

On the Cyclicity of Credit*

Ufuk Devrim Demirel[†]

University of Colorado at Boulder

Abstract

This study documents the cyclical properties of business credit in the U.S. and in the Euro area and constructs a theoretical model that can successfully replicate the observed characteristics. I find that real business loans lag output, i.e., business credit is more strongly correlated with past output than with current output. Furthermore, real business loans correlate negatively with future output and investment and positively with past output and investment. I show that a fairly standard model of business and credit fluctuations with agency costs can neither generate the lagging behavior of business credit nor can it induce the observed cross-correlation patterns of output, investment, and business loans. I introduce a costly financial intermediation mechanism to an otherwise standard macroeconomic framework and show that the evolution of intermediary balance sheets and interaction of intermediation and agency costs can induce the observed regularities.

JEL classification: E32; E37; G00

Keywords: Financial intermediation; Business loans; Boom-bust cycles

*I would like to thank an anonymous reviewer, Marco Airaud, Martin Boileau, Jin-Hyuk Kim, Federico Ravenna and seminar and session participants at LeBow College of Business, Drexel University and at 2011 Midwest Macro Conference for valuable comments and suggestions.

[†]University of Colorado at Boulder, Department of Economics, 256 UCB, Boulder, CO, 80309, USA, tel: (303) 492 2585, email:demirel@colorado.edu.

1 Introduction

The recent financial turmoil and the ensuing recession have spurred a great deal of interest in understanding the role of credit markets in macroeconomic fluctuations. Driven by what many view as outright failure of some of the conventional approaches to account for certain key aspects of the recent crisis, a rapidly expanding literature is reevaluating the interaction of financial markets with the broader economy [see, e.g., Jermann and Quadrini (2012), Liu et al. (2011), Gertler and Kiyotaki (2010), Gilchrist et al. (2009), Kiyotaki and Moore (2008)]. These studies naturally emphasize various forms of credit market imperfections as well as financial sector shocks and investigate their implications in a variety of frameworks. Surprisingly, however, very little has been done to formally evaluate whether the adopted frameworks are consistent with some of the most basic cyclical properties of credit. In this paper, I seek to fill this gap by addressing two basic questions: What are the cyclical properties of credit? What type of model structure is consistent with these characteristics?

The analysis consists of an empirical and a theoretical component. In the empirical part, I focus on identifying the cyclical behavior of business loans in the United States and in the Euro area. In the United States, business loans are defined as total commercial and industrial credit originated by all commercial banks. In the Euro area, they correspond to monetary and financial institutions' loans to non-financial corporations. I find that, in the United States as well as in the Euro area, the cyclical dynamics of business loans are characterized by two distinct properties: 1- Business loans lag output, i.e., current loans are more strongly correlated with past output than current output. 2- Current business loans are positively correlated with past output and investment but negatively correlated with future output and investment. These co-movement patterns are found to be robust under alternative filtering methods and frequency bands.

In the theoretical part, I construct a dynamic-stochastic model that can replicate these findings. I argue that the observed cross-correlation pattern can be interpreted as having been driven by *boom-bust* cycles in output, investment, and loans. I propose a structure that produces an initial boom and a subsequent collapse in output and investment in conjunction with a gradual expansion of business credit in response to a positive productivity shock. The gradual increase in business loans implies a stronger correlation between current output and future loans than between current output and current loans, which is consistent with the lagging behavior of business credit. Furthermore, the gradual expansion of loans and the future collapse in output and investment, taken together, are consistent with a negative correlation between current loans and future output and investment. The theoretical framework is designed so as to induce these response properties in the face of a productivity shock.

I study an economy in which producers must rely heavily on external finance to cover operational costs. Financial intermediaries provide working capital loans to producers in a market characterized by agency problems and costly financial monitoring. Agency costs play a crucial role in driving the observed cross-correlation pattern. The model also features price stickiness in

the final goods sector and an interest rate feedback rule specification, which control for the role of monetary policy as emphasized in Christiano et al. (2008a, 2007).¹ However, the key element in the model that drives the observed cross-correlation profile has to do with the way in which business loans are originated by financial intermediaries. I introduce a setting where financial intermediaries use external as well as internal funds to originate business loans. Internal funds correspond to intermediaries' own net worth (i.e., equity capital) while external funds consist of household deposits and funds raised in the interbank market. In the model, the intermediary can costlessly transform its internal funds into business loans. However, real resources must be used up in the process of raising and managing external funds, which makes it costly to produce loans using externally raised funds. I show that the interaction of intermediation and agency costs can transform what would otherwise be an ordinary shock to labor productivity into a major boom-bust episode and yield the observed cross-correlation properties.

The mechanism that induces the boom-bust cycle and the lagging behavior of business loans works as follows: In the model, intermediaries' internal funds (net worth) are predetermined at the start of each period, thus, cannot be adjusted in response to shocks upon impact. As a result, in response to a positive productivity shock, intermediaries accommodate the increase in loan demand by raising more external funds. Since increased reliance on external funds raises the marginal cost of loan production, producers limit the increase in their loan demand to avoid a sharp increase in the risk premium they face. This constrains the initial expansion of credit in equilibrium relative to a costless-intermediation economy. However, as intermediary net worth accumulates over time, reliance on externally raised funds declines, which gradually reduces the marginal cost of loan production. This results in a hump-shaped response profile for loans and induces the lagging behavior of business credit. The initial weakness of the increase in loan demand coupled with the sharp expansion of supply leads to a steep fall in the risk premium producers face. This brings about a substantial increase in output and investment beyond the levels that would obtain in the absence of intermediation costs. However, as business loans build up gradually and supply of loans start to decline in tandem with firms' productivity, the interest rate faced by producers and the aggregate bankruptcy rate start to rise and eventually exceed their pre-shock levels. As business bankruptcies become more frequent, resources destroyed during financial monitoring become more substantial. This exacerbates the contraction in output and leads to the bust phase of the cycle.

The literature on credit markets pioneered by Bernanke et al. (1999) and Carlstrom and Fuerst (1997) has primarily studied the implications of financial frictions on the real (non-financial) sector. In these studies, model dynamics are driven by a minimal set of reduced-form shocks that are consistent with microeconomic evidence and agency costs play the key role in amplification and propagation of real shocks. In part as a reaction to this exclusive focus on the real sector, recent studies by Gertler and Kiyotaki (2010), Chugh (2010), Gertler and Karadi

¹Christiano et al. (2008a) demonstrate that, under wage stickiness, an inflation targeting regime described in the form of a Taylor rule can trigger boom-bust cycles in the face of news shocks.

(2009), and Christiano et al. (2008b) emphasize the implications of financial sector disturbances and frictions. In a related branch of the literature, Gomes and Schmid (2010) and Miao and Wang (2010) focus on the cyclicity of credit spreads firms face in financial markets. Gomes and Schmid (2010) incorporate capital structure decisions into an asset pricing model populated by heterogeneous firms and evaluate the impact of endogenous fluctuations in credit risk premia. In their model, countercyclical movements in credit spreads forecast future fluctuations in output and investment, which is in line with empirical findings. Miao and Wang (2010) introduce long-term defaultable corporate bonds to a dynamic-stochastic general equilibrium model in which heterogeneous firms form optimal debt/equity decisions by weighing the tax benefits of debt against bankruptcy and agency costs. In their model, credit spreads are countercyclical and forecast future growth of output and investment, which is also consistent with the empirical evidence.

The previous literature on financial frictions has mainly focused on replicating the contemporaneous correlations between financial and real variables. This paper contributes to the literature by identifying the previously overlooked co-movement characteristics of business credit, output, and investment at leads and lags. To the best of my knowledge, this is the first study to explicitly document and theoretically address the lead/lag patterns of the cross-correlations between business credit and measures of real economic activity. I highlight the lagging behavior of business credit and document the sign-switch in cross-correlations from positive to negative as we move from past to future correlations. Then, I show that a fairly standard model of credit and business fluctuations that relies entirely upon the agency cost mechanism cannot generate the observed correlation structure. Yet, I also find that one need not revert to several arbitrary reduced-form shock specifications to account for the key empirical findings. The observed correlation patterns as well as the lagging behavior of business loans can be simultaneously induced when financial intermediation frictions are incorporated into the model alongside agency costs.

The remainder of the paper is organized as follows: Section 2 establishes the empirical regularities explained in the theoretical part. Section 3 presents the theoretical model and discusses the mechanisms that deliver the correlation and lead-lag patterns observed in data. Section 4 lays out the estimation strategy and discusses the properties of the estimated model with particular emphasis on intermediation and agency costs. Section 5 summarizes the results and suggests potential directions for future research.

2 Empirical Analysis

This section explores the cross-correlation characteristics of real business loans, output, and investment in the United States and in Euro area.

2.1 Static Correlations

I start the analysis by computing a series of correlations between real business loans, output (real GDP), and real investment using the United States and Euro area data. Business loans in the United States are defined as all commercial and industrial loans originated by all commercial banks.² In the Euro area, business loans correspond to monetary and financial institutions' (MFIs) loans to non-financial corporations in the Euro zone.³ For both economies, business loans are defined in levels. I use seasonally-adjusted quarterly data and focus on the co-movement patterns of the cyclical components of each series, which are recovered using a Hodrick-Prescott (HP) filter. I also report the results obtained using a 1st difference filter. Note that, while contemporaneous correlations can provide valuable descriptive statistics, an analysis based entirely on this measure is likely to miss important dynamic interactions. To investigate some of these dynamic aspects, I also compute the correlations between current business loans and a certain number of leads and lags of the real GDP and investment.

As can be seen in Table 1, contemporaneous correlations suggest a procyclical stance for real business loans in the United States. It is observed that, while past output is positively correlated with current loans, the correlations between future output and current loans are negative. In addition, the contemporaneous correlation between current loans and current output is weaker than those between current loans and lagged output. A similar cross-correlation pattern is revealed for real business loans and investment. Current loans are more strongly correlated with past investment than with current investment. The estimated correlation coefficients are statistically significant and the same pattern is observed when the 1st difference filter is used.

Table 2 displays the estimates for the Euro area. We observe a similar cross-correlation and lead/lag structure for the Euro zone. Contemporaneous loans are more strongly correlated with past output and investment than with current output and investment. Furthermore, the positive correlations between current loans and past output and investment become negative for future output and investment.

As will be discussed later in detail, the theoretical model adopted to interpret the observed patterns features one-period loan contracts. The results reported in Table 1 and Table 2, however, are computed using loans data that is aggregated across varying maturity types. To assess the sensitivity of the results and to facilitate better comparison with the theoretical model, I next evaluate the correlation patterns for short-term loans in the U.S. and in the Euro area. For the U.S., I use data from *Survey of Terms of Business Lending* (conducted and released by the U.S. Federal Reserve) and only consider the loans that mature in less than 31 days. For the Euro area, I use data from monetary and financial institutions' (MFIs) balance sheet statistics (BSI statistics) provided by the European Central Bank and focus on the loans to non-financial

²The U.S. dataset runs from 1947:1 through 2012:1. Source: Federal Reserve Economic Data (FRED) of St. Louis Fed.

³Euro area data runs from 1997:3 through 2011:4. Source: European Central Bank's Statistical Data Warehouse.

corporations that mature in less than 1 year. Table 3 reports the results obtained using the short-term loans data.⁴ It is observed that short-term loans exhibit similar co-movement characteristics with aggregated loans. In the United States as well as in the Euro area, short-term loans are found to lag output. Furthermore, positive correlations between current short-term loans and past output and investment turn negative for current short-term loans and future output and investment.

2.2 Dynamic Correlations

In order to assess the robustness of these results, following Croux et al. (2001), I next compute dynamic correlations. This measure provides a richer characterization of co-movement patterns and dynamic interactions by describing how variables correlate at different frequency bands. Since we are primarily concerned with identifying the cyclical behavior of business credit, dynamic correlations prove particularly useful as they allow us to assess co-movement specifically at business cycle frequencies.

Let $\rho(W)$ denote the dynamic correlation between two covariance-stationary processes x_t and y_t at the frequency band $W \in [-\pi, \pi]$. Croux et al. (2001) show that $\rho(W)$ corresponds to the static correlation between x_t and y_t after an appropriate band-pass filter (one that isolates the cycles with frequencies that fall into the band W) is applied to both x_t and y_t . Therefore, as explained in Appendix I in detail, the dynamic correlation at the band W is given by

$$\rho(W) = \text{corr}[Z_W(L)x_t, Z_W(L)y_t],$$

where $Z_W(L)$ is a two-sided lag polynomial representing in the time-domain the band-pass filter designed to eliminate the cycles with frequencies outside of W .

