Impacts of Financial Factors on Emerging Market Business Cycle Fluctuations

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Abstract

Our research contributes to a deeper understanding of the interaction between the real and financial sides of the economy by analyzing how balance sheets of not only firms but also banks amplify and propagate business cycles. Based on an open-economy dynamic stochastic general equilibrium model with a double financial accelerator mechanism, our model provides a more complete view of the balance sheet channel of monetary policy transmission and is more useful for an emerging market economy with bank-based financial intermediation than a traditional model with only one financial accelerator.

Keywords: macro-financial linkages, financial accelerator, general equilibrium model, Thailand

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1 Introduction

The extraordinary events that intensified last year and took us to where we are today prompt us to have a deeper understanding of the forces that cause financial disruptions and economic damages of this order. Of no less importance is the mechanism whereby the financial and real sides of the economy are intertwined in a manner that they have the potential to feed into each other. Such a self-reinforcing mechanism, or a spiral, is especially relevant to economies which are at the core of the crisis, as prominently described in the minutes of the March 18, 2008, meeting of the Federal Open Market Committee of the Federal Reserve:

> Evidence that an adverse feedback loop was under way, in which a restriction in credit availability prompts a deterioration in the economic outlook that, in turn, spurs additional tightening in credit conditions, was discussed. Several participants noted that the problems of declining asset values, credit losses, and strained financial market conditions could be quite persistent, restraining credit availability and thus economic activity for a time and having the potential subsequently to delay and damp economic recovery.

It is the objective of this paper that we wish to assess the importance of this self-reinforcing mechanism for the Thai economy. This paper, to the best of our understanding, is perhaps the first study that empirically examines and quantifies the adverse feedback between weakening activity and intense financial strains in Thailand.

Technically, this paper advances the existing tools used in analyzing the adverse feedback effects. While based on Bernanke, Gertler, and Gilchrist (1999), in addition to the balance sheet of firms, the financial accelerator in our model also operates via the balance sheet of financial intermediaries. This "double financial accelerator" has a foundation in Sunirand (2002) which introduces us to the double costly state verification (CSV) problem in that the quality of bank balance sheets has important bearing on the external finance premium faced by firms. Optimal contracting stipulates that a deterioration in balance sheets of banks increases the probability of default and necessitates a higher cost when banks raise external funds (e.g., deposits); consequently a higher deposit interest rate passes on to the lending rate charged on firms. Yet, our model differs slightly. First, we explicitly model the external finance premium banks have to incur that is based on their balance sheet conditions. Having internalized the premium, the deposit rate is then linked to the lending rate via the zero profit conditions, finally resulting in the dynamics of the value of banks. Second, there are multiple interest rates in our model. Here the interest rate at which households discount their stream of incomes is the deposit rate—not the riskless policy interest rate. We hope that such a setting can explain the puzzle pointed out by several studies—for example, Canzoneri, Cumby, and Diba (2007) and Reynard and Schabert (2009)—that the Euler rate empirically is not perfectly related to observed policy rates as characterized by standard models. In the end we hope to fill the gap in the standard model and offer a richer analysis useful for policymaking.

There are, however, some feature that we abstract from the model. Our choice of the external finance premium as the modeling device mainly emphasizes borrowers' costs of raising funds. Thus, as the price of loans rises, the demand for loans falls. In reality, lenders may decide to restrict the supply of funds above and beyond the premium imposed upon borrowers. As in Bernanke, Gertler, and Gilchrist (1999) and Sunirand (2002), we abstract from distinguishing this feature in our theoretical model but instead subsuming such reluctance under a required increase in the risk premium to cover for firms' default risk. However, we will explicitly explore this possibility empirically in the appendix and hope to pursue it in a general equilibrium model subsequently.

The remainder of the paper is organized as follows. Section 2 examines the Thai economy and searches for evidence that implies the existence of macro-financial linkages. Section 3 describes the analytical framework structured to incorporate the intertwining between the financial and real sides of the economy. Section 4 discusses the recent financial crisis in light of our findings. Section 5 concludes. The appendix examines the extent to which financial conditions of banks affect credit availability.

2 Empirical Findings

This section presents evidence that corroborates the existence of the financial accelerator in Thailand. We measure the impact of changes in balance sheet conditions on the external borrowing premium of firms and banks while controlling for other factors. Our hypothesis is to test whether the external finance premium is related to the financial health of borrowers as predicted by theory.

2.1 Evidence from nonfinancial firms

First, we examine the external finance premium in Thailand. Given that data limitation precludes the use of a familiar measure such as corporate bond spreads, in this study we define the external finance premium as the difference between the effective borrowing rate over the risk-free rate. To check robustness of our measure, we construct another indicator based on credit spreads obtained from option pricing models as in Gray and Malone (2009). As the model-implied indicator gives qualitatively similar results, we focus on the first measure.

Table 1 reports summary statistics of the external finance premium in Thailand. The median premium that firms have to pay is approximately 400 basis points. Partitioning the sample period into normal and crisis times, we find that firms' finance premium averages at 300 basis points and 630 basis points respectively. In the noncrisis period, the external finance premium can vary from 70 to 930 basis points (corresponding to the 10th and 90th percentiles respectively). Figure 1 shows the behavior of the risk premium over time. During the period in which extreme credit events occur—especially, immediately after July 1997—the external finance premium increases sharply as (1) leverage multiplies owing to a sharp depreciation of the baht in 1997, (2) profitability drops, and (3) liquidity freezes up. Over the course of the recovery, the external finance premium declines gradually, as firms deleverage. The recent global financial crisis sees firms' external finance premium spike again, however.

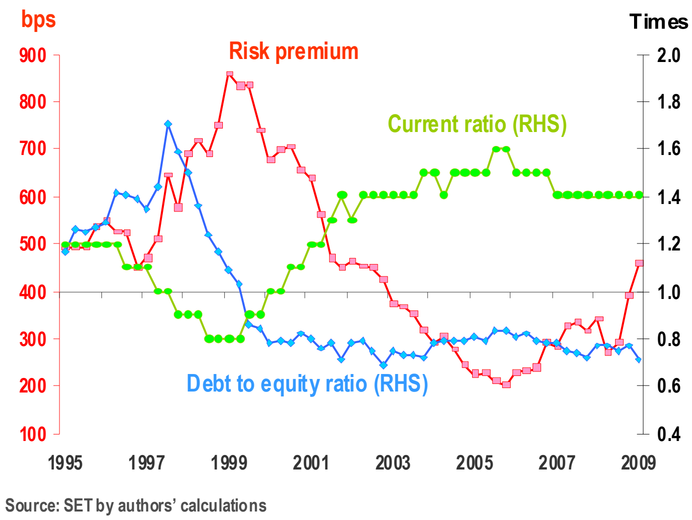


Figure 1: Risk premium and financial health of the corporate sector

Table 1: Risk premium of the corporate sector

Risk premium	Sample Average	Noncrisis Period	Crisis Period
90th Percentile	1,175.3	931.5	1,675.1
75th Percentile	687.6	510.2	1,051.3
50th Percentile	408.6	299.5	632.3
25th Percentile	220.0	158.4	346.3
10th Percentile	107.8	70.0	185.2

Notes. Risk premiums are shown in basis points. The crisis period is defined as 1997Q3–2001Q4 and 2008Q4–2009Q2; the rest is the noncrisis period.

To quantify the importance of firms' balance sheet conditions on their external borrowing premiums, controlling for other firm-specific characteristics that may influence the premium as well as macroeconomic risks, we run a fixed-effect panel regression on an unbalanced panel of 9,637 observations covering 460 firms during the period of 1994Q1–2009Q1. We specify a model as follows:

$$\begin{aligned} RP_{it} &= \alpha + \beta_1 \log\left(EA_{it}\right) + \beta_2 \log\left(CR_{it}\right) + \beta_3 \log\left(STDEBT_{it}\right) \\ &\quad + \beta_4 SIZE_{it} + \beta_5 \Delta_4 GDPR_t + \nu_i + \varepsilon_{it}. \end{aligned} \tag{1}$$

In the equation above RP denotes the risk premium, which is calculated from the difference between the effective borrowing rate and the 1-day repurchase rate in the money market. EA denotes a firm's equity-to-asset ratio. CR is the current ratio which indicates liquidity condition. $STDEBT$ denotes the share of total debt that is short term, reflecting the risks from sudden deleveraging. $SIZE$ is a dummy variable to control for the effect on the borrowing premium that can be attributed to the firm's bargaining power ($SIZE = 1$ if the observed firm is relatively large in terms of asset size (in particular, with asset size in the 75th–100th percentile range). $\Delta_4 GDPR$ is the year-on-year real GDP growth rate to control for market and macroeconomic risks. All variables, except RP and $\Delta_4 GDPR$, are in natural log.

Table 2 presents results from the estimation of equation (1). Here we see a significant and negative relationship between the net worth-to-asset ratio and the finance premium. A ten percent increase in a typical firm's equity-to-asset ratio leads to a reduction of 15 basis points in the premium. Other variables which represent balance sheet conditions in the model, namely the current ratio, the share of short-term debt to overall debt, and size carry expected signs and are statistically significant. Likewise, macroeconomic conditions, represented by GDP growth, have a negative relationship with the finance premium. As expected, market perceives a higher default probability when economic growth declines.

Table 2: Estimation result of determinants of firms' risk premium

Variable	Coefficient	Standard error
$\log(EA)$	-1.506***	0.114
$\log(CR)$	-0.954***	0.126
$\log(STDEBT)$	0.260***	0.052
$SIZE$	-1.622***	0.277
$\Delta_4 GDPR$	-0.764***	0.011
Constant	5.887***	0.154

*** indicates the significance level at 1 percent

2.2 Evidence from banks

In this subsection we start with how to measure the external finance premium faced by Thai banks. First, relying on the deposit interest rates as a main source to extract information about the external finance premium possibly results in a downward bias, because all deposits are guaranteed in Thailand. Second, while using rates charged on bills of exchange issued by banks seems a possible alternative, terms and maturities are not standardized across banks; in addition data limitation does not allow for extensive analysis. Third, we have considered using rates charged in the interbank market. However, interbank rates reflect mostly liquidity risk rather than credit risk. In the end we construct a model-implied measure of banks' external finance premium as in the corporate counterparts. This measure covers six banks over the period of 1995–2009 and forms the basis for analysis in what follows. Table 3 reports our measure of the external premium of Thai banks. That the external finance premium is low—no more than 10 basis points in the normal period—possibly reflects market's perception that the authorities find it prohibitively expensive to let banks fail.

