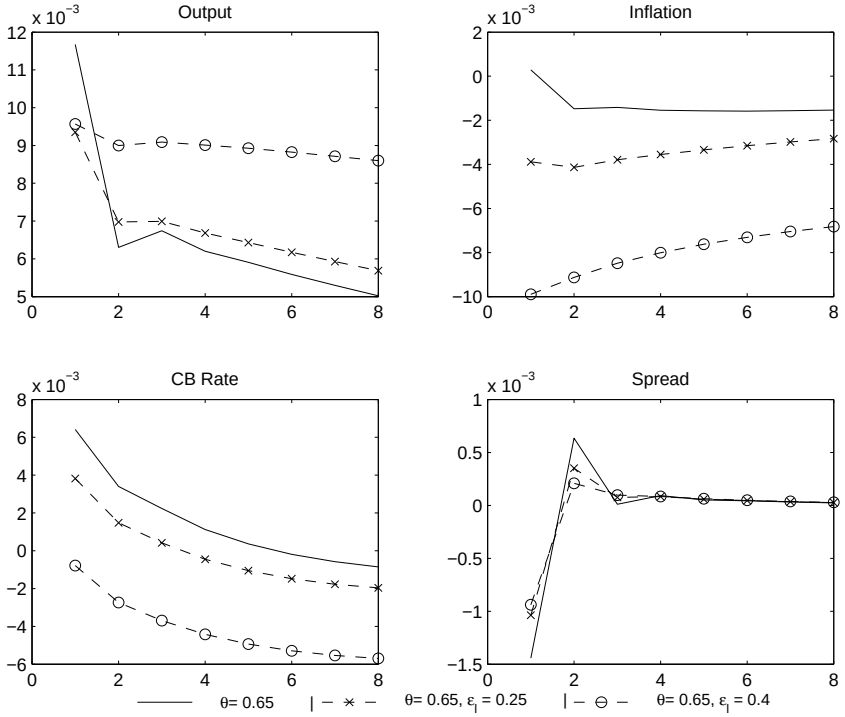


(b) Investment Shock

Figure 6: Credit-Adjusted Taylor Rule

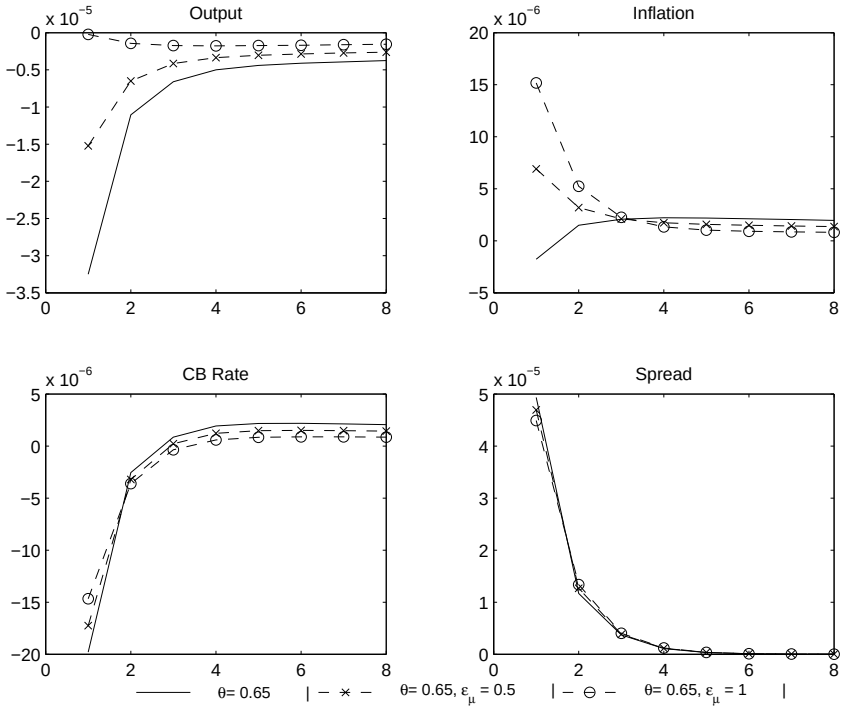


(a) Inflation Shock

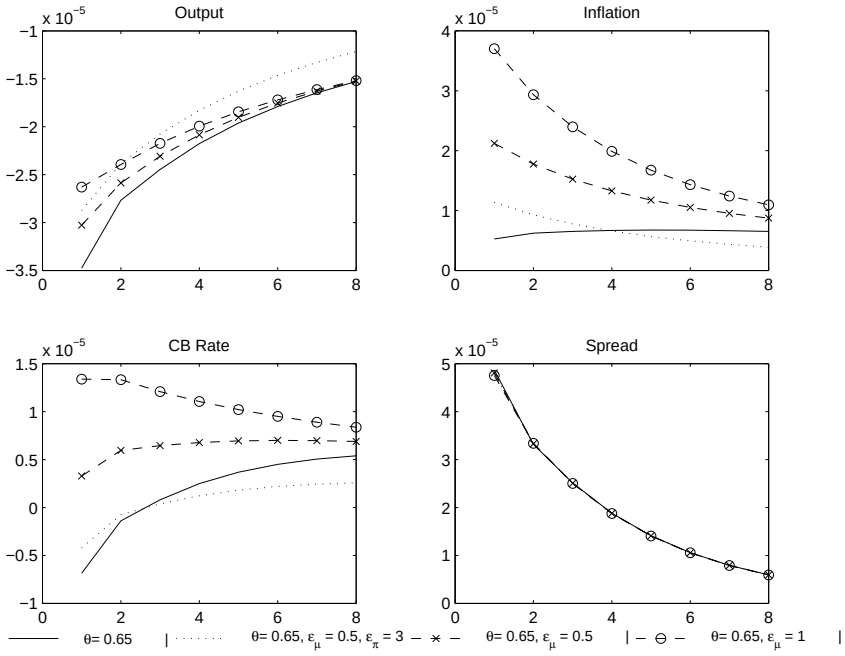


(b) Investment Shock

Figure 7: Banking Shock