Next, I employ the approximate band-pass filtering methods developed by Baxter and King (1999) to compute dynamic correlations of real business loans, output, and investment. Band-pass filters isolate the periodic components with frequencies within a specified band. Tables 4 and 5 exhibit the dynamic correlations for aggregate and short-term real loans, respectively. Correlations are calculated for ± 4 quarters of leads and lags of output and investment using the U.S. and the Euro area data.⁵ To evaluate the co-movement patterns at different frequency bands, two alternative band-pass filters are considered: The first one (BP_{6-32}) isolates the business cycle frequencies, i.e., cycles with periodicities between 6 and 32 quarters. The second one (BP_{24-64}) picks lower frequency cycles with periodicities between 24 and 64 quarters.⁶ It is

⁴Figures in Table 3 are computed using HP-filtered data. In this exercise, the U.S. and the Euro area datasets respectively run from 1997:2 to 2012:1 and from 1997:3-2011:4.

⁵In this exercise, aggregate loans data runs from 1974:1 to 2010:1 for the United States.

⁶To calculate the cross-correlations with aggregate loans, I use an approximate band-pass filter with a moving-average representation that includes ± 12 leads and lags, which is motivated by the findings of Baxter and King (1999). To calculate the cross-correlations with short-term loans, I use a filter with ± 6 leads and lags in the moving average representation. This serves to limit the number of observations dropped from the short-term

found that, in both frequency bands and for aggregate as well as short-term loans, dynamic cross-correlations share the previously highlighted common pattern: While current business loans are positively correlated with past and current output and investment, they correlate negatively with future output and investment. Furthermore, business loans correlate more strongly with past output and investment than with current output and investment. These findings characterize both the U.S. and the Euro area data and are in line with the results obtained earlier by using 1st difference and HP filters.

2.3 Level vs. Flow

Correlation statistics presented thus far have been calculated using level data, i.e., aggregate real loans are measured as outstanding amounts in each period. The correlation results obtained using level data are consistent with the findings of Covas and den Haan (2011). Using yearly firm-level data, Covas and den Haan (2011) find that firms' debt issuance is procyclical in the United States. They also find that current debt is more strongly correlated with past output (defined as the gross real product of the corporate sector) than with current output and is negatively correlated with next year's output.

In addition to the level approach, Covas and den Haan (2011) also consider defining debt as a flow variable. The flow of debt in a particular period is measured as the change in the level of debt during that period. Along similar lines, I next reevaluate the correlation patterns using flow data. Table 6 shows that, when measured as a flow variable, business loans cease to exhibit the previously emphasized lagging behavior.⁷ Furthermore, the cross-correlation patterns (particularly the sign-switch from positive to negative) that characterize the level data also disappear. These results are again consistent with the findings of Covas and den Haan (2011) for the flow case. In the following theoretical analysis, we shall study the cyclical behavior of loan levels rather than flows. For this reason, in the calibration exercise, we shall seek to replicate the correlation statistics obtained using the level data.

3 Model

Having identified the cross-correlation properties of output, investment and business loans, I next proceed to construct a theoretical model that can replicate the observed patterns. The adopted framework builds on the basic structure laid out in Demirel (2009). The model economy is inhabited by five types of agents: Households, producers, retailers, financial intermediaries, and a government.

loans series, which is only about half as long as the aggregate loans series.

⁷In the flow exercise, aggregate loan data is used for both the U.S. and the Euro area. Flow of short-term loans exhibit similar cross-correlation and lead/lag patterns. Output and investment data are HP-filtered.

3.1 Households

Households are infinitely lived, identical and have time-separable preferences that depend on consumption of a private composite good and work effort. Households seek to maximize

$$U_s = E_s \sum_{t=s}^{\infty} \beta^{t-s} \left(\frac{C_t^{1-\sigma} - 1}{1-\sigma} - \frac{L_t^{1+\phi}}{1+\phi} \right) \quad (1)$$

where $\beta \in (0, 1)$ is the subjective discount factor, $\sigma > 1$ denotes the inverse of the intertemporal elasticity of substitution, $\phi > 0$ is the inverse of labor supply elasticity, the variable C_t denotes consumption and L_t stands for work effort. The consumption good is specified as a CES aggregate of a continuum of differentiated products indexed by $i \in [0, 1]$. More specifically, $C_t = \left(\int_i C(i)_t^{1-(1/\theta)} di \right)^{\theta/(\theta-1)}$ where $C(i)_t$ is the consumption of the i^{th} product and θ denotes the elasticity of substitution between differentiated products. This specification implies that the aggregate price index is $P_t = \left(\int_i P(i)_t^{1-\theta} di \right)^{1/(1-\theta)}$ where $P(i)_t$ denotes the price level for the i^{th} differentiated product. Note that the aggregate price index defines the minimum expenditure needed to assemble one unit of the composite consumption index. Furthermore, the CES specification implies that the optimal allocation of expenditures among differentiated products is governed by the rule $C(i)_t = (P(i)_t/P_t)^{-\theta} C_t$.

Households start each period with money and capital holdings of M_{t-1} and K_{t-1} . They provide capital and labor services to producers and make deposits at the financial intermediary. Expenditures on consumption and investment goods require cash. At the start of each period, the representative household receives wage and capital income in cash and makes consumption, investment and deposit (B_t^H) decisions. At the end of the period, households receive dividend payments from the financial intermediary, producer and retailer firms as well as principal plus interest on their deposits. The household also pays lump-sum taxes (T_t) in cash (or receives transfers) at the end of each period. Then, the relevant constraints for the household problem can be constructed as

$$M_t \leq M_{t-1} - P_t(C_t + I_t) - B_t^H + W_t L_t + R_t K_{t-1} - T_t + R_t^f B_t^H + \Gamma_t \quad (2)$$

$$P_t(C_t + I_t) \leq M_{t-1} + W_t L_t + R_t K_{t-1} - B_t^H \quad (3)$$

$$\Gamma_t = \int_i \Gamma(i)_t^r di + \int_j \Gamma(j)_t^m dj + \Gamma_t^I \quad (4)$$

where $I_t = K_t - (1 - \delta)K_{t-1}$, the variables W_t and R_t denote the nominal wage and capital rental rates, R_t^f stands for the gross nominal risk-free interest rate, $\int_i \Gamma(i)_t^r di$, $\int_j \Gamma(j)_t^m dj$ and Γ_t^I respectively denote the dividends distributed by retailers, producers and financial intermediaries in nominal terms. Equation (2) is the the sequential budget constraint and (3)

describes the cash-in-advance constraint which states that consumption and investment expenditures cannot exceed nominal balances at the start of the period net of bank deposits. The household chooses the sequences $\{C_t, I_t, L_t, B_t^H, M_t\}_{t=s}^{\infty}$ to maximize (1) subject to (2)-(4) given $\{W_t, R_t, P_t, R_t^f, T_t, \Gamma_t\}_{t=s}^{\infty}$ and the initial values $M_{s-1}, K_{s-1} > 0$. Household optimization yields

$$C_t^{-\sigma} = \beta E_t \left[R_t^f \frac{P_t}{P_{t+1}} C_{t+1}^{-\sigma} \right] \quad (5)$$

$$C_t^{-\sigma} = \beta E_t \left[\left(1 - \delta + \frac{R_{t+1}}{P_{t+1}} \right) C_{t+1}^{-\sigma} \right] \quad (6)$$

$$\frac{L_t^\phi}{C_t^{-\sigma}} = \frac{W_t}{P_t} \quad (7)$$

$$P_t(C_t + I_t) = M_{t-1} + W_t L_t + R_t K_{t-1} - B_t^H. \quad (8)$$

Expressions (5) and (6) are the familiar intertemporal substitution equations associated with the optimal deposit and capital accumulation decisions and (7) is the standard labor supply equation. In addition, the cash-in-advance constraint must bind, as suggested by (8), in an equilibrium with a positive net nominal interest rate.

3.2 Producers

The economy is inhabited by a large number of manufacturing firms indexed by $j \in [0, 1]$. Producers hire labor and capital services from competitive factor markets and use a Cobb-Douglas production technology to produce homogenous goods. Manufactured products are then used by retailer firms as intermediate inputs to produce a final retail good.

Manufacturing firms are subject to idiosyncratic as well as aggregate uncertainty. Specifically, the amount of intermediate goods produced by producer j in period t ($Y(j)_{m,t}$) is given by

$$Y(j)_{m,t} = A(j)_t \tilde{K}(j)_{t-1}^\alpha (Z_t N(j)_t)^{1-\alpha} \quad (9)$$

with

$$\tilde{K}(j)_{t-1} = K(j)_{t-1} + \bar{K} \quad (10)$$

where $K(j)_{t-1}$ denotes the amount of capital used by producer j , the constant $\bar{K} > 0$ is a fixed factor of production that substitutes private capital services and is available to all producers in a similar fashion. The fixed factor \bar{K} can be thought to represent unpaid public services or infrastructure that support private production activities. The variable $N(j)_t$ denotes the amount of labor hired by producer j and Z_t is a labor-augmenting productivity parameter, which follows the process $\log Z_t = \rho_z \log Z_{t-1} + \varepsilon_{z,t}$ where $\varepsilon_{z,t} \sim N(0, \sigma_z^2)$ and $\rho_z \in [0, 1]$. The variable $A(j)_t$

is a firm-specific total factor productivity parameter distributed independently over time and across producers. This parameter is the source of idiosyncratic uncertainty in the model. For analytical simplicity, it is assumed that $A(j)_t$ is distributed uniformly on the support $[\underline{A}, \bar{A}]$ with $\bar{A} > \underline{A} \geq 0$ for all j and t .

Due to a friction in the mechanism that governs the transfer of funds from firms to the household, producers are required to pay for a certain fraction of their operational costs in advance. Each producer borrows the funds it needs to finance operational costs from financial intermediaries. As in Demirel (2009) and Cooley and Nam (1998), the amount of credit needed by producer j is given by

$$D(j)_t = \tau(W_t N(j)_t + R_t K(j)_{t-1}) \quad (11)$$

where $\tau > 0$ is the fraction of the costs that is required to be paid in advance. Given the production technology described by (9) and (10), the optimal factor demand decisions must satisfy

$$N_t = \left(\frac{D(j)_t}{\tau} + R_t \bar{K} \right) \frac{1 - \alpha}{W_t} \quad \text{and} \quad K_{t-1} = \left(\frac{D(j)_t}{\tau} + R_t \bar{K} \right) \frac{\alpha}{R_t} - \bar{K}. \quad (12)$$

Capital and labor demand functions expressed in (12) imply that a firm who borrows the amount $D(j)_t$ is able to produce

$$Y(j)_{m,t} = A(j)_t H(D(j)_t) \quad (13)$$

where

$$H(D(j)_t) = \left(\frac{D(j)_t}{\tau P_t} + \frac{R_t \bar{K}}{P_t} \right) \left[\frac{\alpha}{R_t/P_t} \right]^\alpha \left[\frac{(1 - \alpha) Z_t}{W_t/P_t} \right]^{1 - \alpha}. \quad (14)$$

The right-hand-side of (14) is obtained by incorporating the factor demand equations (12) into the production function (9).

3.3 Financial Intermediation

Financial intermediaries fund business projects by providing working capital loans to producers. To create these loans, the intermediary uses external as well as internal funds. External funds consist of household deposits and funds raised in an interbank market. Internal funds correspond to the intermediary's own net worth (i.e., equity capital). At the end of each period, external funds are repaid using the proceeds of the business loans.

In the interbank market, financial intermediaries trade one-period government bonds with the central bank. The central bank sets the return on the government bond (i.e., the risk-free interest rate R_t^f) by conducting open market operations in the interbank market. Note that since, in equilibrium, the interest rate on the funds an intermediary can raise in the interbank

market should be equal to the interest rate on the funds raised from households, the deposit rate households face must be equal to the risk-free interest rate R_t^f .

