อิทธิพลของปัจจัยทางการเงินต่อวัฏจักรธุรกิจไทย

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บทคัดย่อ

แนวคิดทฤษฎีเศรษฐศาสตร์ดั้งเดิมมักอธิบายสาเหตุของวัฏจักรธุรกิจ (Business Cycle) ว่าเกิดจากตัวแปรทางเศรษฐกิจจริงเท่านั้น ขณะที่ตัวแปรทางการเงินเป็นเพียงภาพสะท้อนภาวะเศรษฐกิจ แต่ประสบการณ์ในอดีตบ่งชี้ว่า หากเกิดปัญหาในภาคการเงินควบคู่ไปกับการเสื่อมถอยของฐานะทางการเงินของหน่วยเศรษฐกิจ จะทำให้วิกฤตเศรษฐกิจมีแนวโน้มที่จะทวีความรุนแรงและยืดเยื้อมากกว่าปกติ ด้วยเหตุนี้หลายฝ่ายจึงตั้งข้อสงสัยถึงแนวคิดดั้งเดิมดังกล่าว และจุดประกายให้นักเศรษฐศาสตร์และผู้ดำเนินนโยบายต้องกลับมาทบทวนทำความเข้าใจถึงบทบาทของปัจจัยทางการเงินที่มีต่อความผันผวนของวัฏจักรธุรกิจให้ดียิ่งขึ้น

บทความนี้พยายามที่จะทำความเข้าใจถึงบทบาทของปัจจัยทางการเงินที่มีต่อวัฏจักรธุรกิจของไทยโดยวิเคราะห์ถึงความสัมพันธ์ระหว่างปัจจัยทางการเงินและภาคเศรษฐกิจจริงที่มีผลกระทบต่อกัน ซึ่งเป็นที่มาของวงจรผลกระทบย้อนกลับ (Feedback Loop) โดยผลการศึกษาเชิงประจักษ์พบว่า ฐานะทางการเงินของทั้งภาคธุรกิจและภาคสถาบันการเงินต่างมีบทบาทสำคัญต่อกิจกรรมทางเศรษฐกิจ ผ่านต้นทุนการกู้ยืมและพฤติกรรมการปล่อยสินเชื่อ โดยฐานะทางการเงินของผู้กู้จะมีความสัมพันธ์ในทิศทางตรงกันข้ามกับค่าชดเชยความเสี่ยง (Risk Premium) อย่างมีนัยสำคัญทางสถิติ ขณะที่พฤติกรรมการปล่อยสินเชื่อส่วนหนึ่งขึ้นอยู่กับฐานะเงินกองทุนของสถาบันการเงิน นอกจากนี้ ในการศึกษานี้ยังได้สร้างแบบจำลอง Dynamic Stochastic General Equilibrium ซึ่งรวมกลไกการทำงานของตัวเร่งทางการเงิน (Financial Accelerator) ของเศรษฐกิจไทย โดยผลการศึกษาจากแบบจำลองชี้ว่าปัจจัยทางการเงินสามารถขยายผล (Amplify) ให้วัฏจักรธุรกิจของไทยผันผวนรุนแรงและยาวนานมากยิ่งขึ้นได้ โดยผลของตัวเร่งทางการเงินจะยิ่งมีมากขึ้น หากความอ่อนไหวของค่าชดเชยความเสี่ยงต่อฐานะการเงินเพิ่มขึ้น ดังนั้น ในช่วงภาวะวิกฤตที่ค่าความอ่อนไหวดังกล่าวอาจเพิ่มขึ้นผิดปกติ ผู้ดำเนินนโยบายจึงควรตระหนักและเตรียมพร้อมรับมือกับการเกิดวงจรผลกระทบย้อนกลับดังกล่าวอย่างทันท่วงที

บทสรุปผู้บริหาร

อิทธิพลของปัจจัยทางการเงินต่อวัฏจักรธุรกิจไทย

วิกฤตเศรษฐกิจในปัจจุบันและอีกหลายครั้งในอดีต มักเกิดขึ้นจากหรือเกิดควบคู่ไปกับปัญหาในภาคการเงิน ยิ่งไปกว่านั้นวิกฤตเศรษฐกิจมีแนวโน้มที่จะรุนแรงและยืดเยื้อมากขึ้น หากฐานะทางการเงินของภาคธุรกิจและสถาบันการเงินมีความเปราะบาง ดังนั้น ปัจจัยทางการเงินจึงมิได้เป็นเพียงภาพสะท้อนของภาวะเศรษฐกิจเหมือนที่เคยเข้าใจ แต่น่าจะเป็นปัจจัยที่มีอิทธิพลต่อความผันผวนของวัฏจักรเศรษฐกิจอย่างมีนัยสำคัญ โดยเฉพาะภายใต้โครงสร้างเศรษฐกิจที่มีความเชื่อมโยงกับภาคการเงินในระดับสูง สมมติฐานดังกล่าวได้จุดประกายให้นักเศรษฐศาสตร์และผู้กำหนดนโยบายต้องกลับมาทบทวนและทำความเข้าใจถึงความเชื่อมโยงและอิทธิพลของปัจจัยทางการเงินที่มีต่อภาคเศรษฐกิจจริงให้ดียิ่งขึ้น

ในช่วงที่ผ่านมา ทฤษฎีหนึ่งที่นักเศรษฐศาสตร์มักจะหยิบยกขึ้นมาเพื่อใช้อธิบายความเชื่อมโยงดังกล่าว คือทฤษฎี **“ตัวเร่งทางการเงิน”** (Financial Accelerator) ของ Bernanke, Gertler, and Gilchrist (1999) ที่อธิบายถึงปฏิสัมพันธ์ (Interaction) ระหว่างฐานะทางการเงินกับภาวะเศรษฐกิจที่มีผลกระทบซึ่งกันและกัน กล่าวคือ ในช่วงเศรษฐกิจถดถอย รายได้ของภาคธุรกิจและครัวเรือนที่ลดลงส่งผลให้ฐานะงบดุลเสื่อมด้อยลง ทำให้ผู้ปล่อยกู้หรือสถาบันการเงินจำเป็นต้องเพิ่มความเข้มงวดในการปล่อยสินเชื่อมากขึ้น ผ่านการเรียกร้องค่าชดเชยความเสี่ยง (Risk Premium) ที่สูงขึ้น เนื่องจากฐานะการเงินที่เลวลงสะท้อนถึงโอกาสการผิดนัดชำระหนี้ที่สูงขึ้น เมื่อต้นทุนการกู้ยืมแพงขึ้น ย่อมส่งผลกระทบต่อกิจกรรมทางเศรษฐกิจทั้งการบริโภคและการลงทุนให้ชะลอตัวลง ซึ่งเท่ากับยิ่งซ้ำเติมให้เศรษฐกิจอ่อนแอลง และในที่สุดก็จะส่งผลกระทบย้อนกลับไปยังฐานะการเงินของหน่วยเศรษฐกิจให้แย่ลงไปอีก กลายเป็นวงจรที่เกิดขึ้นต่อเนื่องหรือที่เรียกว่า **“วงจรผลกระทบย้อนกลับ”** (Feedback Loop) ซึ่งความสัมพันธ์ดังกล่าวไม่ได้บังเอิญเกิดขึ้นเฉพาะในช่วงเศรษฐกิจขาลงเท่านั้น แต่ในช่วงขาขึ้นการขยายตัวทางเศรษฐกิจที่ร้อนแรงก็มักจะมาพร้อมกับภาวะการเงินที่ผ่อนคลายมากกว่าปกติเช่นกัน

ดังนั้น ในงานวิจัยนี้จึงพยายามทำความเข้าใจถึงกลไกความเชื่อมโยงระหว่างปัจจัยทางการเงินที่มีต่อวัฏจักรธุรกิจของไทย ว่าเป็นปัจจัยที่สร้าง (Generate) หรือขยายผล (Amplify) การขึ้นลงของวัฏจักรธุรกิจให้รุนแรงและยาวนานขึ้นหรือไม่ อย่างไร โดยศึกษาทั้งในเชิงประจักษ์และจากแบบจำลอง Dynamic Stochastic General Equilibrium (DSGE) ที่ได้พัฒนาขึ้นเพื่อให้สามารถอธิบายกลไกของวงจรผลกระทบย้อนกลับได้

ผลการศึกษาพบว่า

(1) กิจกรรมทางเศรษฐกิจ อาทิ การลงทุน ส่วนใหญ่ไม่สามารถดำเนินการได้โดยใช้เงินทุนภายใน (Internal Finance) ของเจ้าของกิจการเพียงลำพัง แต่จำเป็นต้องพึ่งพิงเงินทุนจากภายนอก (External Finance) ค่อนข้างมาก ข้อจำกัดทางการเงินดังกล่าวทำให้ฐานะการเงินของผู้กู้เป็นปัจจัยสำคัญในการกำหนดต้นทุนการกู้ยืมผ่านค่าชดเชยความเสี่ยง

(2) ค่าชดเชยความเสี่ยงของภาคธุรกิจและสถาบันการเงินต่างขึ้นอยู่กับความเข้มแข็งของฐานะการเงิน (Net Worth) โดยมีความสัมพันธ์ในเชิงผกผันอย่างมีนัยสำคัญทางสถิติ เนื่องจากฐานะการเงินเป็นเครื่องชี้วัดสำคัญของความสามารถในการจ่ายคืนหนี้สินในอนาคต ในช่วงที่ผ่านมา ค่าชดเชยความเสี่ยงของภาคธุรกิจและสถาบันการเงินจะเปลี่ยนแปลงไปตามสุขภาพทางการเงินหรือความเข้มแข็งของฐานะการเงินที่เปลี่ยนแปลงไปตามภาวะเศรษฐกิจ

(3) การเรียกร้องค่าชดเชยความเสี่ยงที่สูงขึ้น ย่อมส่งผลให้ภาคธุรกิจเผชิญกับต้นทุนทางการเงินที่เพิ่มขึ้น ซึ่งจะกดดันให้การลงทุนลดลงอย่างมีนัยสำคัญ เช่นเดียวกับในภาคสถาบันการเงิน เมื่อควบคุมตัวแปรด้านอื่นๆ พบว่า ฐานะการเงินที่เลวลงของสถาบันการเงิน จะส่งผลกระทบต่อความสามารถหรือความเต็มใจในการปล่อยสินเชื่อของสถาบันการเงินให้น้อยลง ซึ่งหลักฐานเชิงประจักษ์ดังกล่าวสามารถบ่งชี้ว่า ตัวเร่งทางการเงินน่าจะเกิดขึ้นจริงในระบบเศรษฐกิจไทย