Table 3: Risk premium of selected Thai banks

Risk premium	Sample Average	Noncrisis Period	Crisis Period
90th Percentile	481	133	592
75th Percentile	93	7	205
50th Percentile	49	2	107
25th Percentile	25	1	57
10th Percentile	25	1	57

Notes. Risk premiums are shown in basis points. The crisis period is defined as 1997Q3–2001Q4 and 2008Q4–2009Q2; the rest is the noncrisis period.

To examine whether banks' external finance premiums relate to their financial health, we construct an index to measure bank capital weakness, defined as one over the squared difference between banks' capital adequacy ratios and the minimum capital required by the authority. Figure 2 shows the positive comovement between the implied external finance premium and bank capital weakness. We then run a random-effect panel regression, with 273 observations covering 1995Q1–2009Q2, specified as

$$RP_{it} = \alpha + \beta_1 BIS_{it} + \beta_2 \Delta_4 GDPR_t + \beta_3 ROA_{it} + \beta_4 NPL_{it} + \varepsilon_{it}.$$

RP is the implied spread in percent per annum. BIS is the BIS capital adequacy ratio. Here, we use this indicator as a summary statistic for the financial health of banks for two reasons. As the BIS ratio is calculated as risk-bearing regulatory capital as a proportion of risk-weighted assets, an increase in the BIS ratio indicates an improvement in the balance sheet conditions from a prudential perspective. $\Delta_4 GDPR$ is the year-on-year growth rate of real gross domestic product to control for macroeconomic conditions. ROA is the return on assets ratio to capture banks' ability to repay debt. NPL is the year-on-year growth rate of nonperforming loans to control for asset quality.

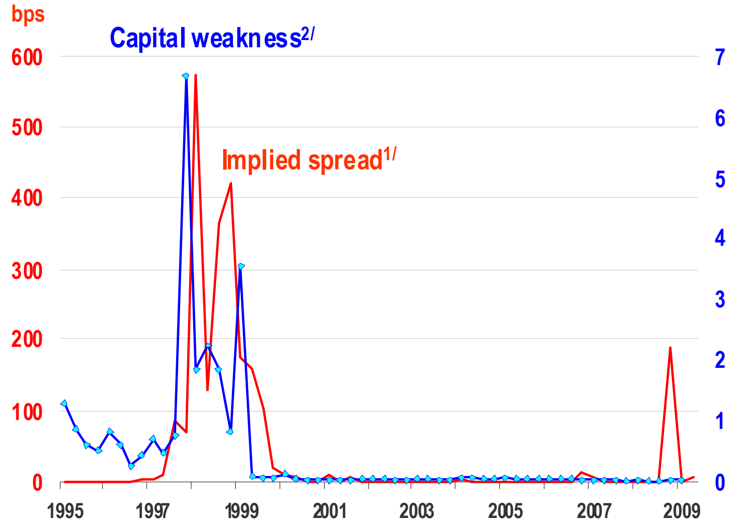
Table 4 reports a main finding. As anticipated, the BIS ratio has a statistically significant relationship with the implied spread. With 90 percent confidence, a one percent change in the BIS ratio raises the spread by 14.7 basis points *ceteris paribus*.

Table 4: Estimation result of determinants of banks' risk premium

Variable	Coefficient	Standard error
BIS	-0.147*	0.077
$\Delta_4 GDPR$	-0.102*	0.061
ROA	-0.163**	0.073
NPL	0.014***	0.004
$Constant$	2.651**	1.130

*,**, and *** indicate the significance levels at 10, 5, and 1 percent respectively

To recap in this section we have demonstrated important features of the financial accelerator mechanism in Thailand. We have measured the impact of changes in balance sheet conditions



Note: 1/ Based on the contingent claims approach.
2/ Banks' capital weakness defined as = 1 / (BIS ratio – Minimum requirement)^2
Source: Bank of Thailand by authors' calculations

Figure 2: Banks' implied spreads and capital weakness

on the external borrowing premium of firms and found that the premium varies inversely with the financial health of firms as predicted by theory. We have found the result to hold for banks as well, even though banks' borrowing premium is on average very small. These features are incorporated in the theoretical model described in details in the next section.

3 The Model

Our model has a foundation in Bernanke, Gertler, and Gilchrist (1999), which lays the theoretical groundwork, and is closely related to Sunirand (2002), which introduces us to the important role of bank balance sheets. Yet, our model slightly differs from them in the following aspects. First, it is a small open economy, whereas these previous models characterize a closed economy. Second, banks in our model also face the external finance premium, whereas in Sunirand (2002) banks' external finance premium that explicitly depends on their balance sheet composition is absent.

3.1 Model environment

This subsection provides a detailed description of various agents in the economy, the first order conditions that govern their optimal behavior, exogenous processes which are not affected by but have bearings on agents' actions, market clearing conditions, steady-state conditions, and the equilibrium that characterizes this model economy.

There are five types of agents interacting in the model economy: households, firms, capital producers, banks, and the fiscal and monetary authorities. Each of the first three explicitly maximizes an objective function subject to a set of well-defined constraints. Households maximize their utility subject to a budget constraint. Firms hire inputs—namely labor from households, an intermediate good imported from abroad, and capital supplied by capital producers—to produce. Firms also set the price of their output. Banks take deposits from households and lend to firms that face financial frictions. Meanwhile, the government consumes and the central bank sets the policy interest rate according to stylized fiscal and monetary rules. In what follows, each type of economic agents is described in details.

3.1.1 Households

There is a continuum of households optimizing their utility by taking various decisions on consumption, labor supply, and financial asset holdings. Algebraically, the representative household maximizes

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left[(1-\chi) \log \tilde{C}_t - \varphi^L \frac{L_t^{1+\eta}}{1+\eta} \right] \tag{2}$$

subject to

$$P_t^D C_t + B_t^B \leq \left(1 + R_{t-1}^B\right) B_{t-1}^B + W_t L_t + \textstyle\sum_j \Phi_j. \tag{3}$$

In the budget constraint (3), C_t, L_t, and B_t^B denote respectively time t consumption, labor supply, and deposits. The timing convention in this quarterly model is such that, in each period t, B_{t-1}^B is predetermined and B_t^B is the stock of deposits to be determined at the end of the period. The price of the consumption good is given by P_t^D. W_t, the nominal wage, is the price of labor. The gross interest rate on B_{t-1}^B is predetermined and given by $1 + R_{t-1}^B$. Φ_j denotes firm's j's profits that are remitted to the households who are the ultimate owners of firms.

In the utility function (2), E_0 is the expectation operator conditional on the information at time 0. β is the discount factor. φ^L is the scaling parameter for the disutility of supplying labor and η is the inverse of the Frisch elasticity of labor supply. $\tilde{C}_t$ is the habit-adjusted consumption which depends on C_t and C_{t-1} and the parameter χ. In order to generate persistent consumption dynamics, we introduce consumption habit persistence by assuming that utility obtained from consumption in this period does not depend on how much is consumed today, but instead depends on this period's consumption with respect to some "habit," which is in turn related to the previous period's consumption. Algebraically,

$$\tilde{C}_t = \frac{C_t - \chi h_t}{1-\chi} \quad \text{with} \quad h_t = (1+\alpha) C_{t-1}. \tag{4}$$

$\tilde{C}_t$ is the habit-adjusted consumption that enters the household's utility function, C_t is today's consumption, and h_t is the level of habit. In the simple setting where the steady-state growth rate of the economy, α, is zero, we have $h_t = C_{t-1}$. Here the household obtains utility from consumption only if today it consumes more than yesterday. When $\alpha > 0$, the reference point needs to be adjusted up instead of simply taking yesterday's consumption as a benchmark. How strongly the household refers to past consumption depends on the value of the parameter χ that governs habit persistence. When $\chi = 0$, the household completely disregards the previous period's consumption: $\tilde{C}_t = C_t$. Note also that consumption in the steady state

$$\tilde{C}_t^{ss} = \frac{C_t^{ss} - \chi(1+\alpha)C_{t-1}^{ss}}{1-\chi} = \frac{C_t^{ss} - \chi C_t^{ss}}{1-\chi} = C_t^{ss}.$$

That is, habit persistence is irrelevant along the balanced growth path.

Finally, the Lagrangian for the household's problem (2)–(3) is given by

$$\mathcal{L} = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \begin{array}{c} (1-\chi)\log \tilde{C}_t - \varphi^L \frac{L_t^{1+\eta}}{1+\eta} \\ +\lambda_t \left[\left(1 + R_{t-1}^B\right) B_{t-1}^B + W_t L_t + \sum_j \Phi_j - (1-\chi) P_t^D \tilde{C}_t - \chi P_t h_t - B_t^B \} \right] \end{array} \right\}$$

where λ_t is the marginal utility of nominal income.

Consumption decision The household's intertemporal problem with respect to consumption decision can be solved by setting $\partial\mathcal{L}/\partial\tilde{C}_t = 0$:

$$\frac{1}{\tilde{C}_t} = \lambda_t P_t^D.$$

In words, utility forsaken by consuming one unit less $\left(1/\tilde{C}_t\right)$ is equal to marginal utility of nominal income (the Lagrange multiplier, λ_t) times the nominal income gained from not consuming that unit of consumption (i.e., P_t^D—the price of one unit of the consumption good).

Wage setting and labor supply decisions It is assumed that the continuum of monopolistically competitive households supplies differentiated labor to firms as a production input. As in Erceg, Henderson, and Levin (2000) and Christiano, Eichenbaum, and Evans (2005), it is instructive to assume a labor aggregator (or an "employment agency") that combines households' differentiated labor into a bundle and sets the price of that bundle on behalf of the households.