3.3.1 Loan Origination and Intermediary Net Worth

The financial intermediary enters period t with net worth of X_{t-1} and, at the start of the period, accepts deposits from households. In each period, the intermediary pours its entire net worth and external funds into business loans. The amount the intermediary lends to producers (denoted D_t) is then given by

$$D_t = B_t + X_{t-1} \quad (15)$$

where, $B_t = B_t^H + B_t^G$ denotes the external funds, which includes the amount households deposit into the intermediary (previously referred to as B_t^H) as well as the funds raised in the interbank market (denoted B_t^G). Equation (15) describes the intermediary's balance sheet. Note that X_{t-1} and B_t can be thought to represent the intermediary's equity capital and debt, respectively.

A key feature of the model is the presence of financial intermediation costs. In the loan production process, the intermediary can costlessly transform its internal funds into business loans. However, to convert externally raised funds into loans, the intermediary must use up real resources. These resources are consumed in the process of collecting and managing these funds. There are two types of intermediation costs in the model. The first type is a fixed time cost. It is assumed that each intermediary is endowed with a fixed amount of labor time denoted $L^I > 0$. In order to originate loans, an intermediary must dedicate all of its time to the process of loan production. The second type is a variable intermediation cost. As in Curdia and Woodford (2009), variable costs are described by a function $G(b_t) > 0$ that satisfies the properties

$$G'(\cdot) > 0 \quad \text{and} \quad G''(\cdot) > 0, \quad (16)$$

where $b_t = B_t/P_t$.⁸ As mentioned in Curdia and Woodford (2009), a strictly convex intermediation cost function may arise due to a capacity constraint or scarcity of managerial resources. In this paper, I do not seek to explicitly model the exact source of variable intermediation costs. Instead, I evaluate its implications and show that it can help to understand the previously discussed empirical findings. Also note that, due to the convexity of (16), the marginal cost of loan production increases in the volume of loans originated but decreases in the intermediary's net worth. As shall be discussed later in detail, this property (together with the time evolution of intermediary net worth) plays an important role in driving the co-movement patterns discussed in the empirical section.

⁸Financial intermediation costs are defined in terms of final (retail) goods.

3.3.2 The Loan Contract

The loan contract between the typical intermediary and the producer is characterized by an asymmetric information structure in which producers have private information about their idiosyncratic productivity, however, financial intermediaries can access that information only at a cost. At the start of each period, *ex ante* identical producers submit loan applications to acquire working capital. If a loan application is accepted, the requested amount is provided to the producer at the lending rate determined in the contract. After the loan transaction, idiosyncratic uncertainty resolves and production takes place. At the end of the period, a producer may choose to default on its loan in which case all of its manufacturing revenue is confiscated by the financial intermediary. As in Bernanke et al. (1999) and Carlstrom and Fuerst (1997), upon a default decision, the financial intermediary's attempt to monitor the real state of the producer results in a loss of output defined as a fraction $\mu \in [0, 1]$ of $H(D(j)_t)$. This assumption leads to the well known costly state verification setup studied in Townsend (1979).

The default decision of the producer is characterized by a critical productivity level $A(j)_t^*$. If the realization of $A(j)_t$ is above this threshold level the producer fully repays the loan and the interest. The producer declares default if otherwise. Since all producers are *ex ante* identical, their default thresholds, factor and loan demand decisions are similar. Therefore, a symmetric equilibrium involves $A(j)_t^* = A_t^*$ and $D(j)_t = D_t$ for all $j \in [0, 1]$. Dropping the firm index, the expected producer profit can be expressed as

$$\Gamma_t^m = \int_{A_t^*}^{\bar{A}} \left(Q_t A_t H(D_t) - R_t^l D_t \right) dF(A_t) \quad (17)$$

where Q_t denotes the price of the intermediate product and R_t^l denotes the gross lending rate on the loan.⁹ Likewise, the expected revenue of the intermediary can be expressed as

$$\int_{\underline{A}}^{A_t^*} Q_t (A_t - \mu) H(D_t) dF(A_t) + \int_{A_t^*}^{\bar{A}} R_t^l D_t dF(A_t). \quad (18)$$

Note that (18) includes loan repayments in the case the producer remains solvent (when $A_t^* \leq A_t \leq \bar{A}$) as well as confiscated revenue in the case the producer defaults (when $\underline{A} \leq A_t \leq A_t^*$), taking into account the loss of output resulting from the attempt to monitor the state of the producer upon a default decision.

An intermediary approves a credit application as long as the loan contract promises to deliver an expected return that is greater than or equal the loan's total opportunity cost. Note that, at the start of each period, an intermediary has the option of investing its entire net worth in government bonds. Also, in the process of loan origination, the intermediary must incur the fixed time cost and variable costs defined by (16). Therefore, by agreeing to originate the

⁹Producer profits are directly transferred to the household budget through dividend payments $\Gamma(j)_t^m$. Since producers are *ex ante* identical, we have $\Gamma(j)_t^m = \Gamma_t^m \forall j \in [0, 1]$.

requested business loan, the intermediary effectively gives up the interest income its designated net worth can yield in the interbank market as well as the wage income its time endowment can earn in the labor market. In addition, the variable cost of transforming external funds into loanable funds must also be covered. Therefore, the following condition must be satisfied for a loan application to be approved:

$$\int_{\underline{A}}^{A_t^*} Q_t(A_t - \mu)H(D_t)dF(A_t) + \int_{A_t^*}^{\bar{A}} R_t^l D_t dF(A_t) \geq R_t^f D_t + P_t G(b_t) + W_t L^I \quad (19)$$

As discussed above, the left-hand side of (19) is the expected revenue of the intermediary from a loan operation. The right-hand side of (19) corresponds to the total opportunity cost of a loan. It includes the cost of external funds, the interest foregone on the designated internal funds as well as the value of the real resources (including labor time) that must be used up in the origination process.

The threshold value, A_t^* , is the productivity level at which the producer is indifferent between declaring default and repaying the loan and the interest. That is, $Q_t A_t^* H(D_t) = R_t^l D_t$. Incorporating this definition into (17) and (19), the producer problem can be compactly rewritten as

$$\max_{D_t, A_t^*} Q_t \phi(A_t^*) H(D_t) \text{ subject to } Q_t \gamma(A_t^*) H(D_t) \geq R_t^f D_t + P_t G(b_t) + L^I W_t, \quad (20)$$

where $\phi(A_t^*) = \int_{A_t^*}^{\bar{A}} (A_t - A_t^*) dF(A_t)$ and $\gamma(A_t^*) = \int_{\underline{A}}^{A_t^*} (A_t - \mu) dF(A_t) + \int_{A_t^*}^{\bar{A}} A_t^* dF(A_t)$. Note that the optimal demand for business loans described by the solution of (20) immediately translates into labor and capital demand decisions through (12). Given (14), the first-order optimality conditions can be expressed as

$$\frac{Q_t}{\tau P_t} \left[\frac{\alpha}{R_t/P_t} \right]^\alpha \left[\frac{(1-\alpha)Z_t}{W_t/P_t} \right]^{1-\alpha} = \frac{R_t^f + G'(b_t)}{\Phi(A_t^*)} \quad (21)$$

$$\frac{Q_t}{P_t} \gamma(A_t^*) H(D_t) = R_t^f d_t + G(b_t) + L^I \frac{W_t}{P_t} \quad (22)$$

with

$$\Phi(A_t^*) = \frac{\phi'(A_t^*) \gamma(A_t^*) - \gamma'(A_t^*) \phi(A_t^*)}{\phi'(A_t^*)}, \quad (23)$$

where $d_t = D_t/P_t$, $\phi'(A_t^*) = \partial \phi(A_t^*) / \partial A_t^*$ and $\gamma'(A_t^*) = \partial \gamma(A_t^*) / \partial A_t^*$.¹⁰

Expression (21) describes the producer's loan demand. The left-hand side of (21) is the expected real revenue created by an additional dollar of loan. The right-hand side is the marginal cost of the loan. The term $G'(b_t)$ represents the impact of variable intermediation costs on the

¹⁰See Appendix II for a detailed derivation of the first order conditions.

marginal cost of working capital loans. Note that equilibrium cost of borrowing also includes a default-risk premium embedded in the expression $\Phi(A_t^*)$ in addition to the risk-free interest rate R_t^f .

Equation (22) describes the supply of risky producer loans. According to (22), the producer is able to borrow until the participation constraint of the intermediary binds. Equations (21) and (22) jointly determine the equilibrium default rate and loan volume.

For future reference note that, given (13), aggregate output in the manufacturing sector can be found as

$$\int_j Y(j)_{m,t} dj = \int_{j \in \Lambda_t} (A(j)_t - \mu) H(j)_t dj + \int_{j \notin \Lambda_t} A(j)_t H(j)_t dj \quad (24)$$

where the set Λ_t corresponds to the group of producers that choose to default in period t . That is,

$$\Lambda_t = \{j \in [0, 1] : A(j)_t < A(j)_t^*\}.$$

In a symmetric equilibrium, (24) reduces to

$$Y_{m,t} = \xi(A_t^*; \mu) H_t$$

where

$$\xi(A_t^*; \mu) = \int_{\underline{A}}^{A_t^*} (A_t - \mu) dF(A_t) + \int_{A_t^*}^{\bar{A}} A_t dF(A_t). \quad (25)$$

Note that the function $\xi(A_t^*; \mu)$ is inversely related to the fraction of output that is destroyed during financial monitoring. In this sense, it captures the physical impact of agency costs in the model. In a version of the model economy in which agency issues do not result in any loss of output, we would have $\xi(A_t^*; \mu) = E[A_t] = (\bar{A} + \underline{A})/2$.¹¹ The implications of agency costs in the model will later be assessed by comparing the case $\xi(A_t^*; \mu) = (\bar{A} + \underline{A})/2$ with the full model specification, which involves (25) with $\mu > 0$.

3.3.3 Evolution of Intermediary Net Worth

Time evolution of intermediary net worth plays a central role in the model by generating a crucial propagation mechanism. In order to determine the evolution of X_t , however, one also needs a characterization for the intermediary's dividend policy. To this end, the intermediary is assumed to maximize the discounted sum of present and future dividend payments to households. The objective function of the intermediary is then given by

$$E_s \sum_{t=s}^{\infty} \Lambda_{t,s} \Gamma_t^I, \quad (26)$$

¹¹As an example, consider a case in which households provide financial monitoring services to intermediaries and are paid a fee in exchange for their monitoring services. Thus, even though default is costly from the viewpoint of financial intermediaries in the sense that they still face a costly state verification problem, it does not result in any loss of output in the economy.

where

$$\Lambda_{t,s} = \beta^{t-s} \frac{C_t^{-\sigma}/P_t}{C_s^{-\sigma}/P_s}. \quad (27)$$

The variable $\Lambda_{t,s}$ represents the stochastic discount factor with which the intermediary values future random payouts and, as noted earlier, Γ_t^I denotes dividend payments to households.¹² Following Jermann and Quadrini (2012), it is assumed that the intermediary faces a quadratic payout cost of the form

$$\frac{\omega}{2} \left(\frac{\Gamma_t^I}{X_t} - \eta \right)^2,$$

where $\omega \geq 0$, and η can be thought of as a long-term target value for the ratio of dividends to net worth.¹³ This specification serves to pin down the equilibrium dividend payments in the model, which is needed to fully determine the evolution of the intermediary net worth. But perhaps more importantly, the payout costs result in dividend smoothing in equilibrium, which falls in line with empirical observations as discussed in Jermann and Quadrini (2012).

Given a sequence for Γ_t^I , intermediary net worth evolves according to the rule

$$X_t = Q_t \gamma(A_t^*) H(D_t) - R_t^f B_t - P_t G(b_t) - \Gamma_t^I - P_t \frac{\omega}{2} \left(\frac{\Gamma_t^I}{X_t} - \eta \right)^2 + \varphi_t. \quad (28)$$

The random variable φ_t represents a liquidity shock. It follows the process $\varphi_t = \rho_\varphi \varphi_{t-1} + \varepsilon_{\varphi,t}$ where $\varepsilon_{\varphi,t} \sim N(0, \sigma_\varphi^2)$ and $\rho_\varphi \in [0, 1)$. Plugging the definition $B_t = D_t - X_{t-1}$ in (28), we find

$$X_t = \left[\frac{Q_t \gamma(A_t^*) H(D_t)}{D_t} - R_t^f \right] D_t + R_t^f X_{t-1} - P_t G(b_t) - \Gamma_t^I - P_t \frac{\omega}{2} \left(\frac{\Gamma_t^I}{X_t} - \eta \right)^2 + \varphi_t. \quad (29)$$

Note that the term $\frac{Q_t \gamma(A_t^*) H(D_t)}{D_t}$ corresponds to the gross return on producer loans. Therefore, the bracketed term in (29) gives the excess return (i.e., the premium above the risk-free rate) on business loans. Observe that a positive excess return on loans results in a growth in intermediaries' equity capital that is beyond the risk-free return.