(4) จากแบบจำลอง DSGE ของเศรษฐกิจไทย ชี้ว่าตัวเร่งทางการเงินทำให้ความผันผวนของวัฏจักรธุรกิจไทยมีมากขึ้น เมื่อเทียบกับกรณีที่ไม่มีตัวเร่งทางการเงิน โดยเมื่อเกิด Shock ขึ้นในระบบเศรษฐกิจ ตัวเร่งทางการเงินจะขยายผลกระทบของ Shock ดังกล่าวให้มีขนาดใหญ่และคงอยู่ยาวนานขึ้น แม้ว่าผลของ Shock ในตอนต้นจะมีขนาดเล็กและจบลงในระยะเวลาอันรวดเร็วก็ตาม ไม่ว่าจะเป็นกรณีการปรับเพิ่มขึ้นของอัตราดอกเบี้ยนโยบายในระยะสั้น การด้อยลงของฐานะการเงินของภาคธุรกิจและสถาบันการเงิน ซึ่งกลไกสำคัญที่ทำให้ผลกระทบของ Shock รุนแรงขึ้นก็คือ ความสัมพันธ์ผกผันระหว่างค่าชดเชยความเสี่ยงและฐานะการเงิน

(5) อิทธิพลของปัจจัยทางการเงินต่อวัฏจักรธุรกิจจะมีมากน้อยเพียงใดนั้น ขึ้นอยู่กับความอ่อนไหวของค่าชดเชยความเสี่ยงต่อฐานะการเงินเป็นสำคัญ หากกำหนดให้ความอ่อนไหวดังกล่าวเพิ่มขึ้น จะทำให้ผลของตัวเร่งทางการเงินมีมากขึ้น และกดดันให้กิจกรรมทางเศรษฐกิจหดตัวมากกว่ากรณีที่ความอ่อนไหวต่ำ ซึ่งค่าความอ่อนไหวดังกล่าวจะไม่คงที่ และอาจเพิ่มขึ้นสูงโดยเฉพาะในช่วงวิกฤตเศรษฐกิจ ซึ่งจะยิ่งทำให้ผลของตัวเร่งทางการเงินมีมากขึ้น

ผลการศึกษาข้างต้นสะท้อนถึงบทบาทของปัจจัยทางการเงินหรือตัวเร่งทางการเงินที่มีต่อภาคเศรษฐกิจจริง ซึ่งมีนัยต่อการส่งผ่านนโยบายการเงิน อาทิ นโยบายการเงินที่ควรตอบสนองต่อภาวะเศรษฐกิจถดถอยอย่างรวดเร็วและมากพอ เพื่อพยุงฐานะทางการเงินของภาคเศรษฐกิจต่างๆ ขณะที่นโยบายการคลังควรเข้ามาสนับสนุนเพื่อลดความเสี่ยงของระบบเศรษฐกิจ เพื่อตัดวงจรผลกระทบย้อนกลับให้มีน้อยที่สุด หรือเพื่อป้องกันมิให้เศรษฐกิจตกอยู่ในวังวนของภาวะถดถอยอย่างรุนแรงและยาวนานเกินไป

Impacts of Financial Factors on Thailand's Business Cycle Fluctuations[1]

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Abstract

This paper illustrates that financial conditions are not simply a reflection of macroeconomic developments. In fact, one feeds the other, and both are mutually dependent. Adverse financial conditions have the potential to exacerbate negative disturbances on the real economy—converting the initial effects of small and short-lived shocks into large and persistent impacts—and consequently generate a downward spiral in which such adverse financial conditions and the deterioration in the macroeconomy feed into each other. A key factor causing the amplification mechanism is the negative relationship between the external finance premium and the quality of borrowers' balance sheets—the latter is summarized by how much the balance sheet is saddled with debt relative to internal funds. Empirical evidence points to the existence in the Thai economy of this negative relation. Incorporating this feature in a well-articulated model for Thailand that emphasizes the crucial role of the balance sheets of firms and banks in a small open economy allows us to assess the degree of feedbacks between financial and real variables. The key parameter affecting the intensity of the feedback effects is the elasticity of the external finance premium to borrowers' financial health that could temporarily increase during crises. We urge policymakers to look forward and be ready to forestall such a likely feedback loop, and, if it sets off, must react with sufficient vigor in a timely manner to arrest this corrosive self-reinforcing mechanism.

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

[1]This paper is prepared for the Bank of Thailand Annual Symposium to be held during September 15–16, 2009. The views expressed in this paper are those of the authors and do not necessarily represent the Bank of Thailand's policies.

[2]The authors wish to thank participants of the Symposium workshop for several helpful discussions in preparing this document. We are especially grateful to Ashvin Ahuja for coauthoring parts of the paper and for his insightful comments and guidance throughout the course of this project. The usual disclaimer applies.

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. In particular, we want to examine the impacts of financial factors (here interpreted as the components of the balance sheets, such as certain financial ratios) on fluctuations in the real economy. Questions we wish to answer include: Do financial factors interact with output fluctuations? What is the role of financial factors—generating, amplifying, or propagating business cycles?

Standard economic models used for monetary policy analysis—be it macroeconometric models or micro-based models—assume that firms can borrow as much as they want, and focus on real variables exclusively. Such models are probably oversimplified: unknowingly ignoring important features of the economy, missing potential interactions between financial factors and business cycles, and potentially misguiding policies.

Our study aims to fill this gap and to offer a richer analysis useful for policymaking. We give insight on business cycle fluctuations by recognizing the critical role of financial factors. Our model is capable of explaining several phenomenons previously unaccounted for in traditional macro models—in particular, the negative feedback loop that is currently in play in a number of economies—and offering a richer policy analysis. The theoretically coherent modeling of financial intermediation makes it possible to analyze several other issues related to the financial-real linkages that have been of interest to the public and policymakers.

The remainder of the paper is organized as follows. Section 2 gives a nontechnical summary of the mechanism behind the workings of the feedback loop. Section 3 examines the Thai economy and searches for evidence that implies the existence of macro-financial linkages. Section 4 describes the analytical framework structured to incorporate the intertwining between the financial and real side of the economy. Section 5 draws on policy implication in light of our findings. The last section concludes.

2 Mechanisms behind the Feedback Loop

This section provides a nontechnical summary of key theoretical underpinnings—such as financial frictions, information asymmetry between borrowers and lenders, the premium for external finance the borrowers have to incur, and the role of the borrowers' net worth—that form the basis of the feedback loop between financial factors and the real economy as shown in Figure 1.

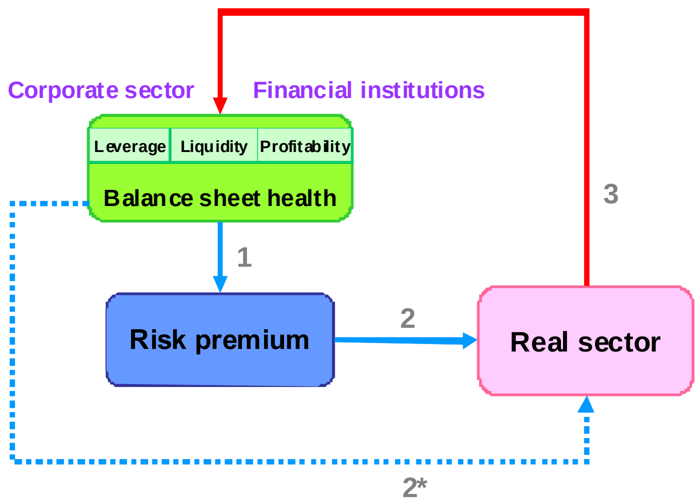


Figure 1: Feedback loop

Financial frictions are key imperfection that links the financial sector and the macroeconomy. In a frictionless capital market firms always have access to capital, and thus characteristics of their balance sheets—for example, debt in relation to equity, or cash flows—do not matter. In reality, it is found that firms' investment is significantly determined by cash flow among other factors. Furthermore, the link between cash flow and investment tends to be especially strong for relatively small firms—those borrowers who implicitly have limited access to capital markets.

Such an imperfect financial market gives rise to a complication between lenders and borrowers, namely, the *principal–agent problem*. That one party to a financial contract (the lender or the "principal") has less accurate information about the distribution of outcomes or the probability of the success of their enterprise than does the other party (the borrower or the "agent") gives rises to the monitoring problem—lenders cannot observe the outcome of the borrowers' project—and thus have to incur the monitoring costs. The lenders then pass on monitoring costs that may arise to the borrowers in the form of the premiums on borrowing interest rate.

This *external finance premium*, measured as the difference between the interest rate charged on risky borrowers and the riskless interest rate, critically provides an important link between the financial conditions and the real economy. Bernanke and Gertler (1995) show that the external finance premium varies inversely with the borrower's financial position. The idea is that the borrower's significant stake in the enterprise reduces the lender's need for intensive monitoring, because, given the same likelihood of adverse shocks, the probability that the borrower cannot repay the loan is small compared with another case in which the borrower is highly leveraged. Consequently, we have established a linkage from the financial position of the borrower to the external finance premium as depicted in linkage 1 of Figure 1. This external finance premium will in turn constrain the borrower's economic activity as shown in linkage 2.

To complete a loop, we need to establish the other linkage from economic activity to financial conditions, as required by linkage 3. Here *endogenous evolution of net worth* provides for such a loop and furthermore works to amplify as well as propagate the effect of shocks in the economy. Endogenous evolution of net worth relates more to the real world. In general, firms' net worth depends on the value of the assets currently held, which contains information about economic prospects, and the revenue and expenditure flows. Thus, net worth is affected by changes in real variables (e.g., the amount of output produced and inputs employed), changes in prices of output and inputs, and changes in financial variables (e.g., the amount of debt, the borrowing interest rate, and asset prices). Consequently, for a firm to rebuild its balance sheet after being hit by shocks, it will take time depending on various developments in the economy, thereby prolonging the initial effects of shocks even after they no longer exist. Models without endogenous net worth would fail to create a feedback loop that amplifies and propagate the initial disturbance effects. This feedback loop is termed as the *financial accelerator* in a seminal study by Bernanke, Gertler, and Gilchrist (1999), and has recently been referred to in a number of occasions.

If net worth is exogenously a fixed proportion of the total value of the firm, then there will be no feedback from the real economy to the firm's balance sheet, and hence the effects of the initial shock will not get amplified. Furthermore, given a temporary shock to the firm's balance sheet, the ratio of net worth to total assets will deviate from the predetermined level just momentarily and induce a blip in the external finance premium. That is, once the shock disappears, its effects on the real economy will vanish. In short, an exogenous net worth (in other words, completely irrelevant to developments in the real economy) is unlikely to create a situation where a recession that is caused by shocks in the financial sector takes a relatively long time to recover in accordance to what we have understood.