In the first stage the representative household makes the labor supply decision. The first-order condition obtained from setting $\partial\mathcal{L}/\partial L_t = 0$ is given by

$$\lambda_t Q_t^L = \varphi^L L_t^\eta.$$

In utility terms, the shadow value of labor—which is the product of the shadow price of labor, Q_t^L, times the Lagrange multiplier, λ_t—equals the disutility of supplying labor, $\varphi^L L_t^\eta$.

In the second stage the labor aggregator sets the nominal wage on behalf of the household. In a hypothetical flexible-price setting, the optimal wage (W_t^*) is set as a wage markup (μ^W) over marginal cost (Q_t^L):

$$W_t^* = \mu^W Q_t^L.$$

In the present model where wage rigidities are present, the labor aggregator wishes to set wage, W_t, as close as possible to W_t^*, but also needs to take account of wage indexation such that this period's wage inflation, ΔW_t, is not too different from the previous period's wage inflation, $\Delta \bar{W}_{t-1}$, which is taken as given. That is, the labor aggregator solves

$$\min_{W_t} \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left[(W_t - W_t^*)^2 + \xi^W (\Delta W_t - \Delta \bar{W}_{t-1})^2 \right]$$

where ξ^W represents the degree of wage rigidity. The case for which no rigidity is present is given by $\xi^W = 0$; here the labor aggregator will indeed set W_t equal to W_t^* in each period. When $\xi^W > 0$, the first-order condition with respect to W_t is given by

$$W_t = W_t^* + \xi^W \left[- \left(\Delta W_t - \Delta \bar{W}_{t-1} \right) + \beta \left(\mathrm{E}_t \Delta W_{t+1} - \Delta \bar{W}_t \right) \right].$$

According to the first term in the square brackets, if this period's wage inflation is higher than the previous period's, then W_t is too high and needs to be adjusted down. The second term in the square brackets states that, if the expected wage inflation in the next period happens to be higher than this period's, $\Delta W_{t+1} - \Delta \bar{W}_t > 0$, then the present period's wage is too low relative to W_{t+1} and is suboptimal, and thus needs to be adjusted up.

Saving and borrowing decisions The representative household has two decisions to make regarding holdings of financial instruments: depositing with local banks and borrowing from international financial markets.

With regard to the household's decision on deposits, as shown in the budget constraint (3), the household at the beginning of each period t receives the gross amount of $(1 + R_{t-1})\, B_{t-1}^B$, and it decides B_t^B at the end of the period. Consequently, the first-order condition with respect to B_t^B is given by

$$\lambda_t = \beta \mathrm{E}_t \lambda_{t+1} \left(1 + R_t^B \right). \tag{5}$$

In words, the optimal deposit must be such that this period's marginal utility of nominal wealth is equal to the expected discounted marginal utility of wealth in the next period.

With regard to the household's decision on foreign financial instruments, it is assumed that there is a foreign exchange agent which acts on behalf of the household. Toward the end of each period, a foreign exchange agent accumulates foreign debt denominated in the foreign currency, B_t^*, by solving the following intertemporal problem

$$\max_{B_t^*} \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \lambda_t S_t \left\{ B_t^* - \left[1 + \frac{\xi^{Bf}}{2} \left(\frac{S_{t-1} B_{t-1}^*}{4 Y_{t-1}^N} - \psi \right) \right] \left(1 + R_{t-1}^* \right) B_{t-1}^* \right\}.$$

S_t is the nominal exchange rate—the price of one unit of the foreign currency in terms of the local currency—and R_t^* is the foreign interest rate. The term in the square brackets is the premium on the rate at which the household can borrow, and this premium is increasing in the ratio of debt to nominal GDP with the factor of proportionality $\xi^{Bf}/2$. (Because GDP is a quarterly flow variable, Y_{t-1}^N needs to be multiplied by 4 before comparing it with B_{t-1}^* which is a stock variable.) The parameter ψ is the steady-state debt-to-GDP ratio. In essence, the term in the square brackets is an interest rate premium which works to ensure that the household will not run up infinite debt: it will be increasingly costly to borrow as the household becomes more indebted.

The first-order condition with respect to B_t^* gives a variant of the uncovered interest parity (UIP) condition:

$$R_t^B - R_t^* = \mathrm{E}_t dS_{t+1} + \xi^{Bf}\left(\frac{S_t B_t^*}{4Y_t^N} - \frac{\psi}{2}\right)$$

where dS_{t+1} is the rate of nominal exchange rate depreciation in the next period. It will be helpful later on when taking the model to data to define a variable $B_t^f = S_t B_t^*$, which is the foreign debt that is denominated in the local currency. Moreover, to create a differential between the domestic and foreign interest rates in the steady state, we introduce a constant parameter υ so that the UIP condition becomes

$$R_t^B - R_t^* = \mathrm{E}_t dS_{t+1} + \xi^{Bf}\left(\frac{B_t^f}{4Y_t^N} - \frac{\psi}{2}\right) + \upsilon.$$

Finally, the law of motion of B_t is given by

$$B_t^f = \left(1 + R_{t-1}^B\right) B_{t-1}^f - \left(P_t^X X_t - P_t^M M_t\right).$$

Note how earnings on net exports work to reduce the foreign debt position.

3.1.2 Firms

There are two types of firms in the economy: one selling to the local market, the other to the foreign market. In terms of production technology, both domestic and export firms share the Cobb–Douglas production function, with the only difference residing in the relative input share. In terms of pricing, the domestic firms are modeled as monopolistically competitive firms that have pricing power and, in light of pervasive government price administration in Thailand, face price rigidities. On the other hand, as Thailand is a small open economy, the exporters are price takers and must instantaneously adjust their prices consistently with those set in the world market.

Production decision The representative domestic firms' production function is given by

$$Y_t^D = \left(A_t L_t^D\right)^{\gamma_L^D} \left(M_t^D\right)^{\gamma_M^D} \left(K_t^D\right)^{1-\gamma_L^D-\gamma_M^D} \tag{6}$$

where domestic output is denoted by Y_t^D and the three factor inputs are labor (L_t^D), imported intermediate good (M_t^D), and capital (K_t^D). A_t is the labor-augmented productivity.

The demand for labor and imported intermediate good is standard and given by

$$W_t L_t^D = \gamma_L^D Q_t^D Y_t^D \tag{7}$$

$$P_t^M M_t^D = \gamma_M^D Q_t^D Y_t^D \tag{8}$$

where W_t and P_t^M denote the nominal wage and the import price, respectively, and Q_t^D denote the nominal marginal cost of the domestic good.

The demand for capital with the presence of financial frictions, however, is not as straightforward as the other two inputs, given that the capital acquired by the firm has an explicit bearing on the balance sheet. Define the firm's balance sheet as

$$Q_t K_t^D = B_t^D + N_t^D. \tag{9}$$

In the left side of (9) Q_t is the price of capital and thus $Q_t K_t^D$ is the nominal value of the firm's total assets. The right side consists of nominal debt, B_t^D, and the firm's net worth, N_t^D. The optimal demand for capital is determined by the two relationships below.

The first equation defines the interest rate at which the domestic firm has to pay in order to obtain external funds to finance capital purchased, R_t^D, which must be equal to the return on capital as shown in the right side of (10):

$$1 + R_t^D = \frac{\left(1 - \gamma_L^D - \gamma_M^D\right) Q_{t+1}^D Y_{t+1}^D}{Q_t K_t^D} + (1 - \delta) \frac{Q_{t+1}}{Q_t} \tag{10}$$

where Q_t^D is the competitive price of the domestic good (which is equal to its marginal cost), Q_t is the price of capital, and δ is the depreciation rate of capital. Equation (10) states that in equilibrium the borrowing rate of interest must be equal to the rate of return on capital. The latter in turn depends on (1) how much that additional unit of capital contributes to production and (2) how much that unit of capital is valued net of depreciation.

The second equation, following Bernanke, Gertler, and Gilchrist (1999) and in particular Sunirand (2002), relates capital demand K_t^D (or $Q_t K_t^D$ in nominal terms) and the marginal financing cost, R_t^D:

$$R_t^D - R_t = \left(\frac{Q_t K_t^D}{N_t^D + N_t^{BD}} \right)^{\nu}. \tag{11}$$

In the demand curve (11), price now is given in terms of the premium on top of the risk-free interest rate, $R_t^D - R_t$. This external finance premium increases in the ratio of $Q_t K_t^D$ to $N_t^D + N_t^{BD}$, where N_t^D is the domestic firm's net worth and N_t^{BD} is the bank's capital that implicitly supports lending to the domestic firm. Intuitively, the bigger is the firm's enterprise relative to its internal funds and the bank's capital, the greater is the probability that the firm will not be able to repay the borrowed funds and thus the higher is the risk premium.

Figure 3, based on Sunirand (2002), illustrates three scenarios. First, when $QK^D < N^D$, the size of the firm's project is smaller than its net worth, and thus the firm's internal funds suffice to finance its project. Hence there is no need to seek external finance and the external finance premium in this case is zero. Second, when $N^D < QK^D < N^D + N^{BD}$, the firm must seek external funds, which can be supported by the financial intermediary. This is the case analyzed by Bernanke, Gertler, and Gilchrist (1999). Third, when $QK^D > N^D + N^{BD}$, total internal funds of the firm and the bank are not sufficient. The firm's external finance premium will depend on the bank's internal funds as well. The intuition is that when the bank raises external finances from households, the latter will require a premium depending on the health of the bank's balance sheet. The bank in turn passes this premium onto the firm. Hence the firm's external finance premium will ultimately depend on the size of its project relative to the total internal funds of the firm *and* the bank.