Given an initial value $X_{s-1} \geq 0$, the intermediary chooses the sequences $\{\Gamma_t^I, X_t\}_{t=s}^\infty$ to maximize (26) subject to (29). Given the definition (27), intermediary maximization yields

$$\frac{c_t^{-\sigma}}{1 + \frac{\omega}{x_t} \left(\frac{\gamma_t^I}{x_t} - \eta \right)} = \beta E_t \left\{ \frac{R_{t+1}^f}{\pi_{t+1}} \left[1 - \frac{\omega \gamma_t^I}{x_t^2} \left(\frac{\gamma_t^I}{x_t} - \eta \right) \right]^{-1} \frac{c_{t+1}^{-\sigma}}{1 + \frac{\omega}{x_{t+1}} \left(\frac{\gamma_{t+1}^I}{x_{t+1}} - \eta \right)} \right\}, \quad (30)$$

where $\gamma_t^I = \Gamma_t^I/P_t$ and $x_t = X_t/P_t$. Equation (30) describes the intermediary's optimal payout policy and characterizes the corresponding time evolution of its net worth. Left-hand side of

¹²Intermediaries value future random payouts on the basis of households' subjective discount factor and marginal utility of income.

¹³Payout costs are defined in terms of retail goods.

(30) corresponds to the utility gain resulting from a marginal increase in real dividends in period t reduced by the cost of having to deliver that increment in real dividends. Right-hand side of (30) describes the discounted utility gain from a marginal increase in net worth in period t , which delays the dividend payment to period $t + 1$, taking into account the marginal cost of dividend payments at time $t + 1$ as well as the decrease in the cost of dividend payments in period t resulting from the increment in time t net worth (captured by the inverted term in brackets).

3.4 Retailers

The economy is also inhabited by a large number of monopolistically competitive retailer firms. Retailers transform manufactured products into differentiated goods using a constant-returns-to-scale technology. Specifically, the number of differentiated goods produced by the i^{th} retailer is given by

$$Y(i)_t = \bar{X}Y(i)_{m,t} \quad (31)$$

where $Y(i)_{m,t}$ denotes the amount of manufactured inputs used by the retailer i and $\bar{X} > 0$ is a productivity parameter. Each firm sets the price level for its differentiated product to maximize expected present and future discounted profits. Following Rotemberg (1982), firms are assumed to face quadratic price adjustment costs given in real terms by $\frac{\kappa}{2} \left(\frac{P(i)_t}{P(i)_{t-1}} - \bar{\pi} \right)^2$ with $\kappa > 0$ and where $\bar{\pi} > 0$ denotes the steady-state gross inflation rate. This specification introduces price stickiness to the model, which in turn allows for a meaningful account of the role played by monetary policy in the transmission of the shocks that give rise to the observed correlation patterns. Retailer i solves the problem

$$\max_{\{P(i)\}_{t=s}^{\infty}} E_s \sum_{t=s}^{\infty} \Lambda_{t,s} \Gamma(i)_t^r$$

where

$$\Gamma(i)_t^r = (P(i)_t - MC_t)Y(i)_t - P_t \frac{\kappa}{2} \left(\frac{P(i)_t}{P(i)_{t-1}} - \bar{\pi} \right)^2,$$

and $MC_t = Q_t/\bar{X}$. The stochastic discount factor $\Lambda_{t,s}$ is as defined above. In a symmetric equilibrium, each retailer follows the same optimal pricing rule, which is described by the first-order condition

$$\kappa \tilde{\Pi}_t - \theta Y_t \left(\frac{Q_t}{P_t \bar{X}} - \frac{\theta - 1}{\theta} \right) = \kappa E_t \left[\Lambda_{t+1,t} \tilde{\Pi}_{t+1} \right], \quad (32)$$

where $\tilde{\Pi}_t = \pi_t (\pi_t - 1)$.

3.5 Government

The government collects taxes from households and conducts monetary policy by setting the return on the one-period bond that is traded in the interbank market. I follow Christiano et al. (2007) in assuming that monetary policy follows a Taylor-type feedback rule of the form

$$R_t^f = \rho_r R_{t-1}^f + (1 - \rho_r)[\lambda_\pi(\pi_t - \bar{\pi}) + \lambda_y \log(Y_t/Y)] \quad (33)$$

where $Y > 0$ denotes the non-stochastic steady-state value of output, $\rho_r \in [0, 1)$, and $\lambda_\pi, \lambda_y > 0$.¹⁴ The monetary authority participates in the interbank market to ensure that the risk-free interest rate follows (33). The resulting central bank profits or losses are transferred to the consolidated government budget. Then, the government budget constraint can be constructed as

$$T_t + M_t - M_{t-1} + X_t - X_{t-1} = B_t^G - R_t^f B_t^G \quad (34)$$

where, as discussed earlier, B_t^G denotes the net bond position of the central bank in the interbank market. The left-hand-side of (34) simply denotes the government's tax and seigniorage revenue including the liquidity injected into the interbank market. The right-hand-side represents the revenue (or loss) central bank operations generate.

4 Parameterization

The model parameters can be classified in two groups. In the first group, Ψ_1 , lay the parameters that determine the variables' non-stochastic steady-state values. These parameters are identified by targeting some of the long-term averages of the U.S. data. Table 7 summarizes the values assigned to the parameters in Ψ_1 and their target statistics. The subjective discount factor, β , is set so that the implied real rate is 2% in the steady-state. The steady-state elasticity of substitution between differentiated products, θ , and the quarterly depreciation rate, δ , are set so that the implied mark-up and annual capital depreciation rates are both 10%. The share of capital in the Cobb-Douglas production function, α , is set so that labor income share is 65% in the steady-state. As in a typical business cycle calibration, the intertemporal elasticity of substitution, σ , and the labor supply elasticity parameter, ϕ , are respectively set to 2 and 1, both of which are well within reasonable ranges. Following Demirel (2009) and Carlstrom and Fuerst (1997), the monitoring cost parameter, μ , is set to 25%. The upper and lower bounds of the uniform distribution, $[\underline{A}, \bar{A}]$, are determined to ensure that $E[A_t(j)] = 1$ and the quarterly delinquency rate on business loans is 3.2% in the steady-state. This value corresponds to the average delinquency rate on business loans originated by U.S. banks in the period 1987:1-2012:1.

¹⁴The rational expectations equilibrium is determinate under the adopted values for the parameters ρ_r, λ_π , and λ_y . See Pfajfar and Santoro (in press) and Surico (2008) for a discussion of equilibrium determinacy under interest rate feedback rules in models with credit frictions.

As in Adam and Billi (2008), the price adjustment cost parameter, κ , is set so that the slope of the Phillips curve described by the linearized version of (32) is consistent with the value adopted in Schmitt-Grohe and Uribe (2004). To the parameters of the Taylor rule (33) I assign the values used in Christiano et al. (2007).

For the intermediation cost function, I adopt the form $G(b_t) = \psi b_t^2$ with $\psi > 0$. The values for the parameters ψ and η (the payout cost function parameter) are picked so that the return on equity capital for financial intermediaries is 12% in the steady-state. This figure roughly corresponds to the average return on equity for all U.S. banks in the period 1984:1-2012:1.

The second parameter group, Ψ_2 , contains the remaining five structural parameters $\omega, \rho_z, \rho_\varphi, \sigma_z,$ and σ_φ , which do not affect the steady-state allocations of the model. Thus, they cannot be identified by targeting the first moments of the data. These parameters are estimated using the method of simulated moments, which involves assigning values so as to minimize the distance between the cross-correlations produced by the theoretical model and those estimated from the data.¹⁵ Let Ω_T denote the (20×1) target vector that collects the estimated correlations calculated from the band-pass filtered U.S. data.¹⁶ The target vector includes the correlations between real business loans and four leads and lags of the real GDP as well as those between real loans and four leads and lags of investment. It also includes the contemporaneous correlations between real business loans and output and investment as well as the standard deviations of real GDP and investment. Let $\Omega_M(\Psi_1, \Psi_2)$ denote the vector of correlations and standard deviations produced by the theoretical model. Then, the estimation problem can be described as

$$\min_{\Psi_2 \in \Xi} [\Omega_T - \Omega_M(\Psi_1, \Psi_2)]^\top \Delta^{-1} [\Omega_T - \Omega_M(\Psi_1, \Psi_2)] \quad (35)$$

where Δ is a (20×20) diagonal weighting matrix containing the variances of the moment estimates along its main diagonal. This weighting matrix ensures that the estimation procedure places less weight on replicating the moments that are less precisely estimated.

Table 8 presents the estimated parameter values and corresponding search ranges. Note that, under certain parameter configurations, the theoretical model produces equilibrium indeterminacy. To avoid this problem, the search is restricted to a region of the parameter space (denoted Ξ) in which the theoretical model always yields a unique rational expectations equilibrium.

4.1 Correlations

Table 9 compares the cross-correlations produced by the model using the parameter values listed in Tables 7 and 8 with those estimated from the U.S. data. Under the adopted parameterization, the model is quite successful in matching the second moments of the data. All simulated moments lie within two standard error bounds of the estimated data moments. Furthermore, the model

¹⁵This method can also be viewed as a special case of the generalized method-of-moments procedure discussed in Christiano and Eichenbaum (1992).

¹⁶The band-pass filter used to calculate the target moments is BP_{6-32} . See Table 4 for details.

can successfully account for the two defining cross-correlation characteristics identified in the empirical section: 1- Current loans are more strongly correlated with past output and investment than with contemporaneous output and investment. 2- The correlations between current loans and future output and investment are negative, whereas, those between current loans and past output and investment are positive. In addition to these main regularities, the model can also successfully replicate the volatilities of output and investment as can be seen in the last column of Table 9.

I next carry out a series of counterfactual exercises to assess the implications of financial intermediation and agency costs in the model. I first compute the cross-correlations without variable intermediation costs by setting $\psi = 0$. Then, I repeat the exercise by eliminating the impact of agency costs from the model, which involves setting $\xi(A_t^*; \mu) = 1$.¹⁷

Figure 1 exhibits the simulated cross-correlations with and without variable intermediation costs. Observe that, without intermediation costs, the model is unable to replicate the negative correlations between current loans and future output, neither can it generate the lagging behavior of loans. Current loans are positively correlated with future output and are less strongly correlated with past output than with contemporaneous output. When the intermediation cost mechanism is in place, the model can account for both regularities. Figure 2 presents the cross-correlations produced by the model with and without agency costs. While the case with agency costs represents the full model specification, the case without agency costs ($\xi(A_t^*; \mu) = (\bar{A} + \underline{A})/2 = 1$) corresponds to a version of the economy in which business bankruptcies do not lead to any loss of output. It is observed that, in the absence of agency costs, the model can capture the lagging behavior of loans yet it fails to produce negative correlations between current loans and future output. These results, taken together, suggest that one needs both variable intermediation and agency costs in the model in order to generate the sign switch in cross-correlations from positive to negative and at the same time induce lagging behavior in loans.

4.2 Impulse Response Functions

To further highlight the implications of costly financial intermediation and agency costs, I next compute the impulse responses of the economy to productivity shocks under alternative model specifications. Figure 3 exhibits the responses to a 1% positive productivity shock with and without variable intermediation costs. Observe that, in the absence of intermediation costs (when $\psi = 0$), output, investment, and real business loans increase upon impact and monotonically converge back to their steady-state levels. These impulse response characteristics suggest that, without intermediation costs, the model will be unable to deliver negative correlations between current loans and future output and investment. To achieve this, one needs a mechanism which

¹⁷To facilitate comparison between these cases, cross-correlations are simulated by linearizing the model around the same steady-state that corresponds to the baseline parameterization.

will push the responses of output and investment to negative territory after a certain number of periods. This is precisely what costly financial intermediation achieves in the model by generating a boom-bust cycle in output and investment. As can be seen in Figure 3, in the presence of intermediation costs (when ψ =baseline value), the initial responses of investment and output are positive and far more pronounced relative to the case $\psi = 0$. This initial boom, however, is followed by a bust phase in which output and investment responses slip into negative territory after the fourth quarter following the impact. The future collapse in output and investment coupled with the initial positive response of real business loans leads to a negative correlation between current business loans and future output and investment. Also observe that, in the presence of intermediation costs, the model produces a hump-shaped impulse response function for real business loans. As a result, the response of output in the initial period tends to be more strongly correlated with the response of future business loans. This property of impulse response functions drives in the model what we previously referred to as the lagging behavior of loans.