The analytical framework in this paper must incorporate financial frictions, the principal–agent problem, the external finance premium, endogenous net worth, and the financial accelerator. Here we extend the Bank of Thailand's general equilibrium model as described in Tanboon (2008) in order to draw some implications of the impacts of financial factors on the Thai business cycles. The model, to be described in details in Section 4, characterizes a small open economy populated with five broad classes of agents: households, firms, capital producers, banks, and the government. Households make various decisions on consumption, wage setting and labor supply, and saving and borrowing. In addition to hiring factor inputs and producing, domestic and export firms must borrow from banks to finance their acquisition of capital which is one of the factor inputs. The interest rate at which firms can borrow—and hence the external finance premium—will depend on the state of their balance sheets. Banks also subject to such a premium, as they need to raise funds from depositors and financial markets. That both firms and banks need to pay for external finance premiums gives rise to double financial accelerator effects in the model. Finally, the monetary authority sets the interest rate and the fiscal authority spends according to some rules.

In short, 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.

Notable features that we abstract from our model (neither present in the two papers mentioned above) are the role of collateral and the possibility of credit crunch. First, the principal–agent problem can be interpreted in the context of the enforcement problem—lenders cannot force borrowers to repay their debts unless the debts are secured—and hence the need for collateral as opposed to the external finance premium that is required. Our choice of the external finance premium as the modeling device is that, according to Bernanke (2007), it can be applied to all agents that seek external funds. On the contrary, it would be difficult to motivate banks or nonbank financial intermediaries to put up "collateral" when they raise external funds from households. Second, although a restriction in credit availability, which is caused by banks that are reluctant to lend out funds because they are concerned about the effects of a weak economy on loan repayment probability, is another mechanism that has the potential to generate the adverse feedback loop, as shown in linkage 2* in Figure 1, we will abstract from distinguishing this feature in our theoretical model but instead subsuming such reluctance under a required increase in the risk premiums to cover for firm's default risk. As such, in the end we will have the external finance premium as a key unifying mechanism that gives rise to the adverse feedback loop. However, we will explicitly explore linkage 2* empirically.

To recapitulate, the key mechanism behind the feedback loop is endogenous variation in balance sheet quality which enhances the amplitude and prolongs the duration of business cycle fluctuations. This financial accelerator effect is theoretically justified by fundamental building blocks in economics such as financial frictions and information asymmetry, both of which give rise to the external finance premium. In the next section we will look at the Thai economy and discuss empirical findings that imply the existence of the feedback loop.

3 Empirical Findings

The key link between the real side of the economy and its financial side can be summarized as follows: Firms, households, banks, or even governments are financially constrained. They are typically unable to finance large projects without external borrowing. This story is pertinent in the case of Thailand, where, according to the Industrial Census (2007), 70 percent of total investment in the manufacturing sector is made by firms that rely on external finance.[3] Meanwhile, the structure and functioning of the credit markets is such that lenders cannot, without costs, acquire information about the opportunities, characteristics, or actions of the borrowers. Therefore, unless the borrowing is fully collateralized, external finance is more expensive than internal finance. Given the total amount of finance required, the premium for external finance tends to rise and fall with borrower's *ability* to repay. Finally, changes to the borrower's balance sheet condition, typically signifying his ability to service debt or pay dividends, can change either the *premium* on external finance or the *amount* of external finance required, which in turn affect his spending and production.

[3] The Business Trade and Services Survey (2006), conducted by the National Statistical Office, also suggests a similar finding in the service sector. In addition, both surveys highlight the important role of external finances in determining investment by large firms.

Theory suggests, and limited empirical evidence shows, that the financial accelerator exists in a world where businesses or lenders are financially constrained.[4] The mechanism offers a forceful view that explains the "small shocks, large cycles" puzzle in business cycle analysis. To the extent that the negative (positive) disturbance to the economy reduces (increases) the net worth of a borrower or a lender, the spending and production effects of that initial shock will be amplified. In essence, the financial accelerator is the mechanism that amplifies and propagates the effects of an initial (possibly small) real or monetary disturbance brought about by changes in credit market conditions, contributing to the business cycle's amplitude and persistence.

Depending on how theorists rationalize the financial accelerator to suit many diverse features of the credit markets, there are two inherent parts to the mechanism embedded in an economy. The first concerns the variation in borrowers' or lenders' balance sheet conditions over time. The second concerns how movements in balance sheet conditions influence the cost of capital and the amount of capital available, which then influence investment, consumption and lending decisions at the firm and bank levels.

This section presents evidence to support these inherent features of the financial accelerator in the case of Thailand. We focus on (1) firms in their capacity as borrowers and (2) financial intermediaries as lenders cum borrowers in the credit market. Our empirical strategy is to estimate four panel regressions to answer the following. First, we measure the impact of changes in balance sheet conditions to the external borrowing premium of firms, controlling for relevant factors that can affect the premium. This is to show that the borrowing premium is related to the financial health of firms as predicted by theory. We repeat the exercise for banks in their capacity of borrowers in the capital market in the second regression. In the third regression we establish that the financial health of banks matter for their ability to lend by measuring the impact of banks' balance sheets on loan growth. To complete the story, in the fourth regression where firm-level investment is regressed on firms' cost of capital, controlling for other factors, we try to gauge how much costs of capital, which embed risk premiums, can influence decision to invest in the way theory predicts.

3.1 How elastic are the external finance premium to changes in balance sheet conditions? (Linkage 1)

3.1.1 Evidence from the non-financial corporate sector

Before we present our results, some data issue should be discussed. There are a variety of ways to measure the "external finance premium." Generally, the "risk premium" on borrowing, which is generally defined as a compensation for holding risky assets rather than a risk-free one, is used as proxy. In the case of Thailand we find that equivalent measures tend to have short or limited coverage.[5] We require a long time series at the firm level. So we calculate the spreads between effective borrowing rates charged to SET-listed firms' financial statements over the

[4] Testing for the financial accelerator raises difficult identification problems (see Bernanke, Gertler, and Gilchrist, 1996). To circumvent these problems, empiricists have focused on examining cross-sectional implications of the theory.

[5] A simple measure such as corporate bond spreads over government bond yields of the same maturity or credit default swap (CDS) prices can be obtained from financial market data. Unfortunately, these time series are short and available only for large firms that tap the bond market for funding from the last quarter of 1999 onward. Alternatively, the spread between actual interest rates charged on new loans over risk-free interest rates or the reference MLR is also a reasonable proxy. However, aggregating over thousands of loan contracts and control for borrower-specific characteristics is highly time consuming.

risk-free rates. This measure extends from 1994 onward. To confirm that our results are robust to the choice of measures used, we also construct another time series from model-implied credit spreads,[6] as calculated from Merton's (1973) and Black–Scholes (1973) option pricing models. Our sample period is 1994–2009, which is the longest we can find. We do not report results based on this measure, but they are qualitatively similar.

As reported in Table 1, the premium varies over time and across firms. Averaging over time, the median premium (faced by firms) stands at roughly 400 basis points over the risk-free rates. Partitioning the sample period into normal and crisis times, we find that firms' finance premium averages at 300 basis points and 630 basis points during the two separate periods, respectively. In the normal period, external finance premium can vary from 70 to 930 basis points (at 10th and 90th percentile, respectively), owing to a host of different firm characteristics. We find that the external finance premium faced by banks are much lower at only around 20–100 basis points. We suspect that low bank's finance premium reflects market's perception that the authorities find it prohibitively expensive to let banks fail, and thus would go to great length to avoid such a credit event; hence modest credit default risks are reflected in the spreads.

Table 1: Risk premium of the corporate sector (1994Q1–2009Q1)

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.

Before the 1997 crisis, median debt-to-equity ratio of non-financial listed Thai companies averaged at 1.3. However, during the period in which extreme credit events occur—specifically, right after July 1997—the external finance premium increases exponentially as leverage multiplies owing to a sharp depreciation of the baht in 1997, profitability drops and liquidity freezes up (Figures 2 and 3). Over the course of the recovery, the external finance premium declines gradually, as firms deleverage to better financial health. The median debt-to-equity ratio averages around 0.8 during the post-crisis period. The recent global financial crisis sees firms'

[6] See, for example, Gapen et al. (2004), Gray, Merton, and Bodie (2006), and Gray and Malone (2009) how to calculate implied spreads based the contingent claims approach (or commonly known as Moody's KMV). Briefly, the contingent claims approach (CCA) is a new financial risk analytic model that combines balance sheets and financial market information with widely finance theory to construct mark-to-market balance sheet position. There are three key variables used to estimate probability of default which are (1) a distress barrier (promised debt payment value or default-free value of debt) imputed by book value of all short-term and a certain proportion of long-term debt, (2) market values of assets, and (3) volatility of the assets as calculated by stock price volatility. Default occurs when firms cannot service their debt payment, in other words, when the market-value assets fall below the distress barrier. The difference between the market-value assets and the distress barrier, so-called a distance to distress, is used to represent the probability of default. Lower market values of assets, higher leverage, and higher asset volatility all serve to the shorter distance to distress and higher probability of default. To finish, the probability of default can be translated into risk premium over the riskless rate.

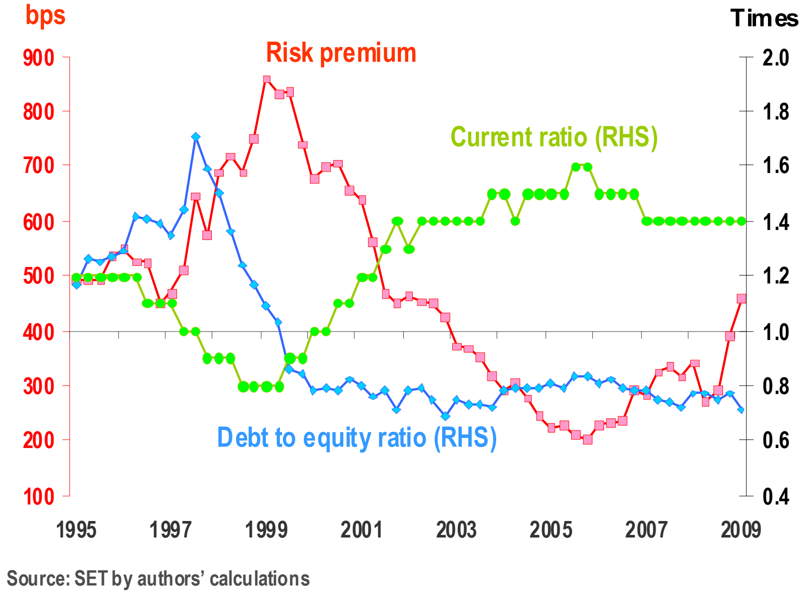


Figure 2: Risk premium and financial health of the corporate sector (1)

external finance premium spike again, however.