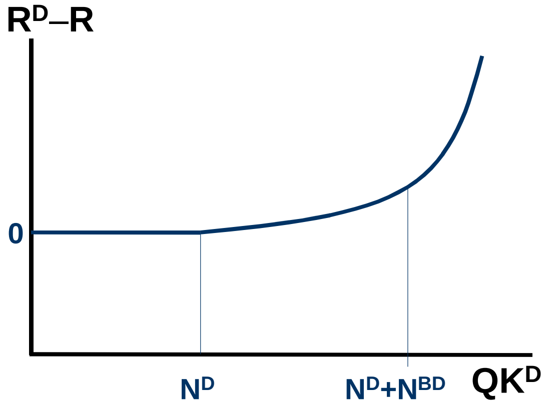


Figure 3: Firm's External Finance Premium—role of net worth and bank capital

Furthermore, the more sensitive this premium is to the firm's intensity in using external finances, as captured in the elasticity ν, the greater is the external finance premium. For a derivation of (11) see Sunirand (2002). Briefly, this optimal demand for capital (or demand for loans) is obtained from maximizing the expected profits of the firm subject to (1) the depositor's zero-profit condition which determines the supply of deposits, (2) the bank's expected zero-profit condition, and (3) the firm's and bank's balance sheet identities.

Endogenous net worth The key element in generating the financial accelerator is the endogeneity of borrowers' net worth. The firm's net worth (N_t^D) is endogenized and is determined by the value of the firm (V_t^D, to be defined below) and the probability that the firm will survive into the next period (ϕ_v):

$$N_t^D = \phi_v V_t^D. \tag{12}$$

Note that in the simple model without the financial accelerator net worth is exogenously determined and is passively a fixed fraction, ϑ, of the firm's balance sheet: $N_t^D = \vartheta Q_t K_t^D$. In such a case the health of the firm's balance sheet is nothing other than an exogenous parameter ϑ. In contrast, when net worth is endogenized, so is the firm's financial position, which has an important bearing on the how much the firm is charged for its external finances.

To complete the endogenization of net worth, we need to specify the dynamics of V_t^D. Define the value of the firm as

$$V_t^D = (1-\delta)Q_t K_{t-1}^D + Q_t^D Y_t^D - \left[W_t L_t^D + P_t^M M_t^D + \left(1 + R_{t-1}^D\right) B_{t-1}^D\right]. \tag{13}$$

That is, the value of the firm is the sum of (1) the value of the capital, owned by the firm, carried over from the previous period net of depreciation; (2) the revenue from selling the product; (3) the expenditure on factor inputs employed, consisting of wage bills, expenses on imported intermediated, and the repayment of external funds borrowed in the previous period. Hence we have effectively created a link from macro variables to the financial position of the firm.

Pricing decision In addition to choosing how much factor inputs to employ, given that domestic firms are monopolistically competitive by the virtue of their differentiated products, they also set prices. As in the case of wage setting by households, the price setting problem of the representative domestic firm takes the following form

$$\min_{P_t^D} \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left[(P_t^D - P_t^{D*})^2 + \xi^D (\Delta P_t^D - \Delta \bar{P}_{t-1}^D)^2 \right].$$

The solution of the above problem is given by

$$P_t^D = P_t^{D*} + \xi^D \left[- \left(\Delta P_t^D - \Delta \bar{P}_{t-1}^D \right) + \beta \left(\mathrm{E}_t \Delta P_{t+1}^D - \Delta \bar{P}_t^D \right) \right] \tag{14}$$

where $P_t^{D*} = \mu^D Q_t^D$.

Export firms Finally, the representative export firms' production function is given by

$$Y_t^X = \left(A_t L_t^X \right)^{\gamma_L^X} \left(M_t^X \right)^{\gamma_M^X} \left(K_t^X \right)^{1-\gamma_L^X-\gamma_M^X}$$

where notation is analogous to that for the domestic firm, except for replacing the superscript D with X. Optimality conditions for export production are similar to (6)–(13).

Regarding pricing, in contrast to the domestic firm which is a monopolistically competitive firm, the export firm is a perfectly competitive firm which takes the market price as given. Thus in equilibrium we have

$$Q_t^X = P_t^X$$

where the export price (in the local currency terms), P_t^X, depends on the nominal exchange rate, S_t, and the exogenous export price, P_t^{Xf}, that is in foreign currency terms:

$$P_t^X = S_t P_t^{Xf}.$$

3.1.3 Capital producers

Intuitively the capital producer and the firms can be merged into one entity; here we distinguish their functions explicitly for ease of algebra. The capital producer solves the following intertemporal problem

$$\max_{I_t} \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \lambda_t \left\{ Q_t \left[(1-\delta) K_t + F(I_t, I_{t-1}) - K_{t+1} \right] - P_t^D I_t \right\}. \tag{15}$$

In words, the capital producer uses capital from firms after they have used it in production, $(1-\delta)K_t$, and combine it with the investment good it has purchased from the retailer of the final goods, $F(I_t, I_{t-1})$, to produce new capital. Here, $F(I_t, I_{t-1})$ is a function that transforms investment made in the present and previous periods into new capital. The capital producer will then return capital, K_{t+1}, to the firms to be used in the subsequent production process.

Hence the terms in the squared brackets represent the amount of capital that comes to be owned by the capital producer in each period. Given that Q_t is the price of capital and $P_t^D I_t$ is the expenditure on investment good used in the production of capital, the terms in the curly brackets are the time-t profits. Given that these profits are returned to the households, λ_t converts them into utility. Finally, such a stream of utility is then discounted by the discount factor β.

It should be noted that in a simple case we can have $F(I_t, I_{t-1}) = I_t$. That is, investment that the capital producer makes this period is fully transformed into capital in the next period. However, when it is costly to adjust investment, the amount of capital accumulated throughout this period is not equal to investment made in the period, but is instead a function of investment this period and the period before. We introduce investment adjustment to capture what we observe in the real world that investment is slow to change in response to shocks. In the present model $F(I_t, I_{t-1})$ takes the form

$$F(I_t, I_{t-1}) = \left[1 - \frac{\xi^I}{2}\left(\frac{I_t}{I_{t-1}} - (1+\alpha)\right)^2\right] I_t \tag{16}$$

where ξ^I is the investment adjustment cost parameter. Note that when $\xi^I = 0$, $F(I_t, I_{t-1}) = I_t$. For $\xi^I > 0$, there will be real costs incurred when the (gross) rate growth of investment, I_t/I_{t-1}, is different from the rate at which the economy grows along the balanced growth path, $1+\alpha$.

Given (15) and (16), the first-order condition is

$$\begin{aligned}
\frac{Q_t}{P_t} &= [F_1(I_t, I_{t-1})]^{-1}\left[1 - \beta \mathrm{E}_t \frac{\lambda_{t+1}}{\lambda_t}\frac{Q_{t+1}}{P_t} F_2(I_{t+1}, I_t)\right] \\
&= \left[1 - \phi \frac{I_t}{I_{t-1}}\left(\frac{I_t}{I_{t-1}} - (1+\alpha)\right) - \frac{\phi}{2}\left(\frac{I_t}{I_{t-1}} - (1+\alpha)\right)^2\right]^{-1} \\
&\quad \times \left[1 - \phi\beta \mathrm{E}_t \frac{\lambda_{t+1}}{\lambda_t}\frac{Q^K_{t+1}}{P_t}\left(\frac{I_{t+1}}{I_t}\right)^2\left(\frac{I_{t+1}}{I_t} - (1+\alpha)\right)\right].
\end{aligned}$$

The left hand side is Tobin's q, which is the ratio of the price of capital to the replacement cost of capital. In the simple case where $F(I_t, I_{t-1}) = I_t$, $F_1(I_t, I_{t-1}) = \partial I_t/\partial I_t = 1$ and $F_2(I_{t+1}, I_t) = \partial I_{t+1}/\partial I_t = 0$, we have the well-known equilibrium condition given by $Q_t/P_t = 1$. On the contrary, there will be more (less) investment if the ratio of the shadow value of capital to the cost of acquiring it is greater (less) than unity.

3.1.4 Banks

In contrast to Bernanke and Blinder (1988) where the bank lending channel works solely through the supply side of credit in that a tight monetary policy reduces the supply of bank loans, and unlike the balance sheet channel of Bernanke, Gertler, and Gilchrist (1999) which works solely through the demand side of credit through the firm's external finance premium, this paper incorporates elements that determine both credit demand and credit supply. While demand for credit remains similar to that in Bernanke, Gertler, and Gilchrist (1999), the supply side, motivated by Sunirand (2002), works through banks' external finance premium, which in turn affects the amount of funds banks obtain externally and hence the amount of credit supplied to firms. In effect, we believe that both the demand and supply sides of credit are accounted for in the present model.

To model banks, let the representative bank's balance sheet be given by

$$B_t = B_t^B + N_t^B \tag{17}$$

where $B_t = B_t^D + B_t^X$ is total loans supplied to the domestic and export firms, B_t^B is the bank's external funds (liabilities such as deposits and borrowings), and N_t^B is bank capital which is equal to the sum of N_t^{BD} and N_t^{BX}, i.e., bank capital implicitly backing loans to the domestic and export firms respectively.

The bank's external finance premium is given by

$$R_t^B - R_t = \left(\frac{B_t^B}{N_t^B}\right)^{\nu^B} \tag{18}$$

which states that the bank's external finance premium is increasing in the ratio of its loans to capital, with the elasticity given by ν^B. Bank capital is endogenous and is in turn given by

$$\begin{aligned} N_t^B &= \phi_v^B V_t^B & (19)\\ V_t^B &= \left(1+R_{t-1}^D\right) B_{t-1}^D + \left(1+R_{t-1}^X\right) B_{t-1}^X - \left(1+R_{t-1}^B\right) B_{t-1}^B = \left(1+R_{t-1}^B\right) N_{t-1}^B. & (20) \end{aligned}$$

According to equation (19), bank capital, analogous to the firm's net worth, is determined by the probability that the bank will survive into the next period (ϕ_v^B) and the value of the bank (V_t^B). In equation (20) V_t^B in turn equals the previous period's bank capital, N_{t-1}^B, carried over into the present period while earning the gross interest rate $1 + R_{t-1}^B$. Here, the first equality of (20) states that the bank's value is the repayment of loans by the domestic and export firms minus its repayment of external funds. Using the bank's the bank's balance sheet identity $\left(B_{t-1}^B = B_{t-1} - N_{t-1}^B\right)$ and the bank's zero-profit condition whereby interests earned equal interest paid $\left(R_{t-1}^D B_{t-1}^D + R_{t-1}^X B_{t-1}^X = R_{t-1}^B B_{t-1}\right)$ gives rise to the second equality.