Figure 4 demonstrates the responses to a 1% positive productivity shock with and without agency costs. It is observed that, in the absence of agency costs, output and investment responses are muted relative to those that obtain under full model specification. Furthermore, the bust phase is lost. That is, output and investment initially respond positively and then monotonically revert back to the initial levels without ever having to fall below their steady-state values. It appears that in order to generate a boom-bust sequence, which is crucial for explaining the negative correlations between current loans and future output and investment, one needs agency costs as well as intermediation costs in the model. Also, observe that the response of real business loans is hump-shaped regardless of whether agency costs are present or not. These results suggest that, although the boom-bust pattern is created jointly by agency and financial intermediation costs in the model, agency costs do not contribute to the emergence of the lagging behavior exhibited by loans in the face of technology shocks.

4.3 Understanding the Lagging Behavior of Loans and the Boom-Bust Pattern

To understand how the model can produce a boom-bust cycle in output and investment and generate lagging behavior in business loans at the same time, it will be useful to intuitively evaluate the interactions between financial intermediation costs, intermediaries' net worth, and the rest of the economy.

4.3.1 Lagging Behavior of Business Loans

Endogenous time evolution of intermediary net worth and variable intermediation costs play the key role in driving the gradual adjustment pattern and the lagging behavior of business loans in the model. In response to a positive productivity shock, the demand for working capital loans

increases. The rise in demand and the corresponding increase in equilibrium business loans, however, fall short of the levels that would obtain in the frictionless counterpart of the economy. This is because financial intermediaries' internal funds (nominal net worth) is a predetermined variable and cannot be adjusted upon impact.¹⁸ In consequence, the intermediary must at first accommodate the increase in loan demand by raising more external funds. In the presence of variable intermediation costs, increased reliance on externally raised funds leads to a rise in the marginal cost of loan origination. This in turn curbs the initial expansion of business lending in equilibrium as producers seek to avoid a steep hike in the lending rate they face by limiting the initial increase in their demand for working capital loans.¹⁹ However, as the intermediary net worth increases over time, reliance on external funds decreases. This parallels a progressive decline in the marginal cost of loan origination, which results in a gradual expansion of business credit in equilibrium as observed in Figures 3, 4, and 5. Due to this gradual build up, the impulse response function of business loans peaks later relative to those of output and investment, which induces the lagging behavior of loans in the model.

4.3.2 Boom-Bust Pattern: The Role of Intermediation and Agency Costs

A positive shock to firms' productivity increases intermediaries' expected return on working capital loans for a given level of default probability and boosts the supply of business credit. As discussed above, the presence of variable intermediation costs limits the initial expansion of the demand for business loans. The sharp increase in the supply of credit coupled with the limited initial expansion of demand results in a steep fall in the equilibrium price of risky producer loans. As Figure 3 shows, this leads to a sharp decline in the risk premium in excess of what would be realized in a costless-financial-intermediation economy. Accordingly, output and investment expand beyond the levels that would obtain in the absence of intermediation costs, which represents the initial boom.

The boom phase is reversed as the volume of working capital loans gradually builds up and the positive productivity shock starts to die out. Along this process, the equilibrium default rate and risk premium start to rise. This is the point where the impact of agency costs becomes palpable as they amplify the reversal process and instigate the bust phase. Due to costly financial monitoring, as business bankruptcies rise, more resources are destroyed during the monitoring process. This leads to greater output losses as labor productivity reverts back to the steady-state. As a result, the responses of output and investment eventually turn negative, resulting in a boom-bust pattern. As demonstrated by Figures 3, 4, and 5, the point at which the risk premium rises above its long-run steady-state level marks the beginning of the bust phase. After this point, output and investment fall below their steady-state levels. The collapse in output and

¹⁸The initial increase in real intermediary net worth realized upon impact (displayed in Figures 3,4, and 5) is driven only by the fall in equilibrium prices.

¹⁹Since, in the loan contract, the producer must satisfy the participation constraint of the intermediary (described by 19), it internalizes the effect of its loan demand on the lending rate it faces.

investment realized after the fourth quarter following the impact drive the negative correlations between current loans and future output. Note that since the bust phase never materializes in the absence of agency costs, the correlations between current loans and future output and investment exhibited in Figure 2 never fall into negative territory in the case $\xi(A_t^*; \mu) = (\bar{A} + \underline{A})/2 = 1$.

4.3.3 Boom-Bust Pattern: The Role of Price Rigidity

The degree of price stickiness and the corresponding inflation dynamics also play an important role in the emergence of the boom-bust sequence. In the outlined economy, inflation affects the evolution of intermediaries' real net worth.²⁰ Through this channel, price level fluctuations influence marginal cost dynamics in the financial intermediation sector and the amount of real loans intermediaries originate in each period. It is in this sense important to control for the degree of price stickiness in the model.

At the initial boom phase, the decrease in firms' real marginal cost (driven by improved productivity and the accompanying fall in the risk premium producers face in the loan market) leads to a fall in equilibrium prices. The implied decrease in the inflation rate realized in response to the positive technology shock is consistent with the empirical findings of Ireland (2004).²¹ It is also in line with the evidence provided by Christiano et al. (2008a) and Adalid and Detken (2006).²² Falling prices increase the value of intermediaries' real net worth upon impact. This in turn limits the increase in the marginal cost of loan origination (led by the necessity to raise more external funds to accommodate the rise in loan demand) and amplifies the initial boom. In the bust phase, the cost-push pressure exerted by increasing risk premia pushes inflation above the long-run steady-state value. The effect of rising inflation on the intermediary's real net worth partially offsets the moderating impact of falling loan demand on the marginal cost of loan creation. This parallels an increase in the cost of borrowing for the producer, which deepens the contraction.

The ease with which prices can be adjusted determines directly the size of the amplification effect associated with price level movements. Our reasoning suggests that, as prices become more flexible, increased inflation volatility should exacerbate the fluctuations caused by technology shocks. To demonstrate this pattern, Figure 5 displays the impulse responses computed under a smaller value for the price adjustment cost parameter ($\kappa = 5$). As argued above, the initial expansion as well as the subsequent contraction in output and investment are amplified under

²⁰This can easily be seen by reexpressing (29) in real terms. Dividing both sides of the equation with P_t we obtain $x_t = \left[\frac{Q_t \gamma (A_t^*) H(D_t)}{D_t} - R_t^f \right] d_t + R_t^f \frac{x_{t-1}}{\pi_t} + G(b_t) - \gamma_t^I - \frac{\omega}{2} \left(\frac{\Gamma_t^I}{X_t} - \eta \right)^2$.

²¹Ireland (2004) estimates a New Keynesian model on U.S. data with a pricesetting structure that is identical to ours. His impulse response analysis on the estimated model shows that inflation responds negatively to a positive technology shock.

²²Christiano et al. (2008a) find that inflation either falls or at least does not increase during the initial phases of the three major boom-bust episodes experienced in the U.S. during the 20th century. Adalid and Detken (2006) find that, in a sample of OECD countries, inflation is weak during the initial expansion stages of the boom-bust cycles.

increased price flexibility relative to the baseline specification.

It is, however, important to note that although balance sheet effects exerted by price level movements amplify the impact of technology shocks, they can dampen the fluctuations caused by other types of shocks. The amplification result is driven by the property that a technology shock tends to increase output while placing a downward pressure on prices. The increase in real net worth caused by falling prices improves intermediaries' capacity to originate loans, which reinforces the shock's positive effect on output. However, for certain types of demand shocks that tend to increase output and prices together, balance sheet effects work in the opposite direction. In the face of these disturbances, rising prices limit the increase in intermediaries' real net worth and constrain their capacity to originate loans, which dampens the shock's positive effect on output.

5 Conclusion

Empirical evidence suggests that real business loans lag output in the United States and in the Euro area. Furthermore, strong growth in business credit predicts future decline in output and investment, whereas strong growth in output and investment predicts future growth in business credit. This study shows that financial market imperfections can help to explain these cyclical characteristics in an otherwise standard New Keynesian model extended to accommodate frictions in financial intermediation. It is argued that, under a reasonable set of parameter values, the interaction of financial intermediation and agency costs and the resulting evolution of financial intermediary net worth can induce a boom-bust pattern in output, investment and business loans in the model, which can drive the observed cross-correlation structure.

This study can be extended in a number of directions. The studied model does not pinpoint the exact source of financial market imperfections that might give rise to variable intermediation costs. Thus, one possible extension involves explicitly accounting for the type of friction that induces variable intermediation costs. Another direction involves evaluating the welfare consequences of alternative monetary policies. As the model already incorporates the elements needed for a meaningful monetary policy discussion, it provides a useful framework to address a number of questions regarding the implications of alternative policy specifications in the presence of financial market frictions.

References

- [1] Adalid, Ramon and Carsten Detken (2006) Excessive liquidity and asset price boom/bust cycles. Unpublished manuscript, European Central Bank.
- [2] Adam, Klaus and Roberto M. Billi (2008) Monetary conservatism and fiscal policy. *Journal of Monetary Economics* 55, 1376-1388.
- [3] Baxter, Marianne and Robert G. King (1999) Measuring business cycles: approximate band-pass filters for economic time series. *The Review of Economics and Statistics* 81, 575-593.
- [4] Bernanke, Ben S., Mark L. Gertler, and Simon Gilchrist (1999) The financial accelerator in a quantitative business cycle framework. In John B. Taylor and Michael Woodford (eds.), *Handbook of Macroeconomics*, pp. 1341-1393. Elsevier.
- [5] Carlstrom, Charles T. and Timothy S. Fuerst (1997) Agency costs, net worth and business fluctuations: a computable general equilibrium analysis. *American Economic Review* 87, 893-910.
- [6] Christiano, Lawrence J. and Martin Eichenbaum (1992) Current real-business-cycle theories and aggregate labor market fluctuations. *American Economic Review* 82, 430-450.
- [7] Christiano, Lawrence J., Cosmin Ilut, Roberto Motto, and Massimo Rostagno (2008a) Monetary policy and stock market boom-bust cycles. Working paper 955, European Central Bank.
- [8] Christiano, Lawrence J., Roberto Motto, and Massimo Rostagno (2008b) Financial factors in business cycles. Unpublished manuscript, Northwestern University and European Central Bank.
- [9] Christiano, Lawrence J., Roberto Motto, and Massimo Rostagno (2007). Two reasons why money and credit may be useful in monetary policy. NBER Working Paper No. 13502.
- [10] Chugh, Sanjay K. (2010) Firm risk and leverage-based business cycles. Unpublished manuscript, University of Maryland.
- [11] Cooley, Thomas F. and Kwanghee Nam (1998) Asymmetric information, financial intermediation and business cycles. *Economic Theory* 12, 599-620.
- [12] Covas, Francisco and Wouter J. Den Haan (2011). The cyclical behavior of debt and equity finance. *American Economic Review* 101, 877-899.

- [13] Croux, Christophe, Mario Forni, and Lucrezia Reichlin (2001) A measure of comovement for economic variables: theory and empirics. *The Review of Economics and Statistics* 83, 232-241.
- [14] Curdia, Vasco and Michael Woodford (2009) Credit frictions and optimal monetary policy. Department of Economics Discussion Papers 0809-02, Columbia University.
- [15] Demirel, Ufuk D. (2009) Optimal monetary policy in a financially fragile economy. *The B.E. Journal of Macroeconomics (Contributions)* 9, Article 15.
- [16] Gertler, Mark L. and Peter Karadi (2009) A model of unconventional monetary policy. Unpublished manuscript, New York University.
- [17] Gertler, Mark L. and Nobuhiro Kiyotaki (2010) Financial intermediation and credit policy in business cycle analysis. In Benjamin M. Friedman and Michael Woodford (eds.), *Handbook of Monetary Economics*, pp. 547-599, Elsevier.
- [18] Gilchrist, Simon, Vladimir Yankov, and Egon Zakrajsek (2009) Credit market shocks and economic fluctuations: evidence from corporate bond and stock markets. *Journal of Monetary Economics* 56, 471-493.
- [19] Gomes, Joao F. and Lucas Schmid (2010) Equilibrium credit spreads and the macroeconomy. Unpublished manuscript, University of Pennsylvania and Duke University.
- [20] Ireland, Peter N. (2004) Technology shocks in the new Keynesian model. *The Review of Economics and Statistics* 86, 923-936.
- [21] Jermann, Urban and Vincenzo Quadrini (2012) Macroeconomic effects of financial shocks. *American Economic Review* 102, 238-271.
- [22] Kiyotaki, Nobuhiro and John H. Moore (2008) Liquidity, business cycle and monetary policy. Unpublished manuscript, Princeton University and Edinburgh University.
- [23] Liu, Zheng, Pengfei Wang, and Tao Zha (2011) Land-price dynamics and macroeconomic fluctuations. NBER Working Paper No. 17045.
- [24] Miao, Jianjun and Pengfei Wang (2010) Credit risk and business cycles. Unpublished manuscript, Boston University.
- [25] Pfajfar, Damjan and Emiliano Santoro (in press) Credit market distortions, asset prices and monetary policy. *Macroeconomic Dynamics*.
- [26] Rotemberg, Julio J. (1982) Sticky prices in the United States. *Journal of Political Economy* 90, 1187-1211.