Data confirm that leverage, or net worth, is a key determinant of the premium charged on external finance. Figure 4 shows that firms with high premiums, ranked in the 50th–90th percentile, tend to have higher debt-to-asset ratios than firms with premiums ranked in the 10th–49th percentile.

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 from 460 firms during 1994Q1–2009Q1. In this case, the Hausman specification test suggests a fixed-effect estimator as appropriate, as a random effect model might imply an inconsistent estimator.

We specify a model as follows:

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

for individual firm i and time period t, and where 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, indicating liquidity condition; and $STDEBT$ 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 a firm's reputation, age, and bargaining power, especially that of large firms, where $SIZE = 1$ if the observed firm is relatively large in terms of asset (as percentage of aggregate assets), i.e., in the 75th–100th percentile range. $\Delta_4 GDPR$ is the year-on-year real GDP growth rate, which helps control for

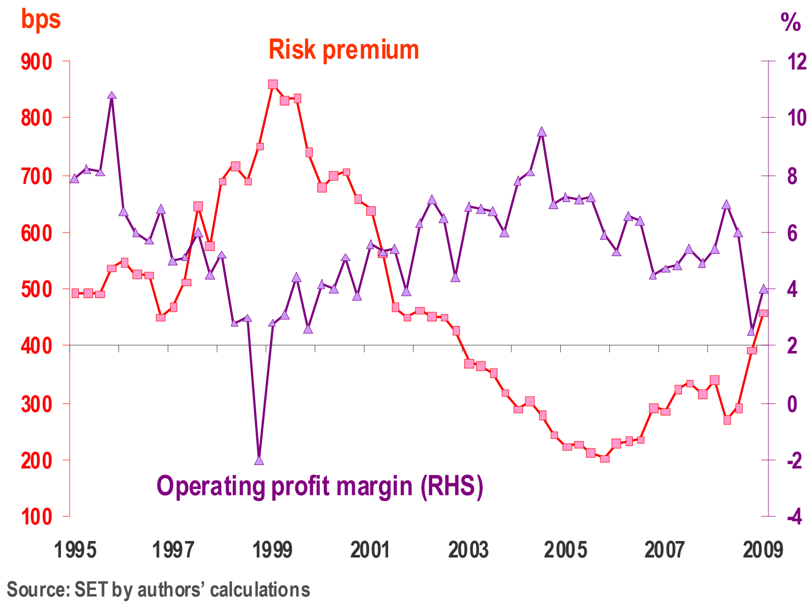


Figure 3: Risk premium and financial health of the corporate sector (2)

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). Consistent with other studies,[7] the estimation shows a significant negative relationship between the net worth-to-asset ratio and the finance premium of firms. A ten percent increase in a typical firm's equity-to-asset ratio leads to a reduction of 15 basis points in the premium levied on its external borrowing.

Table 2: Estimation result of determinants of firms' risk premium (1994Q1–2009Q1)

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

Other variables which represent balance sheet condition in the model, namely the current ratio, the share of short-term debt to overall debt, and size carry expected signs and are statistically significantly. Likewise, macroeconomic condition, represented by GDP growth, has

[7] See Collin-Dufresne, Goldstein, and Martin (2001), Ivaschenko (2003), Durbin and Ng (2005), Cavallo and Valenzuela (2007), and Aysun, Brady, and Honig (2009).

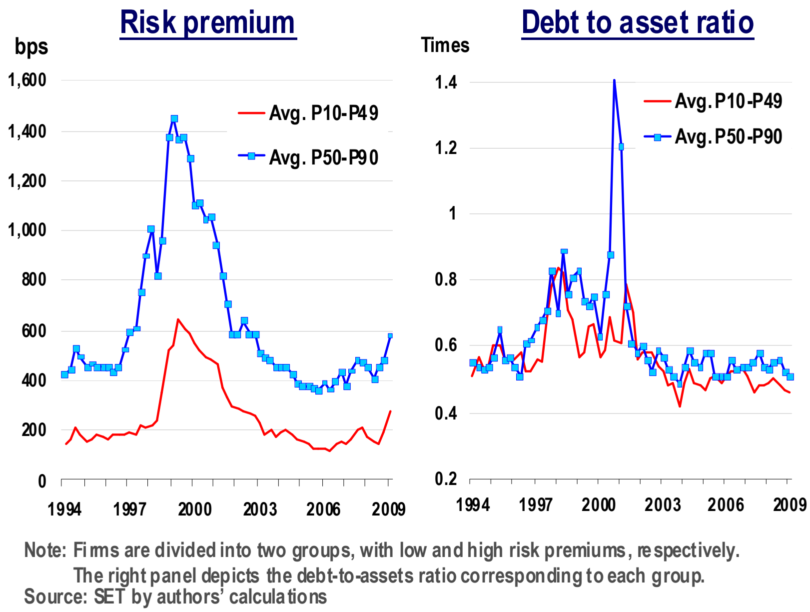


Figure 4: Risk premium and leverage

a negative relationship with the finance premium. As expected, market perceives higher default probability when economic growth declines.

We also find that, holding other factors unchanged, a typical firm should expect to find lower external premium charged on their borrowing in the period after the 1997 crisis was over, compared to the whole sample period. Using data from 2002Q1 onwards, the constant term is only 4.8 percent per annum (versus 5.9 for the whole sample period). We think a fall in the constant term partly reflects better economic and financial health conditions associated with lower default risk after the 1997 crisis.

3.1.2 Evidence from banks

We now repeat the exercise for banks. Banks are highly leveraged by nature. The ability to make loans depends on how they can raise deposits or access funds in the capital market. During 2001–2008, Thai banks' equity-to-asset ratio has been trending upward from 4.8 to 9.6 per cent, averaging at 7.5 percent. These ratios do not differ between large and small banks, but large banks tend to rely on different sources of external funding than their small counterparts. Figure 5 shows that large Thai banks rely mostly on deposits whereas small banks, with a small number of branches, rely less on deposits and more on borrowing in the capital market, through bonds and bills of exchange. In fact, as of end-2009 Q2, small banks' liabilities excluding deposits and net interbank activities average around 31.5 per cent of total assets, compared to 10.1 percent at large banks.

First, we outline how we measure external finance premium of Thai banks. A measure we would like to have is the credit default rate, which does not exist. We have to settle for a measure of capital markets of effective borrowing rate over the risk-free rate of the same duration. As all deposit contracts have been guaranteed to be free of default in Thailand over

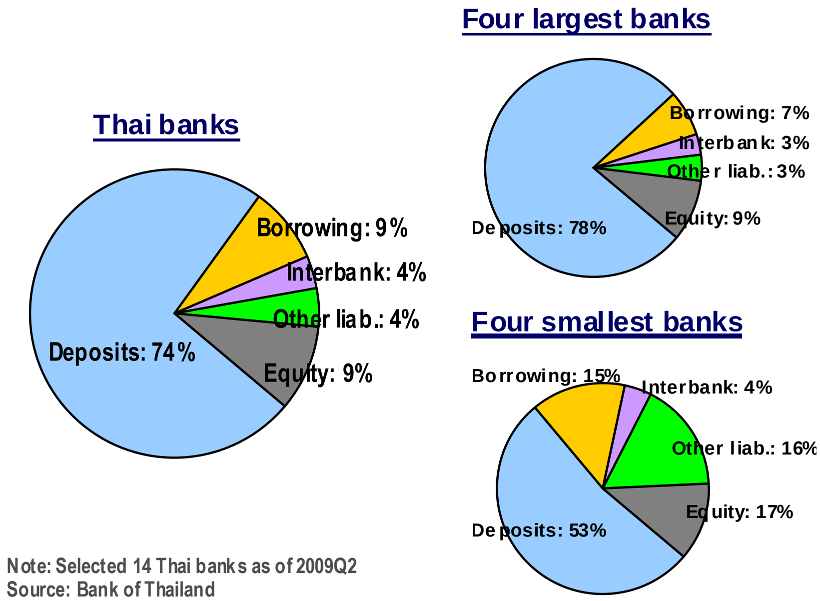


Figure 5: Financing structure of Thai banks

the sample period, including into our measure the effective rates paid to depositors could bias this measure toward the low side. Excluding deposits from the measure is important. Using rates charged on bills of exchange issued by banks is a realistic option, but the time series are short, uneven, and with limited coverage. Besides, the terms on bills of exchange issued and their durations are not standardized across banks. Alternatively, rates charged in the interbank market reflect mostly liquidity risk, and would not be a good option for measuring credit risk under normal circumstances.

With these limitations, we opt for two measures:

1. Without data on corporate bond yields, we make an assumption that, at issue date, coupon rate on corporate bonds issued by a given bank is equal to the yield on the same bond. We define a measure of finance premium faced by banks as the capital market between those coupon rates, as reported by the Thai Bond Market Association (ThaiBMA), and the yields on government bonds of the same duration, which were reported on the same date. We have data for four banks, two of them large, from 2006–2008. This measure is short on length and coverage. Nevertheless, these capital markets average only around 20 basis points and are indifferent across bank sizes. This minute capital market can be rationalized if market perceives bank debt to be nearly as safe as government debt. This perception may not be unreasonable, given low tolerance for bank failure and the focus on bank supervision and governance after the crisis.

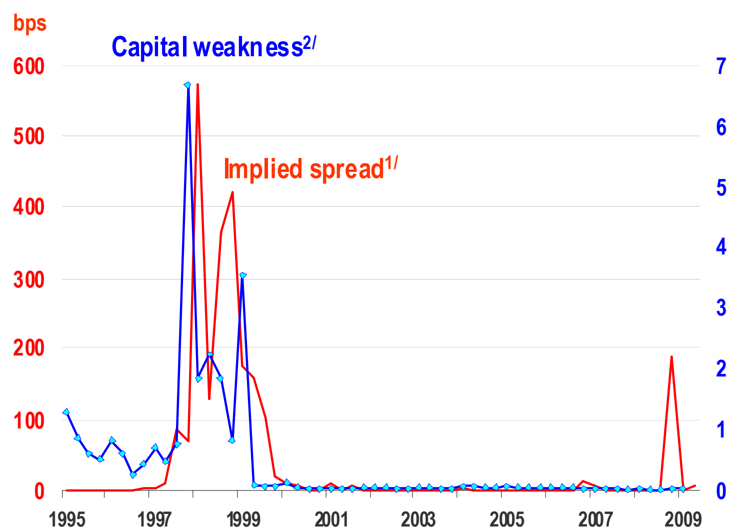
2. For longer data series and more coverage, we also calculate model-implied capital markets based on market expectation, along the line of those calculated for firms reported earlier. We obtained capital markets for six Thai banks spanning 1995–2009, which covers at least one business cycle (peak-to-peak). We trim away outliers in the implied spread data to limit our observations to within 5th–95th percentile of the original sample.