Finally, we specify that in equilibrium the representative bank is equally risk averse to lending to domestic and export firms by having a similar degree of leveraged lending to the two types of firms, that is,

$$\frac{B_t^D}{N_t^{BD}} = \frac{B_t^X}{N_t^{BX}}.$$

3.1.5 Fiscal and monetary authorities

The government is assumed to follow a simple fiscal rule:

$$P_t^D G_t = \rho^G \left(P_{t-1}^D G_{t-1}\right) + \left(1-\rho^G\right)\left(\sigma Y_t^N\right).$$

That is, while this period's nominal government expenditure, $P_t^D G_t$, is targeted as a constant fraction σ of nominal GDP, Y_t^N, it also depends on the previous period's expenditure, $P_{t-1}^D G_{t-1}$, so as to model the persistence in nominal government spending. The degree of persistence is captured by ρ^G.

The central bank is assumed to follow a simple monetary rule:

$$R_t = \rho^R R_{t-1} + \left(1-\rho^R\right)\left[R^{ss} + \kappa\left(dP^D_{t+1} - \bar{\pi}\right)\right].$$

Analogous to the fiscal rule, this period's policy interest rate, R_t, is a weighted average of the previous period's rate and a target, with the weights given by ρ^R and $1-\rho^R$ respectively. The targeted interest rate depends on the steady-state nominal interest rate, R^{ss}, and the extent to which the next period's inflation, dP^D_{t+1}, is projected to exceed the inflation target, $\bar{\pi}$. The parameter $\kappa > 0$ characterizes the degree of responsiveness of the central bank's reaction to the inflation deviation.

3.1.6 Exogenous processes

Exogenous processes are as follows:

$$\begin{aligned} A_t &= A_{t-1} + \alpha + \varepsilon^A_t \\ T_t &= \rho^T T_{t-1} + \varepsilon^T_t \\ dP^{M^*} &= \pi^* + \varepsilon^{P^{M^*}}_t \\ R^*_t &= \rho^{R^*} R^*_{t-1} + \left(1-\rho^{R^*}\right) R^{ss*} + \varepsilon^{R^*}_t \end{aligned}$$

where A_t, T_t, dP^{M^*}, and R^*_t are respectively technology, the terms of trade, foreign inflation, and the foreign interest rate at time t, with the associated steady state values normalized to 1 for technology and the terms of trade and given by π^* and R^{ss*} for foreign inflation and the foreign interest rate. ρ^T, and ρ^{R^*} are parameters governing persistence of the processes. The $\varepsilon^{'}_t$s are innovations.

3.1.7 Market clearing conditions

The market clearing conditions at any time t for the factor inputs are given by

$$\begin{aligned} L_t &= L^D_t + L^X_t \\ M_t &= M^D_t + M^X_t \\ K_t &= K^D_t + K^X_t \end{aligned}$$

and the market clearing conditions for outputs are given by

$$Y^D_t = C_t + I_t + G_t.$$

3.1.8 Steady-state Conditions

Steady-state conditions—essentially, the terminal conditions of transition equations described above—are determined according to balanced growth. That is, the steady state is defined such that macro variables *grow* at constant rates such that no variable explodes or implodes over time. Three key parameters that determine steady-state growth rates of variables in the model are the economy's productivity growth rate (α), the target rate of inflation (π), and the foreign inflation target (π^*).

Real variables in the steady state grow at the rate of productivity growth. Thus, output (Y^D, Y^X), output components (C, I, G, X), production inputs except labor (K^D, K^X, M^D, M^X) grow at a constant rate α along the balanced growth path. The steady-state growth rate of labor (L^D, L^X), however, is set to zero to prevent labor from growing indefinitely.

Price variables grow at the target rate of inflation in the steady state. Thus, prices (P^D, P^X, P^M, Q) and marginal costs (Q^D, Q^X) grow at π. Exceptions are the nominal wage and the shadow price of labor (W, Q^L) which grow at $\alpha + \pi$, as well as interest rates (R, R^B, R^D, R^X, R^*) which remain constant in the steady state.

Consequently, nominal variables, namely, nominal GDP and foreign bond holdings (Y^N, B^*), as well as financial variables (V^D, N^D, B^D, V^X, N^X, B^X, V^B, N^B, N^{BD}, N^{BX}, D, B), grow at $\alpha + \pi$.

The foreign export and import prices (P^{Xf} and P^{Mf}) grow at π^*. Hence, the terms of trade (T) is constant in the steady state.

Finally, the exchange rate depreciates at the rate of $\pi - \pi^*$ along the balanced growth path.

3.1.9 Equilibrium

The equilibrium is a collection of prices and quantities that satisfy the first-order conditions, fiscal and monetary rules, laws of motion, the market clearing conditions, and the steady-state conditions.

3.2 Parameterization

This subsection describes parameters of the model. Combining the model structure outlined in the previous subsection, which is a theoretical simplification of the economy, with the parameters that are closely related to features of the economy allows us experiments that can help us understand the economy which is made up of complex dynamics.

There are two broad methods for parameterizing DSGE models: calibration and estimation. We can formally estimate the parameters for the model; however, estimation potentially involves a number of complications. For example, the likelihood corresponding to the model—which is a function of model parameters we wish to solve for via maximization—may contain flat regions, discontinuities, or multiple local maxima. Although recent developments in Bayesian estimation have been shown to solve such problems, and also enable the data to determine model parameters in a more consistent manner while allowing us to incorporate prior beliefs, we reserve it for the future as it potentially entails a number of technicalities. For the moment we choose to calibrate the model, i.e., we select the values of parameters based on empirical findings that result in a model that can characterize the Thai economy to the best of our understanding.

Information from various sources has been used as an input for calibration, including the input–output matrix (National Economic and Social Development Board, 2000), OLS, GMM, and VAR estimation (Sutthasri, 2007), and the Bank of Thailand DSGE model (Tanboon, 2008). We also compare our calibrated parameters with the counterparts in the literature.

In what follows we discuss our methodology for calibrating model parameters, which are classified into two groups. Details on the parameters are summarized in Tables 7 and 8.

3.2.1 Parameters governing the steady state

Steady-state parameters consist of those of households (β, δ, η, φ^L, μ^W, ψ), firms (γ_L^D, γ_M^D, μ^D, γ_L^X, γ_M^X), fiscal and monetary authorities (σ, π), and exogenous processes (α, π^*).

Details on the representative household's parameters are as follows. We set $\delta = 0.0105$ corresponding to the average annual depreciation rate between 1970 and 2006 of 4.2 percent; δ is calculated as the annual depreciation divided by gross capital stock (at 1988 price). η^{-1} is set to 0.33, which corresponds to the wage elasticity of labor supply that is obtained from an OLS estimation of the first-order condition with respect to L_t. We set φ^L to 1, i.e., no scaling for the disutility of labor supply. The parameter μ^W is set to 1.05 calculated using on data from the National Statistical Office and the National Economic and Social Development Board. ψ is set to 0.25. This ratio of foreign debt to nominal GDP has been on a declining trend from an unusually high level after the 1997 financial crisis and appears to stabilize recently: from 0.82 in 1999Q1 to 0.28 when averaged over 2004Q1–2008Q2 and 0.24 over 2007Q1–2008Q2.

The parameters governing firms' production are calibrated based on a calculation using the input–output matrix. μ^D is set to 1.2. This value is within the range of 1.13–1.32 reported in Sutthasri (2007), where the markup is calculated as the ratio of the total value of production to the total cost of production—the latter computed as the difference between the total value of production and the operating surplus. We set $\gamma_L^D = 0.65$ and $\gamma_L^X = 0.60$, implying domestic firms are more labor intensive relative to export firms. (These sectoral labor income shares are roughly in line with Tanboon, 2008, which uses $\gamma_L^D = 0.70$ and $\gamma_L^X = 0.64$.) For shares of imported intermediate good, we set $\gamma_M^D = 0.15$ and $\gamma_M^X = 0.18$, implying that, relative to domestic firms, export firms use more imported inputs (and also more capital) in the production function.

Table 7: Steady-State Parameters

Parameter	Value	Description
Households		
β	0.9968	Discount factor
δ	0.0105	Depreciation rate (4.2% per year)
η	3.0303	Inverse of Frisch elasticity
φ^L	1	Scaling parameter for labor disutility
μ^W	1.05	Wage markup
ψ	0.25	Ratio of foreign debt to nominal GDP
Firms		
μ^D	1.20	Price markup, domestic firms
γ_L^D	0.65	Labor income share, domestic firms
γ_M^D	0.15	Imported input income share, domestic firms
γ_L^X	0.60	Labor income share, export firms
γ_M^X	0.18	Imported input income share, export firms
ϕ_v	0.9874	Probability of firms surviving into next period
ν	0.0170	Elasticity of firms' external finance premium to total internal funds financing firms' projects
Bank		
ϕ_v^B	0.9968	Probability of banks surviving into next period
ν^B	0.0003	Elasticity of bank's external finance premium to bank's capital-to-asset ratio
Government		
σ	0.20	Ratio of government expenditure to nominal GDP
π	0.0074	Inflation target (3% per year)
Exogenous processes		
α	0.0059	Productivity growth rate (2% per year)
π^*	0.0074	Foreign inflation target (3% per year)

The parameters governing firms' financial conditions are as follows. The probability of firms surviving into the next period, which determines the steady-state net worth, is given by 0.9874, following from equations (9) and (12) which in the steady state give $\phi_v = \exp\left(\alpha + \pi - R^D\right)$. Here R^D equals the sum of (1) the real risk-free interest rate of 3 percent, (2) the steady-state rate of inflation of 3 percent in line with the inflation target, and (3) the domestic firm's external finance premium of 4 percent—which is in accordance with empirical evidence. Export firms are assume to take the same survival probability ϕ_v, thereby implicitly assuming that $R^D = R^X$ in the steady state. Further refinement on calibration of financial parameters includes examining empirically whether domestic and export firms are significantly differentiated. Furthermore, we set $\nu = 0.0170$. This elasticity of firms' external finance premium with respect to the total internal funds available to finance their enterprise is close to our empirical finding of 0.02.