- [27] Schmitt-Grohe, Stephanie and Martin Uribe (2004) Optimal fiscal and monetary policy under sticky prices. *Journal of Economic Theory* 114, 198-230.
- [28] Surico, Paolo (2008) The cost channel of monetary policy and indeterminacy. *Macroeconomic Dynamics* 12, 724-735.
- [29] Townsend, Robert M. (1979) Optimal contracts and competitive markets with costly state verification. *Journal of Economic Theory* 21, 265-293.

Appendix I: Dynamic Correlations

Computation of dynamic correlations involves spectral decomposition of time series into constituent frequency components. Any two covariance-stationary processes x_t and y_t can be expressed as

$$x_t = \int_{-\pi}^{\pi} h_x(\omega) d\omega \quad \text{and} \quad y_t = \int_{-\pi}^{\pi} h_y(\omega) d\omega$$

where $h_x(\omega)$ and $h_y(\omega)$ are random periodic functions defined for a particular frequency ω with the property $E[h_i(\omega_1)h_i(\omega_2)'] = 0$ for $\omega_1 \neq \omega_2$ and $i = x, y$. Let $s_x(\omega)$ and $s_y(\omega)$ respectively denote the spectral density functions of x_t and y_t at frequency ω . That is,

$$s_x(\omega) = \text{var} [h_x(\omega)] \quad s_y(\omega) = \text{var} [h_y(\omega)].$$

Define $s_{xy}(\omega) = \text{cov} [h_x(\omega), h_y(\omega)]$. Also, specify a frequency band $W = [\omega_1, \omega_2)$ where $0 \leq \omega_1 < \omega_2 \leq \pi$. Then, the dynamic correlation between the series x_t and y_t at the frequency band W is defined as

$$\rho(W) = \frac{\int_{\omega \in W} \Theta(\omega) d\omega}{\sqrt{\int_{\omega \in W} s_x(\omega) d\omega \int_{\omega \in W} s_y(\omega) d\omega}} \quad (\text{A.1.1})$$

where $\Theta(\omega) = \frac{s_{xy}(\omega)}{\sqrt{s_x(\omega)s_y(\omega)}}$ denotes coherency. Croux et al. (2001) show that (A.1.1) corresponds to the static correlation between x_t and y_t after a band-pass filter that isolates the cycles with frequencies in the band W is applied to both x_t and y_t .

Appendix II: The Optimal Loan Contract

The optimal contracting problem faced by the typical producer is described by (20) in the text. After incorporating the definition $G(b_t) = G\left(\frac{B_t}{P_t}\right) = G\left(\frac{D_t - X_{t-1}}{P_t}\right)$ into the constraint of this problem, the solution can be characterized using a Lagrangian of the form

$$\mathcal{L} = Q_t \phi(A_t^*) H(D_t) + \lambda \left[Q_t \gamma(A_t^*) H(D_t) - R_t^f D_t - P_t G\left(\frac{D_t - X_{t-1}}{P_t}\right) - L^I W_t \right].$$

The first order conditions with respect to A_t^* , D_t , and λ are respectively

$$Q_t \phi'(A_t^*) H(D_t) = -\lambda Q_t \gamma'(A_t^*) H(D_t), \quad (\text{A.2.1})$$

$$Q_t \phi(A_t^*) H'(D_t) = -\lambda [Q_t \gamma(A_t^*) H'(D_t) - R_t^f - G'(b_t)]. \quad (\text{A.2.2})$$

$$Q_t \gamma(A_t^*) H(D_t) = R_t^f D_t + P_t G(b_t) + L^I W_t \quad (\text{A.2.3})$$

From (A.2.1), we find $\lambda = -\phi'(A_t^*)/\gamma'(A_t^*)$. Plugging this expression into (A.2.2) and reorganizing we obtain

$$Q_t H'(D_t) = \frac{R_t^f + G'(b_t)}{\left(\frac{\phi'(A_t^*)\gamma(A_t^*) - \gamma'(A_t^*)\phi(A_t^*)}{\phi'(A_t^*)} \right)}. \quad (\text{A.2.4})$$

Using equation (14), we find $H'(D_t) = \frac{1}{\tau P_t} \left[\frac{\alpha}{R_t/P_t} \right]^\alpha \left[\frac{(1-\alpha)Z_t}{W_t/P_t} \right]^{1-\alpha}$. Plugging this expression into (A.2.4) and defining $\Phi(A_t^*) = \frac{\phi'(A_t^*)\gamma(A_t^*) - \gamma'(A_t^*)\phi(A_t^*)}{\phi'(A_t^*)}$, (A.2.4) can be rewritten as

$$\frac{Q_t}{\tau P_t} \left[\frac{\alpha}{R_t/P_t} \right]^\alpha \left[\frac{(1-\alpha)Z_t}{W_t/P_t} \right]^{1-\alpha} = \frac{R_t^f + G'(b_t)}{\Phi(A_t^*)}$$

which brings us to (21) in the text. Also, dividing both sides of (A.2.3) with P_t , we obtain (22).

Tables and Figures

Cross-Correlations with Aggregate Business Loans (United States) ^a									
Output	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$
1 st Difference	0.342 (0.081) ^b	0.403 (0.079)	0.407 (0.070)	0.314 (0.074)	0.216 (0.062)	0.046 (0.057)	-0.065 (0.061)	-0.117 (0.072)	-0.196 (0.070)
HP ^c	0.609 (0.051)	0.636 (0.040)	0.591 (0.054)	0.470 (0.079)	0.293 (0.098)	0.089 (0.105)	-0.107 (0.100)	-0.271 (0.089)	-0.389 (0.080)
Investment	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$
1 st Difference	0.229 (0.085)	0.332 (0.082)	0.309 (0.079)	0.215 (0.079)	0.122 (0.069)	-0.110 (0.073)	-0.162 (0.073)	-0.281 (0.059)	-0.325 (0.053)
HP	0.551 (0.065)	0.535 (0.057)	0.446 (0.061)	0.287 (0.078)	0.080 (0.095)	-0.156 (0.102)	-0.362 (0.094)	-0.525 (0.076)	-0.607 (0.061)

^aNumbers in column $t + k$ correspond to $\text{Corr} [\text{Loans}_t, x_{t+k}]$ where $x_{t+k} \in \{\text{Output}_{t+k}, \text{Inv.}_{t+k}\}$

^bNumbers in parenthesis are standard errors.

^cHodrick-Prescott Filter (smoothing parameter is set to 1600).

Table 1: Static Cross-Correlations in the United States

Cross-Correlations with Aggregate Business Loans (Euro Area) ^a									
Output	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$
1 st Difference	0.537 (0.077) ^b	0.555 (0.086)	0.494 (0.100)	0.430 (0.072)	0.299 (0.094)	0.134 (0.117)	-0.078 (0.123)	-0.163 (0.158)	-0.260 (0.185)
HP ^c	0.810 (0.071)	0.794 (0.093)	0.711 (0.129)	0.570 (0.179)	0.389 (0.224)	0.187 (0.249)	-0.027 (0.249)	-0.220 (0.228)	-0.381 (0.197)
Investment	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$
1 st Difference	0.589 (0.079)	0.600 (0.089)	0.530 (0.123)	0.466 (0.082)	0.349 (0.084)	0.155 (0.111)	-0.052 (0.119)	-0.133 (0.059)	-0.341 (0.155)
HP	0.880 (0.043)	0.847 (0.063)	0.750 (0.097)	0.598 (0.143)	0.403 (0.189)	0.190 (0.221)	-0.040 (0.229)	-0.253 (0.215)	-0.444 (0.187)

^aNumbers in column $t + k$ correspond to $\text{Corr} [\text{Loans}_t, x_{t+k}]$ where $x_{t+k} \in \{\text{Output}_{t+k}, \text{Inv.}_{t+k}\}$

^bNumbers in parenthesis are standard errors.

^cHodrick-Prescott Filter (smoothing parameter is set to 1600).

Table 2: Static Cross-Correlations in the Euro Area

Cross-Correlations with Short-Term Business Loans ^a									
Output	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$
United States	0.535 (0.114) ^b	0.618 (0.107)	0.591 (0.100)	0.463 (0.106)	0.287 (0.164)	0.090 (0.202)	0.026 (0.219)	-0.093 (0.195)	-0.159 (0.162)
Euro Area	0.826 (0.047)	0.873 (0.041)	0.831 (0.064)	0.711 (0.117)	0.530 (0.175)	0.306 (0.220)	0.075 (0.240)	-0.125 (0.236)	-0.285 (0.213)
Investment	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$
United States	0.522 (0.110)	0.585 (0.118)	0.565 (0.096)	0.398 (0.108)	0.187 (0.156)	-0.023 (0.197)	-0.114 (0.221)	-0.245 (0.185)	-0.257 (0.147)
Euro Area	0.870 (0.037)	0.904 (0.025)	0.864 (0.041)	0.745 (0.083)	0.565 (0.136)	0.337 (0.185)	0.087 (0.213)	-0.149 (0.215)	-0.349 (0.197)

^aNumbers in column $t + k$ correspond to $\text{Corr} [\text{Loans}_t, x_{t+k}]$ where $x_{t+k} \in \{\text{Output}_{t+k}, \text{Inv.}_{t+k}\}$

^bNumbers in parenthesis are standard errors.

All series are detrended using a Hodrick-Prescott Filter (smoothing parameter is set to 1600)

Table 3: Static Correlations for Short-Term Loans

Cross-Correlations with Aggregate Business Loans ^a									
United States									
Output	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$
BP_{6-32} ^b	0.492 (0.078)	0.489 (0.082)	0.432 (0.099)	0.334 (0.114)	0.217 (0.117)	0.096 (0.108)	-0.006 (0.096)	-0.083 (0.094)	-0.133 (0.106)
BP_{24-64}	0.471 (0.095)	0.463 (0.096)	0.426 (0.097)	0.362 (0.101)	0.275 (0.108)	0.176 (0.115)	0.078 (0.122)	-0.010 (0.126)	-0.089 (0.127)
Investment	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$
BP_{6-32}	0.498 (0.070)	0.470 (0.072)	0.381 (0.090)	0.240 (0.106)	0.072 (0.111)	-0.093 (0.105)	-0.229 (0.095)	-0.315 (0.093)	-0.349 (0.105)
BP_{24-64}	0.523 (0.098)	0.459 (0.105)	0.367 (0.114)	0.250 (0.122)	0.117 (0.129)	-0.023 (0.134)	-0.151 (0.134)	-0.261 (0.130)	-0.349 (0.124)
Euro Area									
Output	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$
BP_{6-32}	0.750 (0.065)	0.786 (0.090)	0.728 (0.119)	0.573 (0.170)	0.330 (0.226)	0.039 (0.254)	-0.237 (0.248)	-0.444 (0.221)	-0.551 (0.185)
BP_{24-64}	0.828 (0.059)	0.825 (0.083)	0.735 (0.113)	0.574 (0.153)	0.352 (0.197)	0.085 (0.225)	-0.175 (0.229)	-0.388 (0.216)	-0.531 (0.191)
Investment	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$
BP_{6-32}	0.788 (0.047)	0.815 (0.071)	0.753 (0.102)	0.605 (0.147)	0.373 (0.201)	0.081 (0.234)	-0.213 (0.231)	-0.454 (0.203)	-0.602 (0.168)
BP_{24-64}	0.877 (0.034)	0.859 (0.066)	0.755 (0.100)	0.587 (0.138)	0.365 (0.181)	0.098 (0.209)	-0.171 (0.213)	-0.400 (0.198)	-0.562 (0.173)

^aNumbers in column $t + k$ correspond to $\text{Corr} [\text{Loans}_t, x_{t+k}]$ where $x_{t+k} \in \{\text{Output}_{t+k}, \text{Inv.}_{t+k}\}$

^b BP_{x-y} denotes the approximate band-pass filter that isolates the cycles with periodicities between x and y quarters.