Table 3 reports that implied spreads of selected Thai banks with whole-sample-period median of 50 basis points or average at 1 percent per annum during 1995Q1–2009Q2. As mentioned earlier, banks' risk premium are pretty low—no more than 10 basis points in the normal period. Similar to firms', banks' risk premiums are also likely to depend on the capital strength of banks. We construct an index to measure bank capital weakness, defined as one over the squared difference between the BIS ratio and the authority's minimum capital requirement, to reflect the nonlinear responsiveness of risk premium to bank capital. As depicted in Figure 6, the weaker bank capital is, the higher risk premium becomes.

Table 3: Risk premium of selected Thai banks (1995Q1–2009Q2)

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.



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 6: Banks' implied spreads and capital weakness

We perform a random-effect panel regression with an unbalanced panel of 273 observations during 1995Q1–2009Q2. The model is specified as followed:

$$BRP_{it} = \alpha + \beta_1 BIS_{it} + \beta_2 \Delta_4 GDPR_t + \beta_3 BROA_{it} + \beta_4 NPL_{it} + \varepsilon_{it} \quad (2)$$

where BRP is bank's implied spread in percent per annum; BIS is the BIS ratio obtained from the Bank of Thailand, $\Delta_4 GDPR$ is the year-on-year growth rate of real gross domestic product, $BROA$ is bank's return on asset obtained from banks' financial statements, and NPL is the year-on-year growth rate of nonperforming loans as reported by the Bank of Thailand.

Bank's balance sheet health can be represented by a variety of indicators. Here, we use the BIS ratio banks choose to maintain as a summary measure for two reasons.[8] First, the BIS ratio is calculated as risk-bearing regulatory capital as a proportion of risk-weighted assets. This ratio recognizes both capital and risky assets. An increase in the BIS ratio indicates an improvement in banks' balance sheet condition from a prudential perspective. Second, controlling for macroeconomic condition ($\Delta_4 GDPR$), bank's ability to repay debt and asset quality ($BROA$ and NPL), we can obtain an elasticity of external finance premium with respect to bank's net worth for use in the calibration of our dynamic stochastic general equilibrium model in section 4.

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 (1995Q1–2009Q2)

Variable	Coefficient	Standard error
BIS	-0.147*	0.077
$\Delta_4 GDPR$	-0.102*	0.061
$BROA$	-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

3.2 Banks' balance sheet and their ability to lend (Linkage 2*)

The balance sheet condition of banks may affect spending and investment in the macroeconomic context not only through changes in the external finance premium but also through the amount of credit required and extended. During a downturn, for example, banks may choose to limit risk to their balance sheets through some form of credit rationing, which can occur independently of the hike in the risk premium. See Bayoumi and Melander (2008). Therefore, to describe the loan quantity channel independent of the risk premium channel, we analyze the quantitative relationship between the financial health of banks and their loan supply, controlling for borrowing costs.

Bank-specific characteristics such as balance sheet condition and default risks[9] as well as macroeconomic condition can affect the supply of bank loan. We use the BIS ratio (BIS) to

[8] A number of papers we reviewed use banks' capital as a measure of its financial health. However, high capital base can result from high percentage of impaired loan in the previous periods, so we need a measure that reflects capital relative to risk. Another popular indicator is size. Larger banks are assumed to have healthier balance sheets, which seems an unrealistic assumption. The U.S. subprime crisis in late 2008 provides second thoughts. Many large banks have been in distress while several small and medium-sized banks have not been as badly affected.

[9] The relationship between banks and the financial market has intensified over time. Banks' default risks have larger effects on their ability and willingness to supply loan. A few studies on the transmission mechanism lately

proxy for bank's balance sheet condition. The proxies for their default risks consist of (1) the amount of banks provision for loan loss as a percentage of total loans (LLP) to represent provisioning for anticipated loss from damage to loan quality; and (2) the one-year-ahead probability of loan default[10] (PD), which is a forward-looking measure of banks' riskiness.

Since loan growth cannot be identified as coming from demand or supply factors, we need to control for a shift in the demand for loan. In this case, we use nominal GDP growth to control for loan demand shift as in Altunbas, Gambacorta, and Marqués (2009). We also use minimum loan rate (MLR) to capture the external finance premium of banks' borrowers.

The model is specified as follows:

$$\begin{aligned} \Delta \log (LOANS_{it}) &= \sum_{j=1}^{2} \alpha_j \Delta \log (LOANS_{it-j}) + \beta_1 \Delta \log (GDPN_{t-1}) \\ &\quad + \beta_2 \Delta MLR_{it-1} + \beta_3 BIS_{it-1} + \beta_4 LLP_{it-1} + \beta_5 PD_{it-1} \qquad (3) \end{aligned}$$

for bank $i = 1, ..., N$ and period $t = 1, \ldots, T$. Here, the growth rate of bank lending to residents, $\Delta \log (LOANS_{it})$, is regressed on the quarter-on-quarter nominal GDP growth rate, $\Delta \log (GDPN_{t-1})$, which captures loan demand. The loan supply is controlled by (1) lags of the BIS ratio (BIS_{it-1}), (2) the ratio of loan-loss provisions to total loans (LLP_{it-1}), and (3) the probability of default (PD_{it-1}). All three control variables represent bank balance sheets, ex-post and ex-ante measures of credit risk respectively. One lag of independent variables is used to avoid the endogeneity bias. Furthermore, since a lagged dependent variable is used as an explanatory variable, we estimate it using GMM estimator, as suggested by Arellano and Bond (1991).[11]

Data on domestic banks' balance sheets covering eight Thai banks, four of which are large and three medium-sized, are obtained from the Bank of Thailand. Market capital data, used in the calculation of the probability of default, are obtained from the Stock Exchange of Thailand. The sample period is 2000Q1–2009Q1.

Table 5 summarizes the main results. As expected, economic activities have a positive and significant effect on lending. Better economic condition increases the number of profitable projects and hence increases the demand for bank credit (Kashyap, Stein and Wilcox (1993). A one percent increase in nominal GDP growth (an upward shift in bank loan demand) causes loan growth to increase by around 0.3 percent over the sample period. In contrast, increases in the premium charged on loans (MLR) dampens loan growth one quarter ahead. The negative and significant coefficients of LLP and PD suggest that banks' risk condition matters for the supply of loan.

The positive and significant effect of BIS ratio on lending activities after controlling for loan demand shift and changes in the finance premium suggests that strong banks are more ready to perform their core function and expand their loan portfolios. A one percent increase in the BIS ratio leads to an increase in loan growth of around 0.1 percent. The elasticity seems small, but it is significant even after we control for factors that are well known to impact on loan growth.

Indeed, we can confirm that banks' balance sheet condition can impact on spending and investment of households and firms over and beyond that caused by changes in the risk premium embedded in the minimum loan rate.

have underlined the role of bank by focusing on banks' risks. See Instefjord (2005), Rajan (2005), Hänsel and Krahen (2007), and Borio and Zhu (2008).

[10]The calculation of probability of default follows the contingent claims approach as mentioned above.

[11]The GMM estimator would help mitigate the serial correlation problem and make instruments valid as suggested by the Sargan test. See Altunbas, Gambacorta, and Marqués (2009).

Table 5: Estimation result of determinants of bank lending (2000Q1–2009Q1)

Variable	Coefficient	Standard error
$\Delta \log (LOANS_{it-1})$	1.1***	0.05
$\Delta \log (LOANS_{it-2})$	-0.4***	0.05
$\Delta \log (GDPN_{t-1})$	0.3*	0.16
BIS_{it-1}	0.1***	0.03
LLP_{it-1}	-0.04***	0.02
PD_{it-1}	-0.04***	0.02
ΔMLR_{it-1}	-0.02***	0.01

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

3.3 Cost of capital and firm-level investment (Linkage 2)

To what extent does movement in the cost of capital influence the amount of investment at firm's level? We study this question through a panel regression on an unbalanced panel of 5,263 observations with 376 firms over the period 1999Q1–2009Q1. Aside from removing errors in the data, such as negative sales and interest rate data, we trim away outliers as defined to be in the lowest-5th and highest-5th percentiles for each variable.

In our model, firm-level fixed investment is normalized by the amount of fixed assets owned by that firm so as to control for firm (industry) types along the dimension of fixed investment requirement. At any date the additional fixed investment made relative to the existing gross fixed assets, I_{it}/K_{it-1}, is thought to depend on (1) its past values; (2) growth in sales, $\Delta \log (SALES_{it})$; (3) changes in the user cost of capital, $\Delta \log (UCC_{it})$ which is a weighted average of the apparent interest rate and opportunity cost of equity;[12] and (4) the firm's cash flow (CF_{it}/K_{it-1}) which is its net profit plus depreciation normalized by its fixed assets.[13]

We use the first-difference GMM estimation to quantify the impact of balance sheet conditions on firms' investment. The model is specified as follows:[14]

$$\begin{aligned} \frac{I_{it}}{K_{it-1}} &= \alpha_i + \sum_{l=0}^{1} \beta_1 \frac{I_{it-l}}{K_{it-1-l}} + \sum_{m=0}^{1} \beta_2 \Delta \log (SALES_{it-m}) \\ &\quad + \sum_{n=0}^{1} \beta_3 \Delta \log (UCC_{it-n}) + \sum_{q=0}^{1} \beta_4 \left(\frac{CF_{it-q}}{K_{it-1-q}} \right) + \nu_t + \varepsilon_{it} \end{aligned} \tag{4}$$

First of all, we performed two specification tests to confirm the validity of the GMM estimation. The Sargan test indicates that we cannot reject the null hypothesis of no dependency

[12] The user cost of capital is constructed as in Chatelain et al. (2001):

$$UCC_{it} = \frac{P^I_{st}}{P_{st}} \left[\frac{D_{it}}{D_{it} + E_{it}} i^{apparent} + \frac{E_{it}}{D_{it} + E_{it}} i^{long\text{-}term} + \left(\frac{1-\delta}{1-\tau} \right) \frac{\Delta P^I_{st+1}}{P^I_{st}} + \delta_s \right]$$

where i, s, and t index firm, sector, and time; P^I_{st} and P_{st} are the investment deflator and value-added deflator; δ is the depreciation rate; τ is the corporate income tax, assuming to be 0.3; $i^{apparent}$ is the apparent interest rate, calculated as interest payment over gross debt, and long-term interest rates; $i^{long\text{-}term}$ is 10-year government bond yields; D is gross debt; and E is book-value equity.