The parameters governing banks' financial conditions are the probability of firms surviving into the next period, ϕ_v^B, and the elasticity of banks' external finance premium with respect to the capital-to-asset ratio, ν^B. We set $\phi_v^B = \exp\left(\alpha + \pi - R^B\right) = 0.9968$, which is close to 1 and higher than ϕ_v of firms. This is consistent with what we observe in reality that banks are much more difficult than firms to bankrupt, though in our model the two probabilities are not so much different given that they are tied down by certain parameters and steady-state values in the model. The other parameter for banks, $\nu^B = 0.0003$, cannot also be set freely, as it is governed by equation (18), in which we set the steady-state ratio of banks' capital-to-asset ratio to 0.15.

The ratio of government expenditure to nominal GDP, σ, is set to 0.20, close to the mean and the median over 1993Q1–2008Q2. The central bank's inflation target, π, is set to $\frac{1}{4} \times \log(1.03)$, i.e., 3 percent per annum.

With regard to parameters of exogenous processes, we set α to 2 percent per annum close to Sutthasri's (2007) estimate of 2.4 percent based on data from 1978 to 2006. This value is comparable with Chuenchoksan and Nakornthab's (2008) findings that Thailand's total factor productivity (TFP) growth is 1.8 percent over 1987–1996 and 2.0 percent over 2000–2007 (the average TFP growth during the unusual financial crisis years registers –6.7 percent). π^* is set to 3 percent per annum.

Finally, the value of β is tied down by some of the above steady-state parameters. According to (5) it is given by $\beta = \exp\left(\alpha + \pi - R^B\right) = 0.9968$, where we take the values of π and α as indicated above and use the annualized steady-state Euler interest rate of 3.2 percent in real terms. This is the interest rate at which households discount their utility. Several studies—for example, Canzoneri, Cumby, and Diba (2007) and Reynard and Schabert (2009)—point that the Euler rate are not perfectly related to observed policy rates as standard models characterize. Consequently, instead of assuming the Euler rate to be identical to the real policy interest rate, we set it equal to the annualized steady-state real risk-free interest rate of 3 percent plus the bank's external finance premium the households earn when depositing funds with banks. Banks' steady-state external finance premium is set to 20 basis points, closely in accordance with empirical evidence.

3.2.2 Parameters governing the transition dynamics

Dynamic parameters consist of those of households (χ, ξ^I, ξ^W, ξ^{B^f}, υ), firms (ξ^D), banks (τ), fiscal and monetary authorities (ρ^G, ρ^R, κ), and exogenous processes (ρ^{R^*}, ρ^T).

We set the consumption habit-persistence parameter, χ, to 0.85. This value is within the range of 0.84–0.88 obtained from GMM estimation of the Euler equation using data during 1994Q1–2006Q4. The estimate is comparable with 0.86 and 0.90 calculated respectively by Ravn, Schmitt-Grohe, and Uribe (2006) and Fuhrer (2000) using the U.S. data. We set $\xi^I = 1.5$, $\xi^W = 6$, and $\xi^{B^f} = 0.4$ such that the impulse responses of investment, wage, the exchange rate, as well as other related variables are consistent with our understanding of dynamics of the Thai economy. We set $\upsilon = \frac{1}{4} \times \log(1.02)$, implying the wedge between the domestic and the foreign interest rates of 2 percent per annum in the steady state.

Table 8: Dynamics Parameters

Parameter	Value	Description
Households		
χ	0.85	Consumption habit persistence
ξ^I	1.5	Investment adjustment cost
ξ^W	6	Wage adjustment cost
ξ^{Bf}	0.4	Interest rate premium on foreign debt holdings
υ	0.005	Differential between domestic and foreign interest rate
Firms		
ξ^D	0.7	Degree of price rigidities
Government		
ρ^G	0.80	Persistence in government expenditure
ρ^R	0.90	Persistence in policy interest rate
κ	10	Responsiveness of policy rate to inflation
Exogenous processes		
ρ^{R^*}	0.8	Persistence in foreign interest rate
ρ^T	0.8	Persistence in terms of trade

The parameter governing the degree of nominal rigidity in the domestic firm's price setting, ξ^D, is set to 0.7 so that inflation dynamics are roughly close to what we observe in the data.

The parameters for the fiscal and monetary authorities are set as follows: $\rho^G = 0.8$ to reflect a moderately high degree of persistence in government spending over 1993–2007. We set $\rho^R = 0.90$ and $\kappa = 10$ to generate the strength of the interest rate and the exchange rate channels that conform to our understanding of the monetary transmission mechanism in Thailand.

Finally, the lag-one autocorrelation coefficients for the exogenous processes, (ρ^{R^*}, ρ^T), are set to 0.8.

3.3 Simulation

In this subsection we simulate the model to examine the presence and extent of the financial accelerator effects. Given the parameterized transition equations that characterize the model structure, and given the steady-state conditions implied by the balanced growth path that characterize the terminal conditions, we can solve for transition dynamics toward the steady state after we perturb our model by various kinds of shocks. In what follows, we first focus on the monetary policy transmission. Subsequently, we study the impulse responses to financial shocks to see what happen to our model economy in terms of the amplification and propagation of fluctuations.

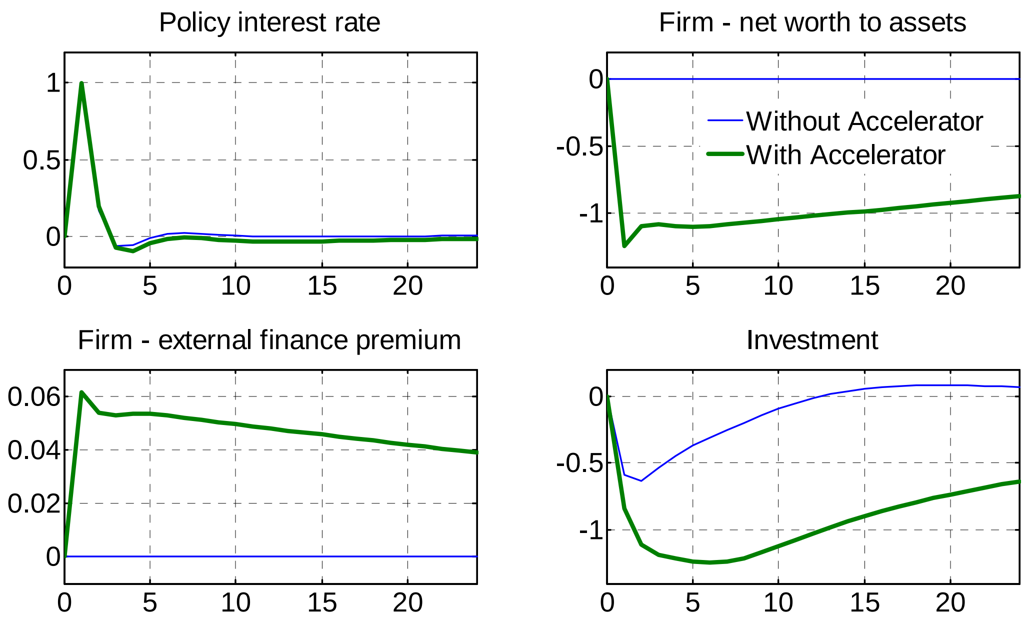


Figure 4: Interest Rate Shock

3.3.1 Interest rate shock

This interest rate shock demonstrates the role of the monetary transmission mechanism in the economy as well as the extent of the balance sheet channel.

Consider a temporary one percentage point increase in the policy interest rate for one quarter from its steady state, the impulse responses to which are shown in Figure 4 in terms of percent deviation from the steady state. The impulses depicted by thin (blue) lines correspond to the case without the financial accelerator (i.e., the firm's net worth and the bank's capital are exogenously fixed as a constant proportion of total assets). The impulses depicted by thick (green) lines correspond to the case in which the financial accelerator is at work (i.e., net worth and capital are endogenous to developments in the economy). Here, we expect to see an otherwise small and short-lived shock gets amplified and prolonged.

Consider the case in which there is no feedback between financial and real variables. When net worth is exogenous, it is not affected by monetary policy tightening and thus leaving the external finance premium unchanged. In the end investment then falls as a result of lower demand and lower production.

In contrast, with the financial accelerator present—i.e., when net worth is endogenous to changes in the real economy including the policy rate hike—we see the net worth to asset ratio falls in response to lower firms' revenues and persists below the steady state. Such a persistent decline in net worth leads to an increase in the firm's external finance premium, which leads to higher costs of borrowings and dampens investment. That is, we see the effects of interest rate shock get (1) amplified by almost twice the case where no feedback effects are present and (2) propagated such that it takes a longer time for investment to revert to its steady state. Such amplification and propagation effects are key features that characterize the financial accelerator.

3.3.2 Net worth shock

Consider a one percent reduction in firms' net worth for one period as shown in Figure 5. Examples of net worth shocks include destruction of firms' physical assets (e.g., by earthquakes or tsunami) and financial assets and liabilities (e.g., by a decline in asset prices or exchange rate devaluation).

In the case where net worth is exogenous, it deviates from the steady state during the period in which the shock is present; once the shock disappears, net worth immediately reverts to its steady state—the fixed proportion of total assets—as shown by the thin line. In other words, given an adverse shock that destroys the firm's inside capital for one period, when net worth is exogenous the impulse response is V-shaped. As a result, we have a spike in the firm's external finance premium, which induces a slight fall in investment temporarily (the magnitude is so small that it cannot be observed in this figure).