(a) Low Persistence - $\rho = 0.3$



(b) High Persistence - $\rho = 0.75$

Figure 8: (More) Persistent Spread Movements

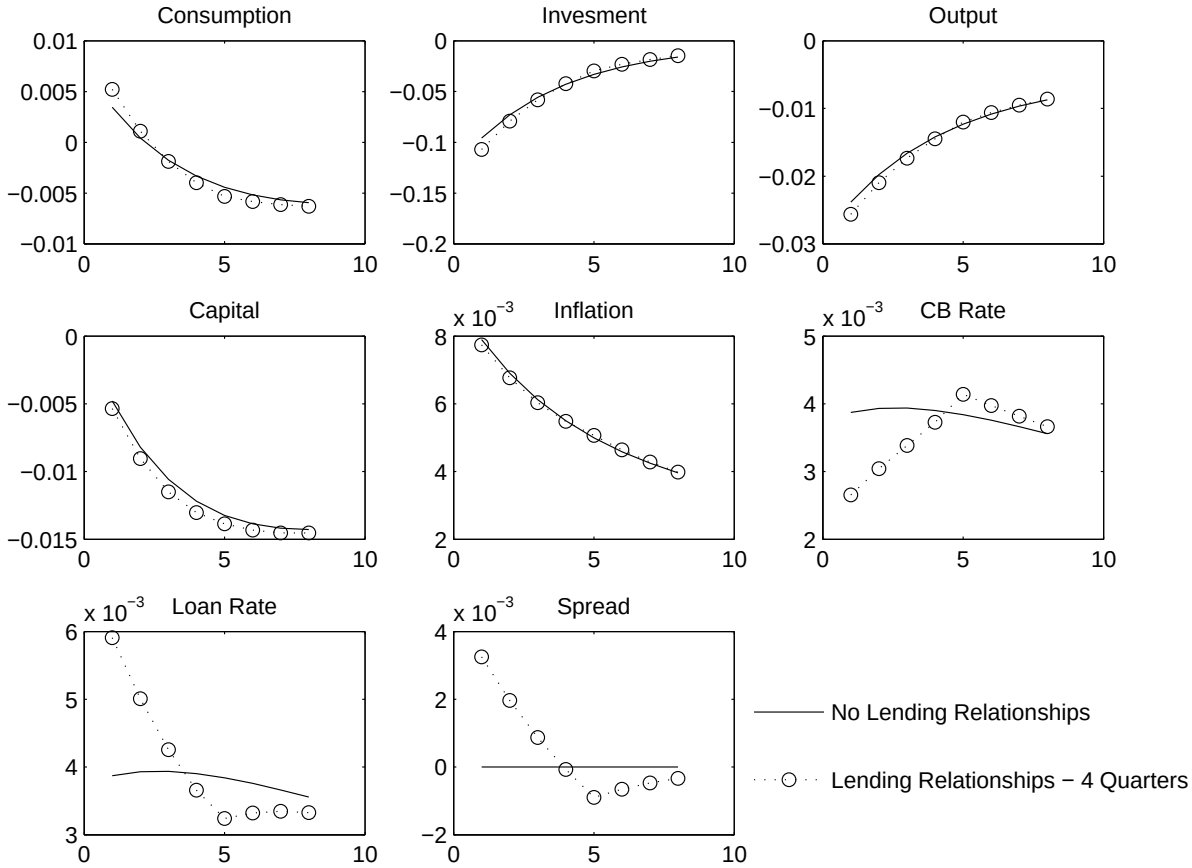
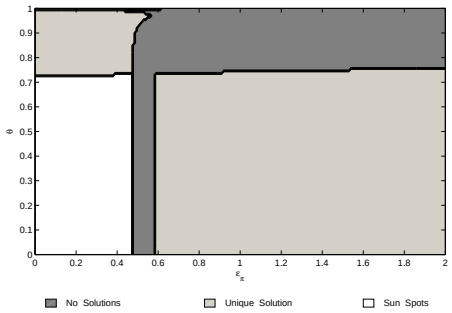
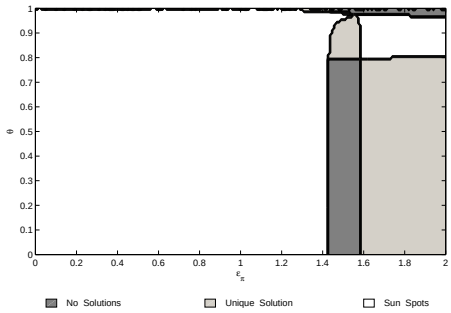