[13] See, for example, Hoshi, Kashyap, and Scharfstein (1991), Gilchrist and Himmerberg (1995), Hubbard, Kashyap, and Whited (1995), and Chatelain and Tiomo (2001).

[14] This is in line with neoclassical demand for capital as described in Chatelain et al. (2001).

between overidentifying instruments and estimated errors. That is, the orthogonality condition required by GMM estimation is satisfied and instruments are valid. We also find present first-order serial correlation in the error terms at the 5 percent level of significance; however, there is no evidence of the second-order serial correlation. These findings validate the use of instruments at lag 2.

Results are reported in Table 6. We see that firms' investment spending decision is typically persistent. A firm that invests in fixed assets today is also going to invest again in the next quarter, holding everything else constant, as evidenced by a statistically significant coefficient of 0.206. Investment today could spill over to the next quarter investment, partly because fixed investment requires time to plan and complete. In addition, firms' investment is positively responsive to sales growth—a proxy for future profitability and business prospects.

Table 6: Estimation result of firms' investment behavior

Variable	Coefficient	Standard error
I_{it-1}/K_{it-2}	0.206**	0.0001
$\Delta \log(SALES_{it})$	1.470**	0.008
$\Delta \log(SALES_{it-1})$	0.995**	0.003
Total Effects of SALES	3.105**	0.008
$\Delta \log(UCC_{it})$	-0.699**	0.003
$\Delta \log(UCC_{it-1})$	-0.978**	0.004
Total Effects of UCC	-2.112**	0.004
CF_{it}/K_{it-1}	1.769**	0.029
CF_{it-1}/K_{it-2}	1.987**	0.032
Total Effects of CF	4.730**	0.018

** indicates the significance level at 5 percent

Notes: (1) In the two-step GMM Arellano and Bond estimates of the investment equation (4), constant terms are not shown; (2) the total effects of explanatory variables are defined as the sum of the coefficients of the explanatory variable divided by one minus the coefficient on the lagged dependent variable. For sales and the user cost of capital, this can be interpreted as a total elasticity; for cash flow this is a total derivative. The standard errors of the total effects are computed using the delta method. See Papke and Wooldridge (2005).

There is a statistically significant adverse relationship between the user cost of capital and investment (both in the immediate quarter and over two quarters). The user cost of capital in the previous quarter has a stronger impact on today's fixed investment than today's cost of capital, indicating that there is persistence. A theoretical model should have this feature built in to be able to describe investment and cost of capital dynamic realistically. Note that both interest rate as well as risk premium are grouped under user cost of capital. In normal period, risk premium accounts for 42 percent of the user cost of capital and rises to over 80 percent during the crisis.

The ratio of cash flow to capital, which indicates liquidity and balance sheet health, enters significantly and with a positive sign. This significant coefficient serves to confirm that firms are financially constrained when it plans to make a fixed investment, and that balance sheet conditions are relatively important in determining firm's investment. This feature should also be present in the theoretical model used to measure the impact from the financial accelerator.

3.4 The feedback loop in Thailand

As macroeconomic condition worsens, financial health of firms and banks are also affected and the risk premium demanded rises as well. We tend to observe spikes in the financial risk indicators when the economy suffers a downturn. Figure 7 shows that data for Thailand confirm this story during the 1997 crisis and the recent global financial crisis. The borrowing premium in the Thai banks' credits and bond market has risen since end-2008—in particular, for unrepayable or poor-rating firms—as shown in Figure 8. This jump in risk premium is due primarily to a decline in profits as seen in Figure 3. Considering the magnitude, the spike in the risk premium does not completely reflect a sharp increase in defaults. According to Kim, Loretan, and Remolona (2009), approximately four-fifths of the increase in the risk premium during this period are due to risk aversion; the rest is due to a rise in defaults.

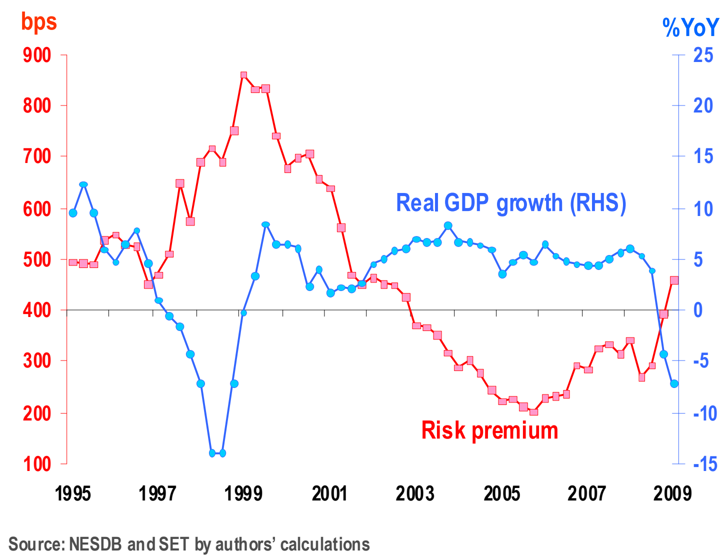


Figure 7: Risk premium and business cycle

Not only does the risk premium rise, Figure 9 shows that credit availability also becomes scarcer. The Business Sentiment Index (BSI) indicates that as the recent global financial crisis plays out, businesses surveyed confirm of tightened credit condition. This observation is corroborated by the senior loan officer survey conducted by the Bank of Thailand. Perceiving higher risks during the downturn, banks tightened their credit standards through higher collateral value demanded, more limited loan or overdraft size, and more stringent loan terms and conditions. For instance, data on large borrowers of commercial banks show a 30 percent decline in credit line for overdraft compared to the normal periods, as shown in Figure 10. Although the number of large firms with credit lines cut is small, the problem of credit availability appears to be more concerned to SMEs, as confirmed by most cases reported to the Bank of Thailand's Credit Resolution Center.

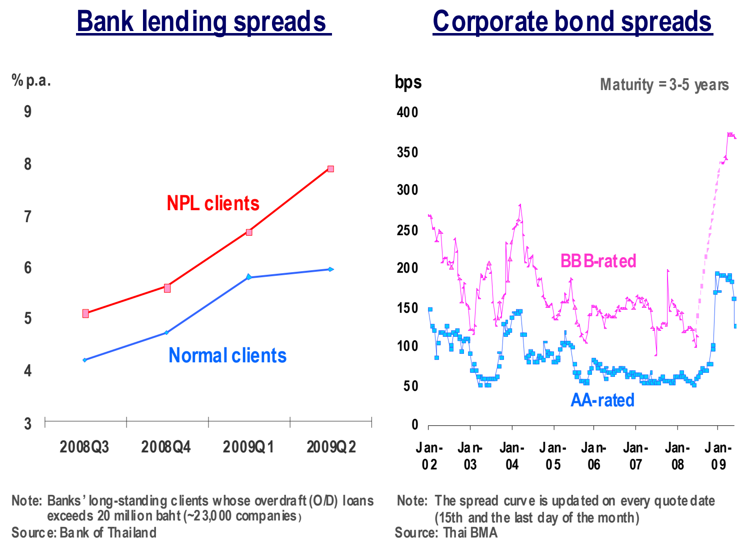


Figure 8: Evidence of risk premium

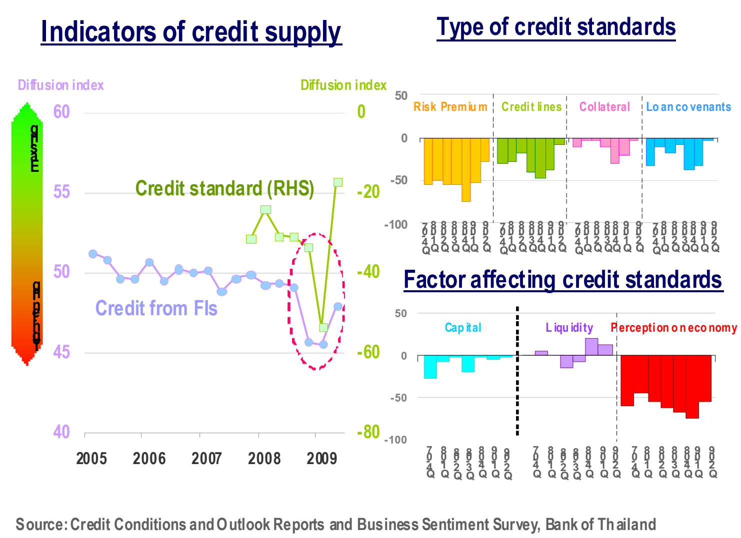


Figure 9: Evidence on credit tightening

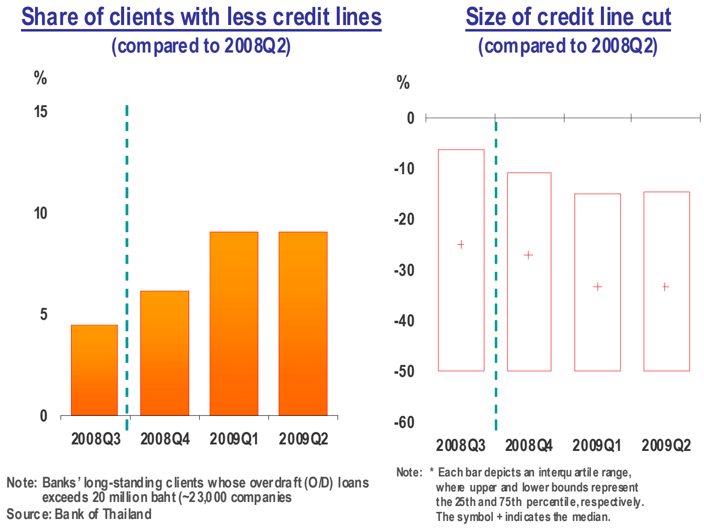


Figure 10: Evidence on tightening in credit availability

The adverse feedback loop can be particularly strong when balance sheets are more vulnerable to begin with. However, the recent global crisis has taken place when Thai firms and banks have not been expanding briskly with high leverage. Because there is no need for quick deleveraging, loan delinquency has picked up only slightly in recent quarters while bad loans, reflected in movements in the NPL ratio, are not rising in the same manner observed during the 1997 crisis, as depicted in Figure 11. Seen in Figure 12, strong financial conditions can help mitigate the risk that macroeconomic downturn can generate an adverse feedback loop.