In contrast, when net worth is endogenous, it takes time to restore the balance sheet. With the two-way linkage between the macroeconomy and financial conditions, the higher external finance premium in the first period will lower the firm's demand for capital and consequently the capital producer's investment. Given a fall in capital demand, the asset price (capital price) will fall, which works to slow down the return to the steady state of the health of the firm's balance sheet. Such a prolonged deterioration in the firm's net worth then works to make the external finance premium persistently high above the steady state. This adverse feedback loop ultimately results in investment that falls below its steady state long even after the initial effects of the one-period shock disappears.

3.3.3 Shock to bank capital

Consider a temporary negative shock to the bank capital, as shown in Figure 6. Examples of shocks to bank capital include losses on bank investments and loan write-offs.

In the case where the financial accelerator is absent—that is, when both net worth of firms and bank capital are exogenous—given a temporary shock the bank's capital-to-asset ratio deviates from the steady state only in the period in which the shock is present, as in the scenario in which we temporarily perturb the firm's net worth. As soon as the shock dies out, net worth suddenly reverts to its steady state as shown by the thin line and we have the usual V-shaped impulse response and a spike in the bank's external finance premium, which then passes on to the firm's external finance premium, in turn inducing a slight fall in investment temporarily (again, the magnitude is so small that it cannot be observed in this figure).

On the contrary, when bank capital (as well as net worth of the firm) is endogenous, deterioration in the bank's capital is persistent and thereby causes the external finance premiums of

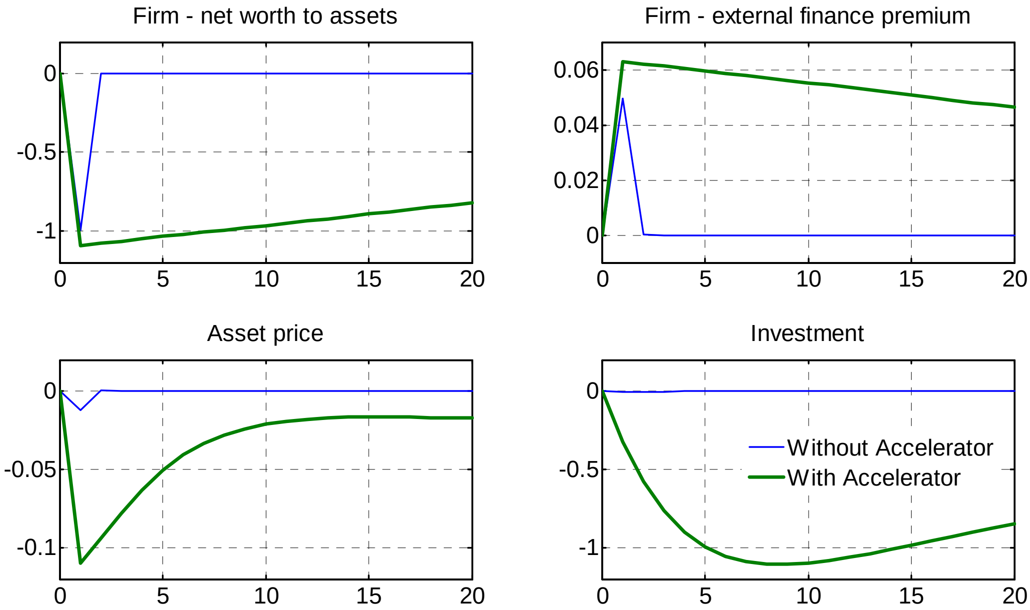


Figure 5: Net Worth Shock

the bank and the firm to persist above the steady state. The resultant adverse feedback loop ultimately results in investment falling below its steady state long even after the initial effects of the one-period shock disappears.

3.3.4 Risk premium shock

Consider a one percent increase in the risk premium of firms for one period, shown in Figure 7, which can be interpreted as a temporary loss of confidence in lending.

In the case without the financial accelerator a temporary shock to the firms' risk premium results in a blip in the external finance premium. Investment falls on impact but begins to revert to the steady state immediately afterward. In contrast, with the presence of the financial accelerator, the firms' external finance premium stays persistently above the steady state, resulting in a fall in investment that gets amplified and prolonged, further deteriorating the firms' balance sheets, which in turn weighing down on the recovery in investment.

3.4 Sensitivity analysis

This subsection conducts a sensitivity analysis, the rationales for which are twofold. First, although the parameters described in Section 4.2 are calibrated to the best of our knowledge, there is uncertainty around the calibrated values owing to data accuracy and the choice of methodologies used. Consequently, we want to know how much the simulations would change

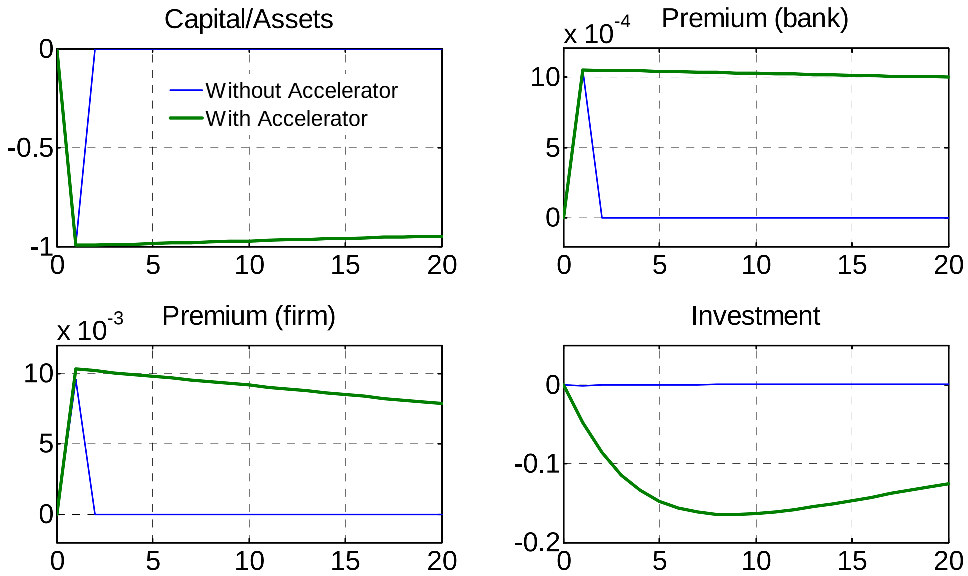


Figure 6: Bank capital shock

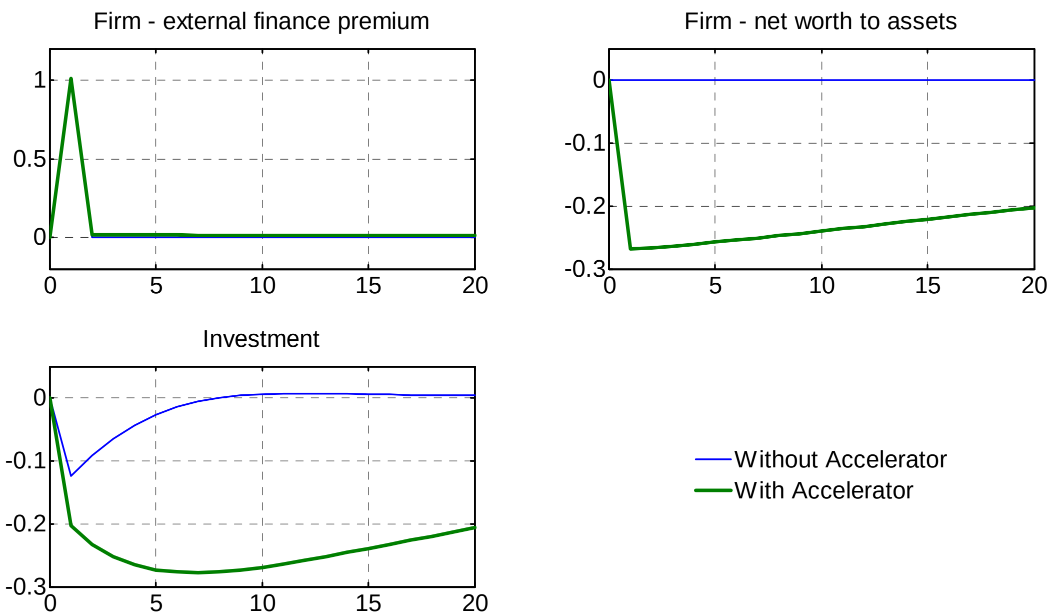


Figure 7: Risk Premium Shock

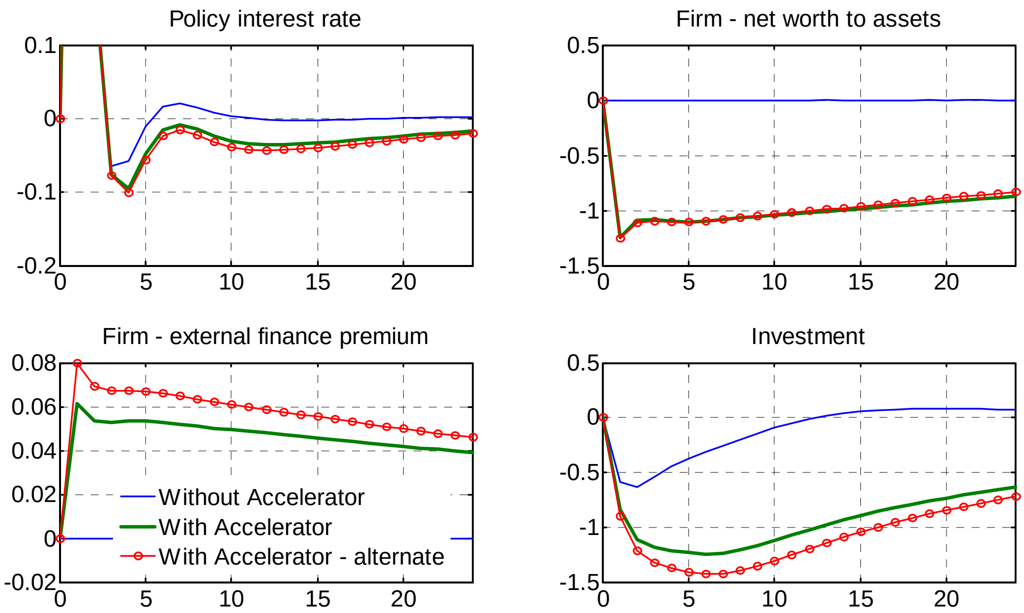


Figure 8: Interest Rate Shock—under different elasticities of finance premium to net worth

given parameter uncertainty. Second, in the context of the financial accelerator and the current crisis, we wish to examine changes in the extent of the amplification and propagation effects when there is a structural change in certain parameters.