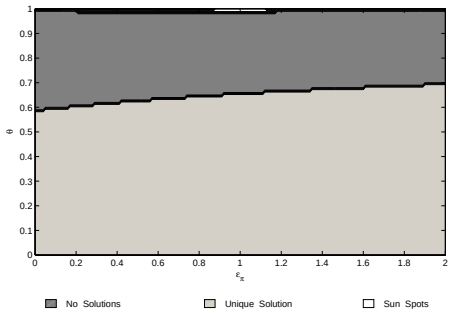
Figure 9: Indeterminacy Analysis - Effect of Firm-Bank Relationship



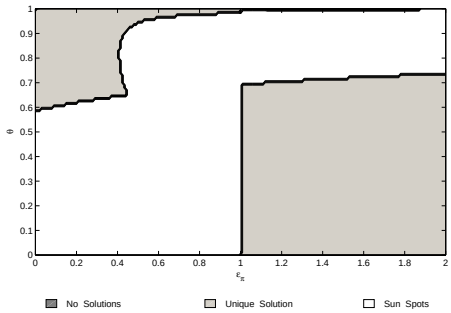
(a) Varying ϵ_π setting $\epsilon_y = 0.5$, $\epsilon_r = 1$



(b) Varying ϵ_π setting - $\epsilon_y = 0.5$, $\epsilon_r = 0$

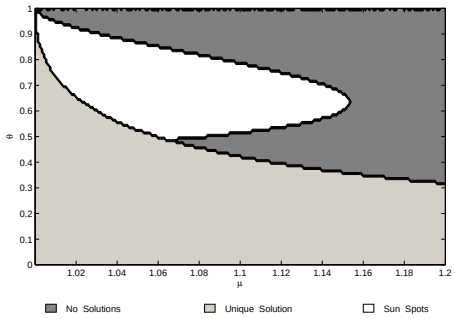


(c) Varying ϵ_π setting - $\epsilon_y = 0$, $\epsilon_r = 1$

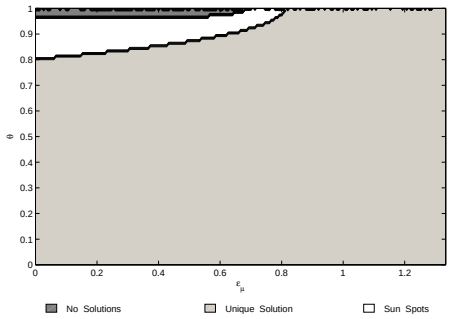


(d) Varying ϵ_π setting - $\epsilon_y = 0$, $\epsilon_r = 0$

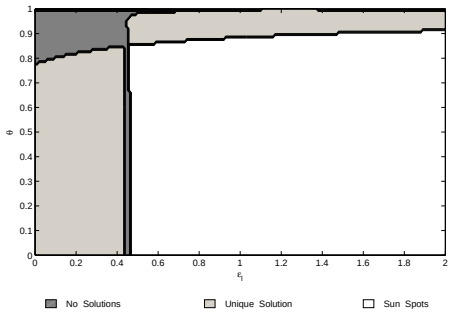
Figure 10: Indeterminacy Analysis - Alternative Steady State Spread and Policy Rules - Setting $\epsilon_\pi = 2$, $\epsilon_y = 0.5$ and $\epsilon_r = 0$



(a) Effect of Increasing Steady State Spread



(b) Spread-Adjusted Policy Rule



(c) Credit-Adjusted Policy Rule