3.5 Summary

We have demonstrated the important features of the financial accelerator in the case of Thailand. First, we have measured the impact of changes in balance sheet condition to external borrowing premium of firms and found that the premium varies inversely with the financial health of firms as predicted by theory. We found the result to hold for banks as well, even though the size of the banks' borrowing premium is minute in this case. We have also shown that, after controlling for other factors including shift in credit demand, banks' balance sheets are an important factor determining loan growth. Lastly, firm-level investment depends inversely and significantly on the finance premium, which is embedded in the cost of capital in the last quarter and today. These features are incorporated in the theoretical model that is described in details in the next section.

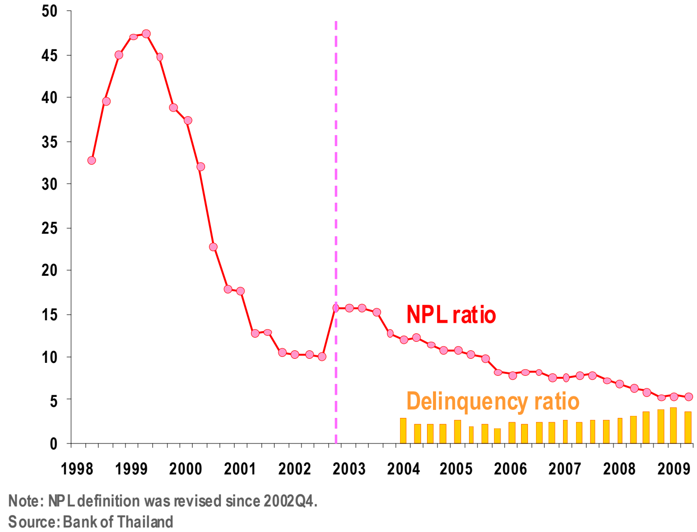


Figure 11: NPL and delinquency ratio

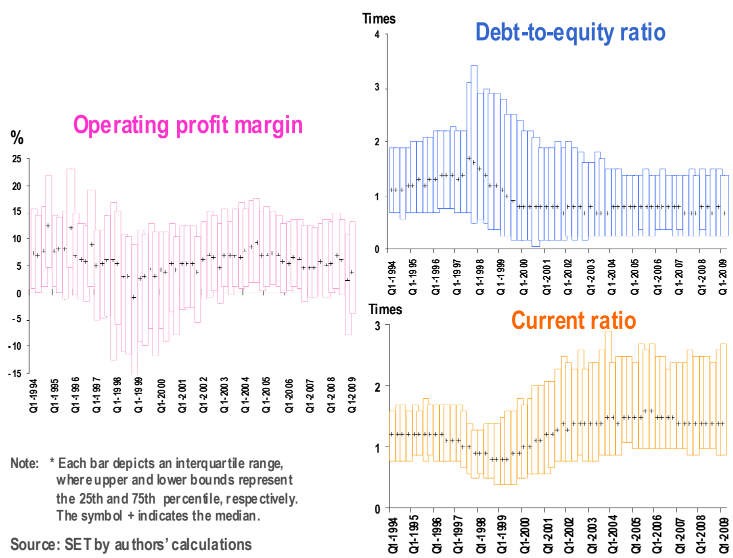


Figure 12: Financial health of the business sector

4 The Model with a Double Financial Accelerator

This section describes a model that is an extension of a dynamic stochastic general equilibrium (DSGE) model for the Thai economy as described in Tanboon (2008), augmented with a double financial accelerator closely related to Sunirand (2002), which in turn has a theoretical foundation in Bernanke, Gertler, and Gilchrist (1999).

4.1 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.

4.1.1 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

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left[(1-\chi) \log \tilde{C}_t - \varphi^L \frac{L_t^{1+\eta}}{1+\eta} \right] \tag{5}$$

subject to

$$P_t^D C_t + B_t^B \leq \left(1 + R_{t-1}^B\right) B_{t-1}^B + W_t L_t + \textstyle\sum_j \Phi_j . \tag{6}$$

In the budget constraint (6), 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 (5), 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,

$$\tilde{C}_t = \frac{C_t - \chi h_t}{1-\chi} \quad \text{with} \quad h_t = (1+\alpha)C_{t-1}. \tag{7}$$

$\tilde{C}_t$ 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 (5)–(6) 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 (6), 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

$$\lambda_t = \beta \mathrm{E}_t \lambda_{t+1} \left(1 + R_t^B \right). \tag{8}$$

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^N_{t-1} 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:

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

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 $B^f_t = S_t B^*_t$, 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

$$R^B_t - R^*_t = \mathrm{E}_t dS_{t+1} + \xi^{Bf}\left(\frac{B^f_t}{4Y^N_t} - \frac{\psi}{2}\right) + \upsilon.$$

Finally, the law of motion of B_t is given by

$$B^f_t = \left(1 + R^B_{t-1}\right) B^f_{t-1} - \left(P^X_t X_t - P^M_t M_t\right).$$

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

4.1.2 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

$$Y^D_t = \left(A_t L^D_t\right)^{\gamma^D_L}\left(M^D_t\right)^{\gamma^D_M}\left(K^D_t\right)^{1-\gamma^D_L-\gamma^D_M} \tag{9}$$

where domestic output is denoted by Y^D_t and the three factor inputs are labor (L^D_t), imported intermediate good (M^D_t), and capital (K^D_t). A_t is the labor-augmented productivity.

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

$$W_t L^D_t = \gamma^D_L Q^D_t Y^D_t \tag{10}$$

$$P^M_t M^D_t = \gamma^D_M Q^D_t Y^D_t \tag{11}$$

where W_t and P^M_t denote the nominal wage and the import price, respectively, and Q^D_t 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

$$Q_t K_t^D = B_t^D + N_t^D. \tag{12}$$

In the left side of (12) 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 (13):

$$1 + R_t^D = \frac{\left(1 - \gamma_L^D - \gamma_M^D\right) Q_{t+1}^D Y_{t+1}^D}{Q_t K_t^D} + (1 - \delta) \frac{Q_{t+1}}{Q_t} \tag{13}$$

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 (13) 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:

$$R_t^D - R_t = \left(\frac{Q_t K_t^D}{N_t^D + N_t^{BD}} \right)^{\nu}. \tag{14}$$

In the demand curve (14), 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 13, 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 depends 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 depends on the size of its project relative to the total internal funds of the firm *and* the bank.

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 (14) see Sunirand (2002). Briefly, this optimal demand for capital (or demand for

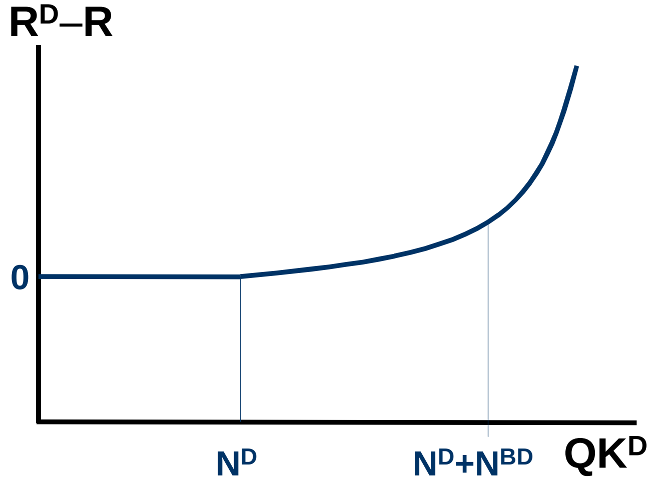


Figure 13: Firm's External Finance Premium—role of net worth and bank capital

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):

$$N_t^D = \phi_v V_t^D. \tag{15}$$

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

$$V_t^D = (1-\delta)Q_t K_{t-1}^D + Q_t^D Y_t^D - \left[W_t L_t^D + P_t^M M_t^D + \left(1 + R_{t-1}^D\right) B_{t-1}^D\right]. \tag{16}$$

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

$$P_t^D = P_t^{D*} + \xi^D \left[-\left(\Delta P_t^D - \Delta \bar{P}_{t-1}^D\right) + \beta \left(\mathrm{E}_t \Delta P_{t+1}^D - \Delta \bar{P}_t^D\right)\right] \tag{17}$$

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 (9)–(16).

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:

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

4.1.3 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

$$\max_{I_t} \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \lambda_t \left\{ Q_t \left[(1-\delta) K_t + F\left(I_t, I_{t-1}\right) - K_{t+1} \right] - P_t^D I_t \right\}. \tag{18}$$

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, $F\left(I_t, I_{t-1}\right)$, to produce new capital. Here, $F\left(I_t, I_{t-1}\right)$ 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

$$F(I_t, I_{t-1}) = \left[1 - \frac{\xi^I}{2}\left(\frac{I_t}{I_{t-1}} - (1+\alpha)\right)^2\right] I_t \tag{19}$$

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 (18) and (19), 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.

4.1.4 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

$$B_t = B^B_t + N^B_t \tag{20}$$

where $B_t = B^D_t + B^X_t$ is total loans supplied to the domestic and export firms, B^B_t is the bank's external funds (liabilities such as deposits and borrowings), and N^B_t 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

$$R_t^B - R_t = \left(\frac{B_t^B}{N_t^B} \right)^{\nu^B} \tag{21}$$

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

$$N_t^B = \phi_v^B V_t^B \tag{22}$$

$$V_t^B = \left(1 + R_{t-1}^D\right) B_{t-1}^D + \left(1 + R_{t-1}^X\right) B_{t-1}^X - \left(1 + R_{t-1}^B\right) B_{t-1}^B = \left(1 + R_{t-1}^B\right) N_{t-1}^B. \tag{23}$$

According to equation (22), 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 (23) 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 (23) 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,

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

4.1.5 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:

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

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_{t+1}^D, 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.

4.1.6 Exogenous processes

Exogenous processes are as follows:

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

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.

4.1.7 Market clearing conditions

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

$$
\begin{aligned}
L_t &= L_t^D + L_t^X \\
M_t &= M_t^D + M_t^X \\
K_t &= K_t^D + K_t^X
\end{aligned}
$$

and the market clearing conditions for outputs are given by

$$Y_t^D = C_t + I_t + G_t.$$

4.1.8 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.

4.1.9 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.

4.2 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.

4.2.1 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.

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' 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.

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 (12) and (15) 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 (21), 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 (8) 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.

4.2.2 Parameters governing the transition dynamics

Dynamic parameters consist of those of households (χ, ξ^I, ξ^W, ξ^{Bf}, 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 $\xi^{Bf} = 0.4$ 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^{B^f}	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.

4.3 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.