^cNumbers in parenthesis are standard errors.

Table 4: Dynamic Cross-Correlations

Cross-Correlations with Short-Term Business Loans ^a									
United States									
Output	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$
BP_{6-32}^b	0.770 (0.070) ^c	0.880 (0.055)	0.782 (0.066)	0.485 (0.137)	0.090 (0.193)	-0.255 (0.208)	-0.468 (0.201)	-0.520 (0.178)	-0.386 (0.152)
BP_{24-64}	0.822 (0.052)	0.887 (0.042)	0.815 (0.065)	0.604 (0.134)	0.296 (0.189)	-0.016 (0.214)	-0.266 (0.222)	-0.427 (0.221)	-0.464 (0.202)
Investment	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$
BP_{6-32}	0.711 (0.076)	0.832 (0.073)	0.763 (0.077)	0.474 (0.134)	0.064 (0.184)	-0.309 (0.193)	-0.545 (0.185)	-0.605 (0.162)	-0.457 (0.127)
BP_{24-64}	0.810 (0.056)	0.848 (0.051)	0.770 (0.083)	0.549 (0.160)	0.227 (0.215)	-0.096 (0.226)	-0.356 (0.215)	-0.514 (0.197)	-0.526 (0.180)
Euro Area									
Output	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$
BP_{6-32}	0.789 (0.051)	0.892 (0.034)	0.853 (0.055)	0.677 (0.110)	0.395 (0.176)	0.080 (0.221)	-0.215 (0.233)	-0.426 (0.223)	-0.522 (0.200)
BP_{24-64}	0.839 (0.052)	0.917 (0.031)	0.874 (0.042)	0.729 (0.092)	0.491 (0.153)	0.196 (0.197)	-0.104 (0.214)	-0.354 (0.211)	-0.511 (0.196)
Investment	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$
BP_{6-32}	0.761 (0.062)	0.871 (0.036)	0.862 (0.052)	0.735 (0.089)	0.495 (0.150)	0.181 (0.200)	-0.149 (0.215)	-0.425 (0.201)	-0.587 (0.175)
BP_{24-64}	0.856 (0.039)	0.926 (0.024)	0.885 (0.039)	0.749 (0.078)	0.529 (0.135)	0.237 (0.180)	-0.076 (0.196)	-0.354 (0.190)	-0.542 (0.174)

^aNumbers in column $t + k$ correspond to $\text{Corr} [\text{Loans}_t, x_{t+k}]$ where $x_{t+k} \in \{\text{Output}_{t+k}, \text{Inv.}_{t+k}\}$

^b BP_{x-y} denotes the approximate band-pass filter that isolates the cycles with periodicities between x and y quarters.

^cNumbers in parenthesis are standard errors.

Table 5: Dynamic Cross-Correlations for Short-Term Loans

Cross-Correlations with Business Loans ^a							
Output	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$
United States	0.125 (0.103)	0.321 (0.089)	0.463 (0.067)	0.549 (0.054)	0.529 (0.055)	0.446 (0.064)	0.336 (0.066)
Euro Area	0.307 (0.188)	0.504 (0.150)	0.650 (0.127)	0.728 (0.104)	0.739 (0.089)	0.651 (0.114)	0.515 (0.173)
Investment	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$
United States	0.281 (0.097)	0.459 (0.086)	0.577 (0.072)	0.635 (0.062)	0.549 (0.059)	0.432 (0.063)	0.249 (0.071)
Euro Area	0.337 (0.190)	0.521 (0.142)	0.660 (0.111)	0.761 (0.093)	0.802 (0.072)	0.745 (0.085)	0.629 (0.128)

^aNumbers in column $t + k$ correspond to $\text{Corr} [\text{Loans}_t, x_{t+k}]$

^bNumbers in parenthesis are standard errors.

Table 6: Cross-Correlations with Business Loans (Flow Approach)

Parameter	Value	Target Statistic
$\beta = \bar{R}^{-1}$	0.9945	2% Annual Real Rate
δ	0.024	10% Yearly Depreciation Rate
σ	2	Business Cycle Calibration
ϕ	1	Unit Labor Supply Elasticity
$[\underline{A}, \bar{A}]$	[0.85, 1.15]	3.2% Quarterly Delinquency Rate and $E[A(j)_t] = 1$
θ	11	10% Mark up
α	0.35	65% Labor-Income Share
μ	0.25	Carlstrom and Fuerst (1997)
\bar{K}	1	Normalization
κ	17.5	Adam and Billi (2008)
$[\psi, \eta, L^I]$	[93, 0.1274, 0.0417]	12% Return on Intermediaries' Equity Capital
$[\rho_r, \lambda_\pi, \lambda_y]$	[0.81, 1.93, 0.18]	Christiano et al. (2007)

Table 7: Baseline Parameter Values and Target Statistics

Parameter	Value	Search Range
ω	0.223	[0, 1000]
ρ_z	0.53	[0, 0.999]
ρ_φ	0.43	[0, 0.999]
σ_z	6.01×10^{-3}	[0, 1]
σ_φ	0.74×10^{-3}	[0, 1]

Table 8: Structural Parameter Estimates

Output	Cross-Correlations with Business Loans									St. Dv.
	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$	
Data	0.49 (0.07)	0.48 (0.08)	0.43 (0.09)	0.33 (0.11)	0.21 (0.11)	0.09 (0.10)	0.00 (0.09)	-0.08 (0.09)	-0.13 (0.10)	1.30%
Model ^a	0.38	0.41	0.42	0.39	0.26	0.05	-0.11	-0.18	-0.19	1.15%
Investment	$t - 4$	$t - 3$	$t - 2$	$t - 1$	t	$t + 1$	$t + 2$	$t + 3$	$t + 4$	-
Data	0.49 (0.07)	0.47 (0.07)	0.38 (0.09)	0.24 (0.10)	0.07 (0.11)	-0.09 (0.10)	-0.22 (0.09)	-0.31 (0.09)	-0.34 (0.10)	6.08%
Model	0.35	0.38	0.39	0.36	0.23	0.01	-0.14	-0.21	-0.22	6.39%

^aModel moments are averages across 1000 simulations.