Among various parameters that affect the financial accelerator mechanism, the most obvious one is the elasticity of the external finance premium to firms' net worth (ν). Figure 8 compares the baseline simulation given an **interest rate shock**, as shown first in Figure 4, with the simulation obtained when the *elasticity of the finance premium to net worth* is increased from the baseline value by 25 percent in absolute value, as shown by the impulses with markers (or in red). Given a one percent increase in the policy interest rate, net worth in the baseline and alternate parameterizations responds with roughly the same magnitude, but the external finance premium rises more in the case with a higher sensitivity, causing investment to contract further.

Would the amplification and propagation effects get intensified in the case of a **net worth shock** when the external finance premium is more responsive to changes in net worth—as in the case of an interest rate shock shown above? In Figure 9 we see that, given a higher responsiveness, the external finance premium deviates more from the steady state, causing the asset price and investment to fall more.

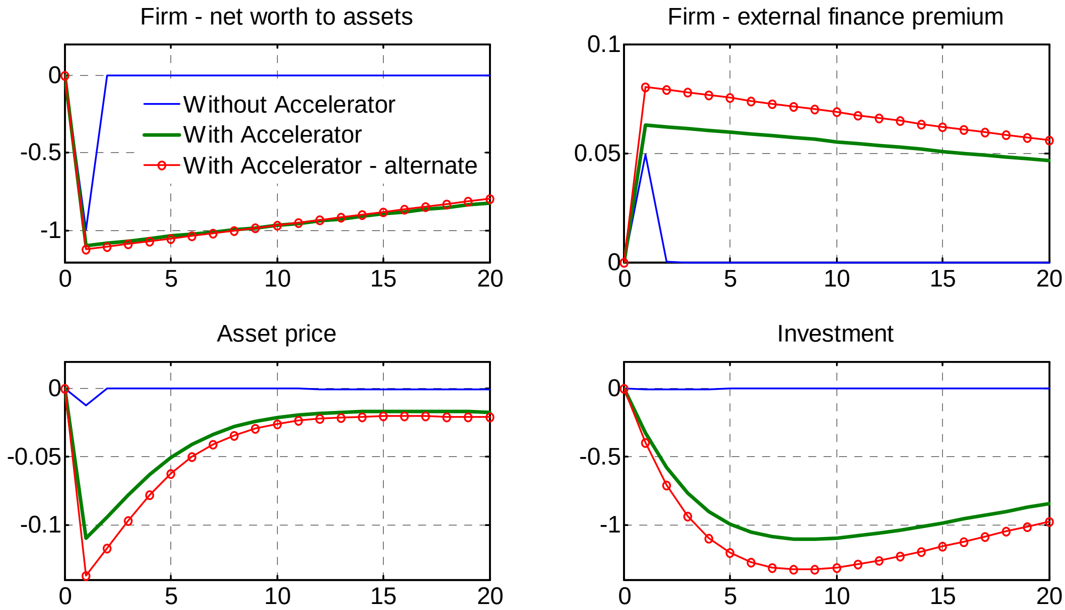


Figure 9: Net Worth Shock—under different elasticities of finance premium to net worth

4 Reflections on the recent crises

An important question in light of the above section is: What in turn determines the *elasticity of the external finance premium* with respect to net worth? Intuition suggests that the borrowing premium should be especially sensitive to the borrower's balance sheet during economic downturns or other times of anxiety. Indeed, according to theory, the borrowing premium is more responsive to the financial position of borrowers when the likelihood of getting the loans back is diminished. Levin, Natalucci, and Zakrajšek (2004) show that the external finance premium is more sensitive when (1) the financial constraints are more severe and (2) the volatility of adverse shocks is heightened. The latter is especially related to the time of crises, when the expected losses are not known for sure.

Yet, it is also possible that the elevated risk premiums witnessed during crisis times were simply a result of shocks other than a *temporary shift in the sensitivity of the external finance premium*. We have seen that *risk premium shocks* can generate amplification and propagation effects, causing investment to fall and persist below its steady-state value. Another candidate is *net worth shocks* that simply destroy the financial health of businesses and financial intermediaries.

Our view is that what happened in the U.S. economy results from a combination of the three shocks. Further works probably tell us which is the key disturbance. For Thailand, we are more assured in postulating that it was the risk premium shock that drove up the external finance premium temporarily—rather than a net worth shock since the balance sheets of Thai firms and banks are mostly intact, or rather than a shift in the borrowing premium elasticity since the exposure of Thai balance sheets to structured credit products is minimal (i.e., investors have a relatively clear idea about the financial condition of Thai businesses and financial intermediaries relative to the U.S. counterparts).

An important reminder is that no economic model, however much articulated, is likely to explain everything we have observed in reality, for models are merely a simplification of complex dynamics that comprise the economy. The validity of most models, which are constructed based on empirical regularities, is further diminished during the times of crises. Nevertheless, once key mechanisms have been identified and incorporated, some models are more useful than others in giving insights previously not available. In particular, the above DSGE model allows us to identify the *source of shocks*—forcing us to think about how the events in financial markets and the real economy map into the shocks and parameters identified in the model. This cannot be done in a reduced-form framework, in which we are limited to descriptions of how certain variables change but not why. We hope that our model has given insights about the interaction between the real and financial sides of the economy that can be useful for policymaking.

5 Conclusions

The exigency of the problems in the financial market that began in 2007, which has led to one of the most severe economic crises, has effectively renewed enthusiasm among researchers and policymakers for a deeper understanding of the interaction between the real and financial sides of the economy—instead of looking at each separately. Our research, with a focus on Thailand, contributes to such an effort by illustrating that adverse financial conditions have the potential to exacerbate negative shocks and generate a downward spiral.

We analyze how balance sheets of firms and banks amplify and prolong the business cycles of a small open economy using a dynamic general equilibrium model that captures important features of the Thai economy to illustrate the workings of the feedback loop in which financial strains and economic weakness feed into each other. Simulations obtained when such feedback effects are present point toward greater economic fluctuations and provide useful guidance in the conduct of monetary and fiscal policy.

That it is only recently the corrosive spiral started to wind down reminds us of how deleterious the adverse feedback loop could be, especially if unchecked. The private sector—households, businesses, and financial intermediaries—must make sure that its financial position is healthy enough to withstand adverse disturbances, so as to prevent the borrowing premium from escalating and to limit the corrosive impacts of the adverse feedback effects. The authorities have an important role in reducing the likelihood of adverse feedbacks—decisively using a combination of monetary and fiscal policies to forestall deterioration of the macroeconomy which could set off the downward spiral.

6 Appendix: Banks' balance sheet and their ability to lend

The balance sheet conditions of banks may affect spending and investment in the macroeconomic context not only through changes in the external finance premium but also through changes in credit availability. Bayoumi and Melander (2008) point out that, during a downturn, banks may choose to limit risks to their balance sheets through some form of credit rationing, which can occur independently of an increase in the risk premium. In this appendix we analyze the interdependence between the financial health of banks and the supply of loan, controlling for changes in the risk premium.

In estimating the supply of loans, we run the following regression

$$\begin{aligned}\Delta \log (LOANS_{it}) &= \sum_{j=1}^{2} \alpha_j \Delta \log (LOANS_{it-j}) + \beta_1 \Delta_4 \log (GDPN_{t-1}) \\ &\quad + \beta_2 \Delta MLR_{it-1} + \beta_3 BIS_{it-1} + \beta_4 LLP_{it-1} + \beta_5 PD_{it-1}\end{aligned}$$

Here, the quarter-on-quarter growth rate of bank loans, $\Delta \log (LOANS)$, is regressed on the over-the-year change in nominal GDP, $\Delta_4 \log (GDPN)$, which captures loan demand. We also control for the riskiness of banks' customers (proxied by the minimum loan rate, MLR), the quality of bank balance sheets (proxied by the BIS capital adequacy ratio, BIS), ex post bank credit risk (proxied by the ratio of loan loss provisions to total loans, LLP), and ex ante bank credit risk (proxied by the probability that banks may default one year ahead (PD). All explanatory variables are lagged one quarter to avoid endogeneity bias. Our data cover four large banks and three medium-sized banks. The sample period is 2000Q1–2009Q1.

Table A1 summarizes the main results. As in Kashyap, Stein, and Wilcox (1993), better economic conditions increase the demand for bank credit. In contrast, increases in the premium charged on loans (MLR) dampens loan growth. The negative and significant coefficients of LLP and PD suggest that the credit risks faced by banks affect the supply of loans. The positive and significant effect of the BIS ratio on lending activities suggests that banks with sound financial conditions are more ready to expand their loan portfolios. A one percent increase in the BIS ratio leads to an increase in loan growth of 0.1 percent. Our conclusion is that, while this elasticity is small, the quality of bank balance sheets can explain credit expansion even after we control for several well-known determinants of loan growth.

Table A1: Estimation result of determinants of bank lending (2000Q1–2009Q1)

Variable	Coefficient	Standard error
$\Delta \log (LOANS_{it-1})$	1.1***	0.10
$\Delta \log (LOANS_{it-2})$	-0.4***	0.04
$\Delta \log (GDPN_{t-1})$	0.4***	0.10
BIS_{it-1}	0.1*	0.05
LLP_{it-1}	-0.04***	0.01
PD_{it-1}	-0.04***	0.01
ΔMLR_{it-1}	-0.02**	0.01

*,**, and *** indicate the significance levels at 10, 5, and 1 percent respectively

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