Table 9: Simulated vs. Estimated Moments

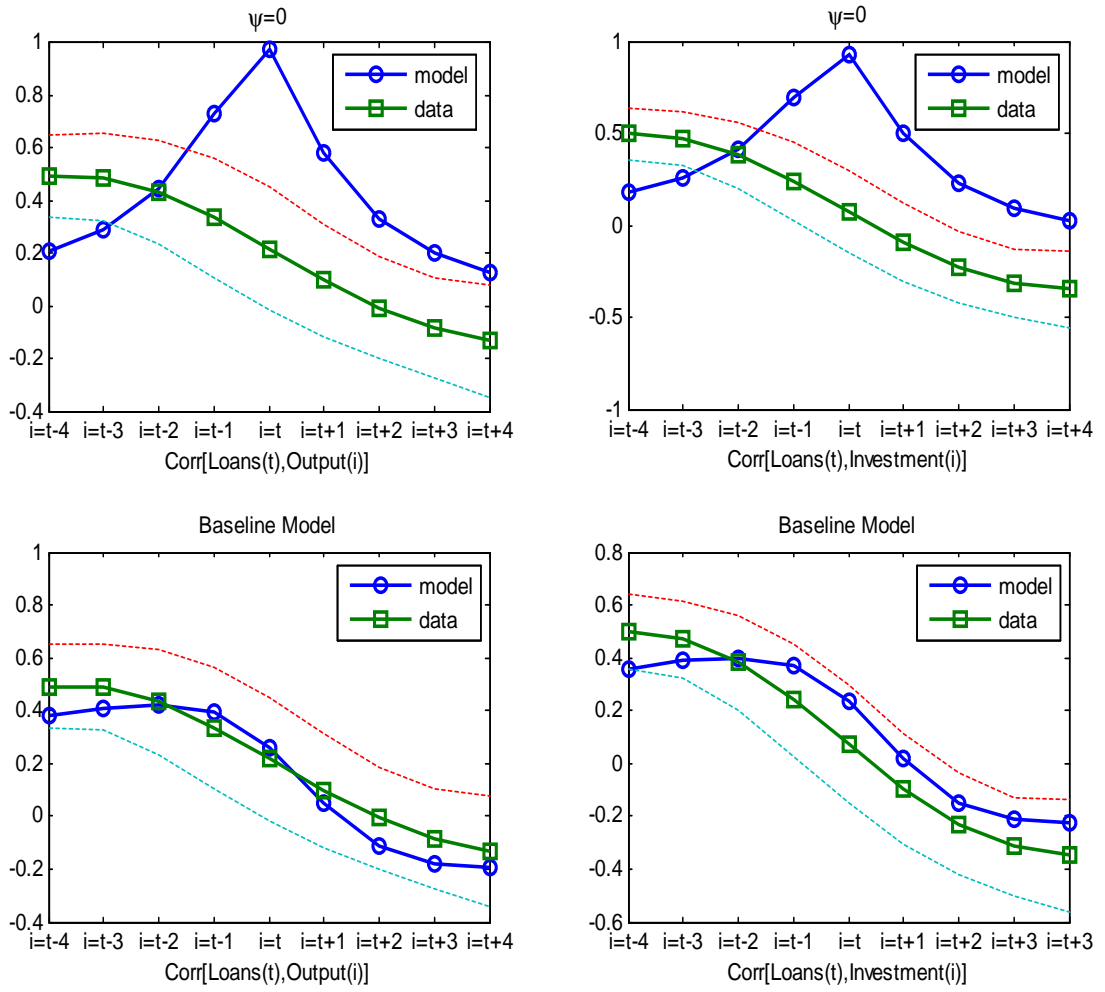


Figure 1: Cross-correlations with and without variable intermediation costs

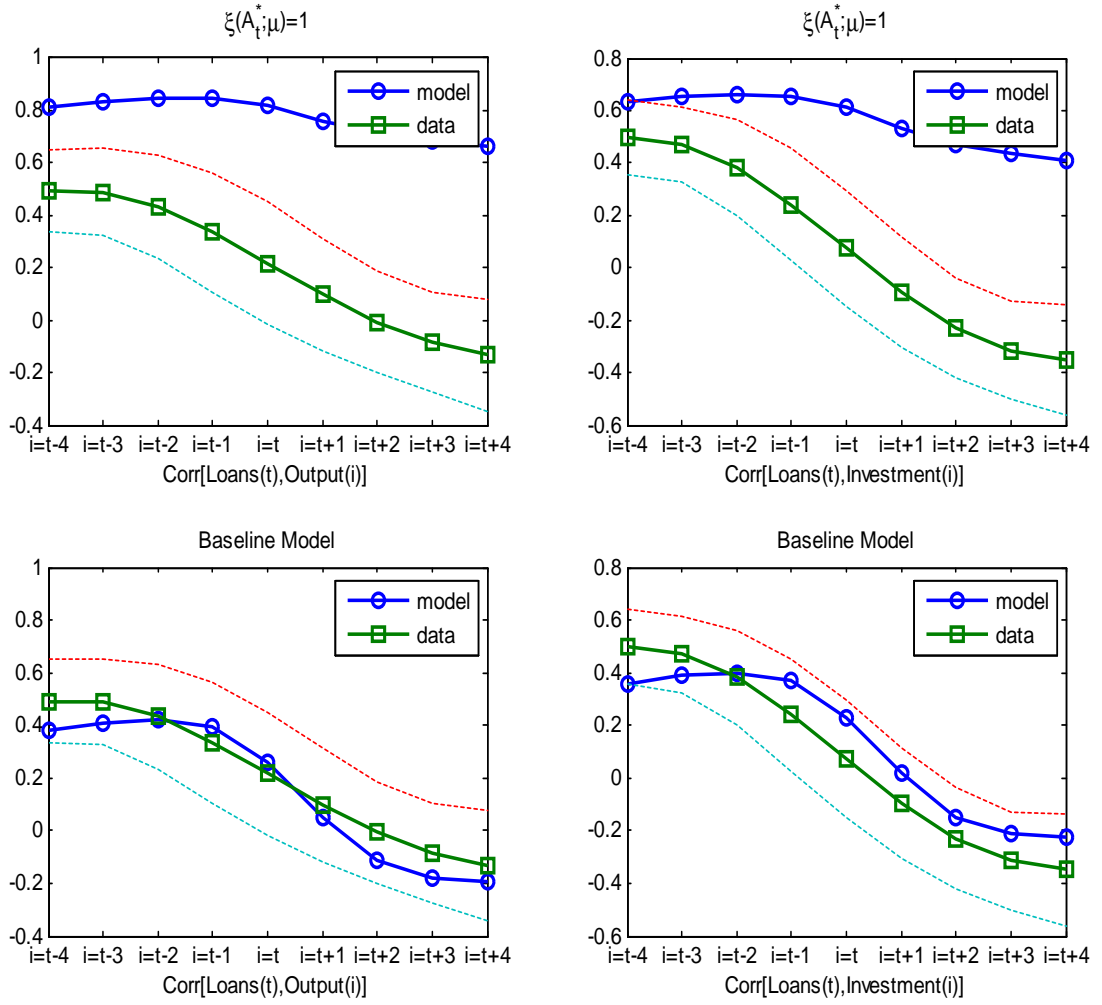


Figure 2: Cross-correlations with and without agency costs

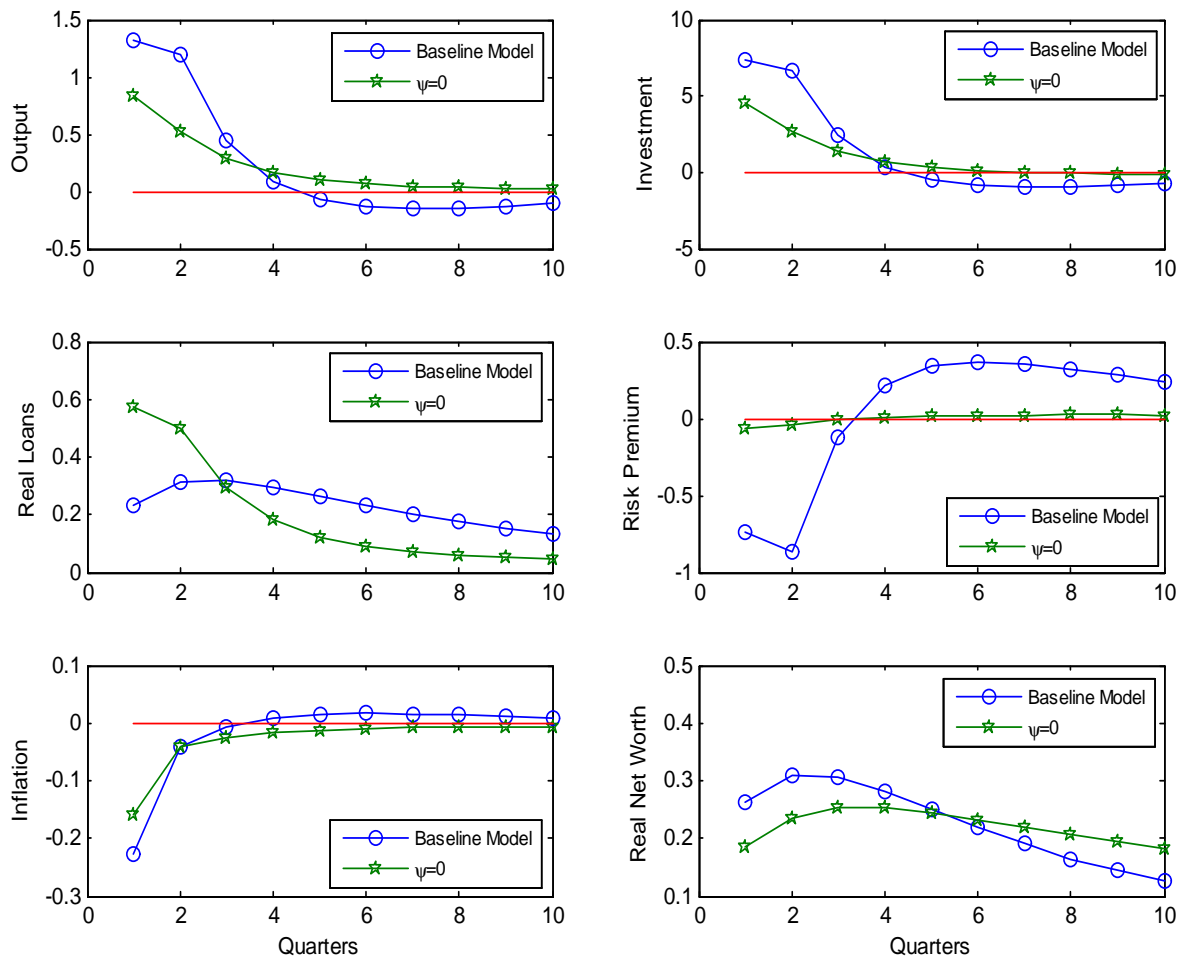


Figure 3: Responses to a 1% positive productivity shock with and without variable intermediation costs

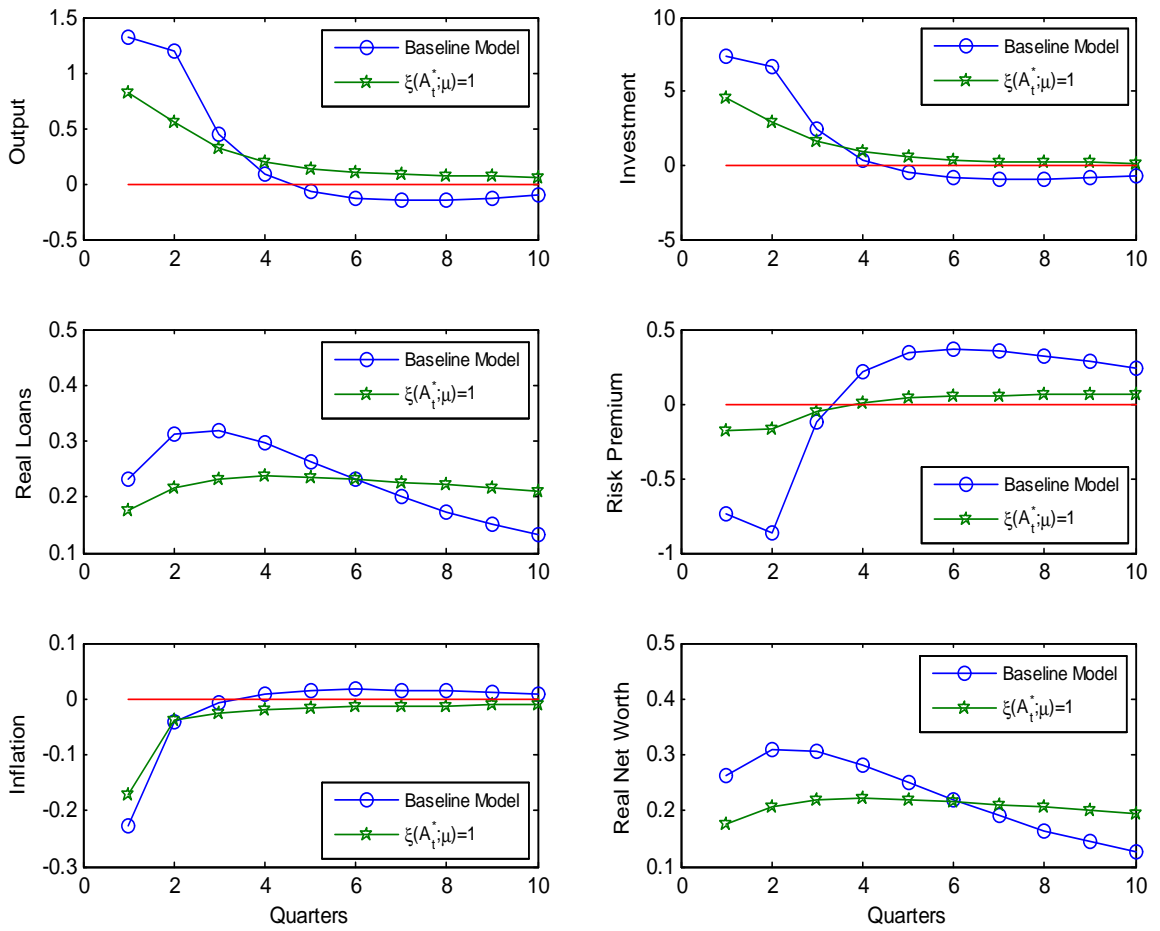


Figure 4: Responses to a 1% positive productivity shock with and without agency costs

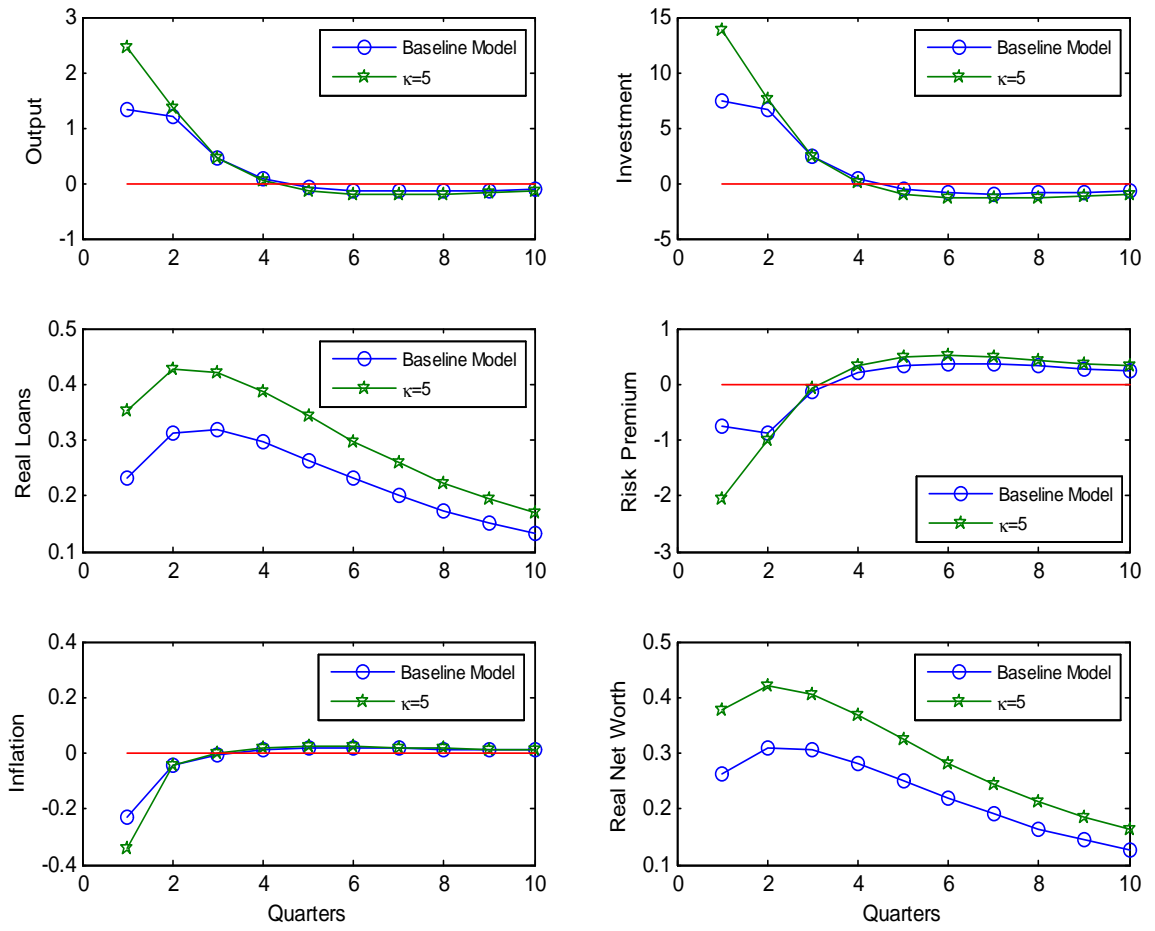


Figure 5: Responses to a 1% positive productivity shock under increased price flexibility