4.3.1 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 14 in terms of percent deviation from the steady state. The impulses depicted by thin (blue) lines correspond to the

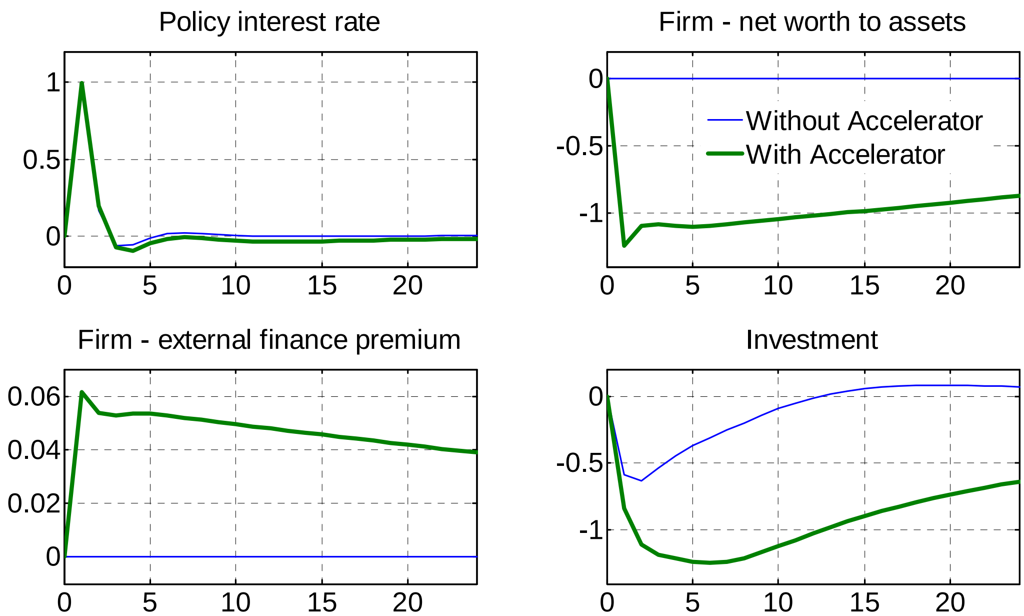


Figure 14: Interest Rate Shock

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.

4.3.2 Net worth shock

Consider a one percent reduction in firms' net worth for one period as shown in Figure 15. 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).

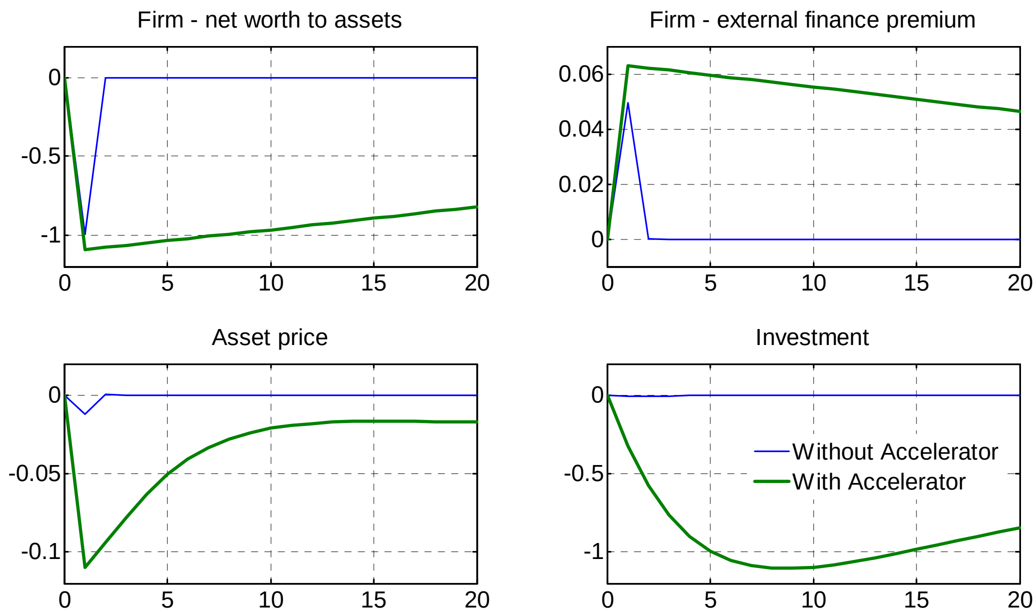


Figure 15: Net Worth Shock

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.

4.3.3 Shock to bank capital

Consider a temporary negative shock to the bank capital, as shown in Figure 16. 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

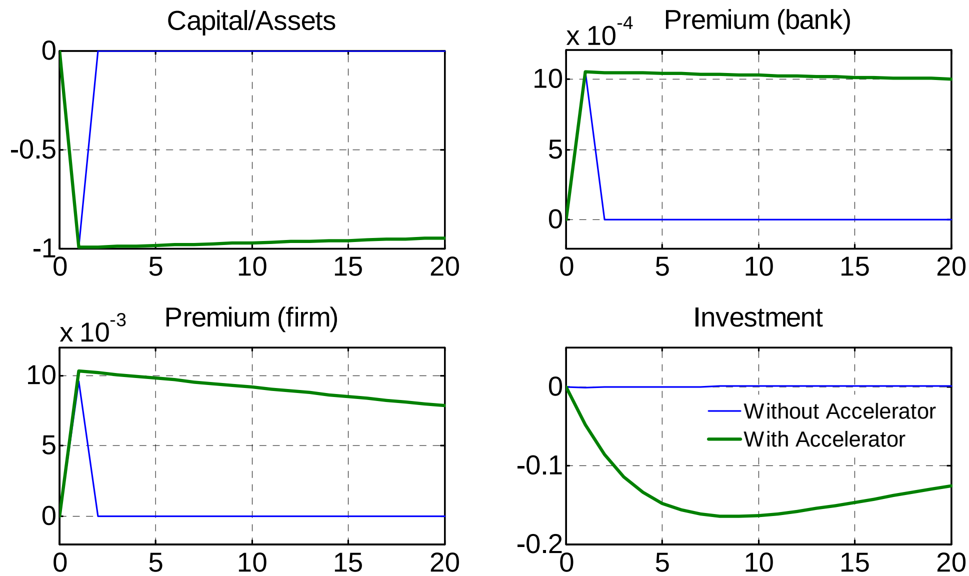


Figure 16: Bank Capital Shock

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 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.

4.3.4 Risk premium shock

Consider a one percent increase in the risk premium of firms for one period, shown in Figure 17, 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.

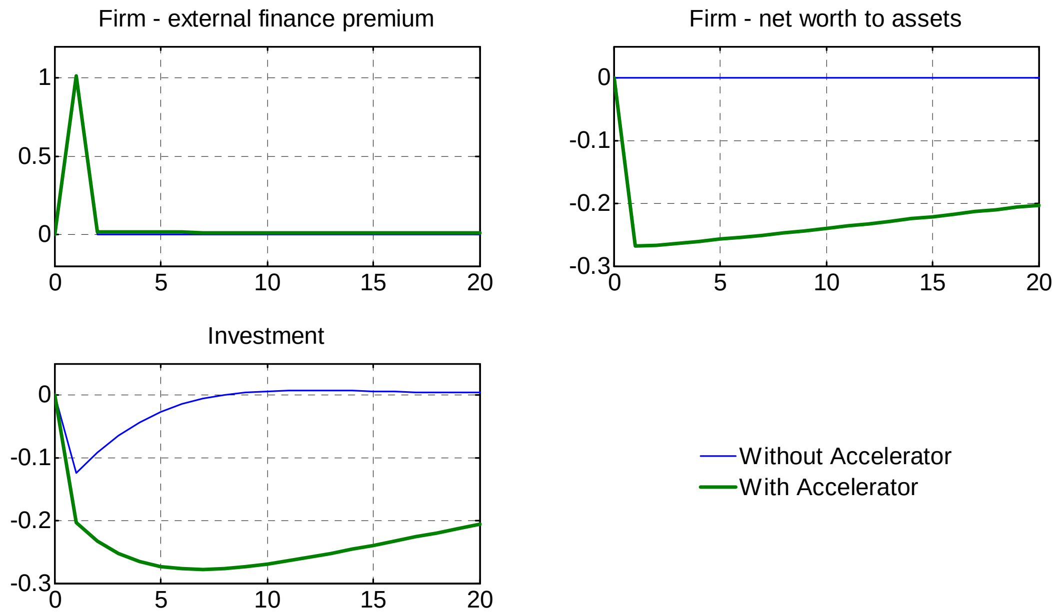


Figure 17: Risk Premium Shock

4.4 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 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 18 compares the baseline simulation given an **interest rate shock**, as shown first in Figure 14, 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 19 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.

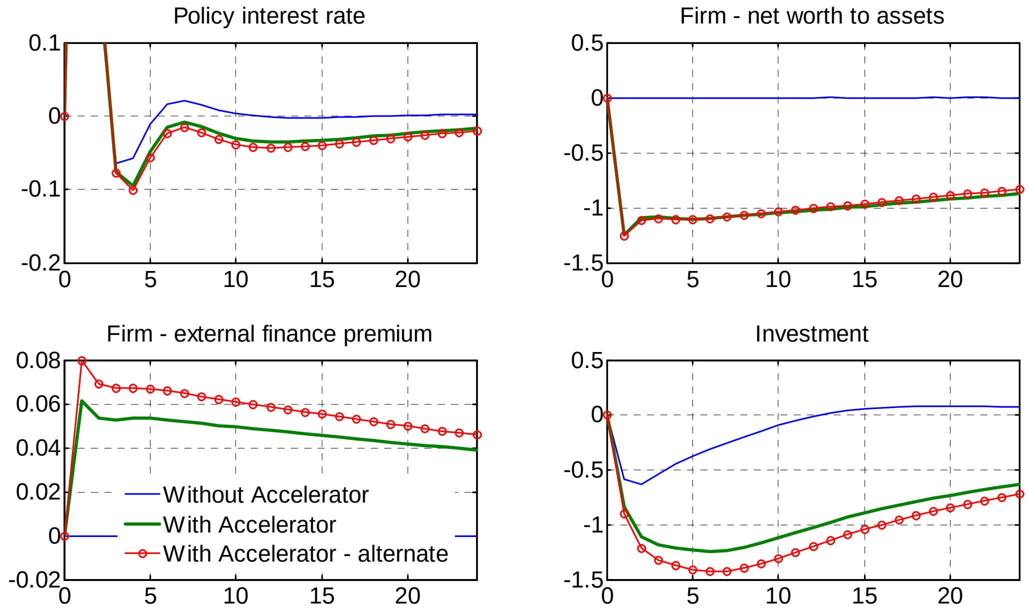


Figure 18: Interest Rate Shock—under different elasticities of finance premium to net worth

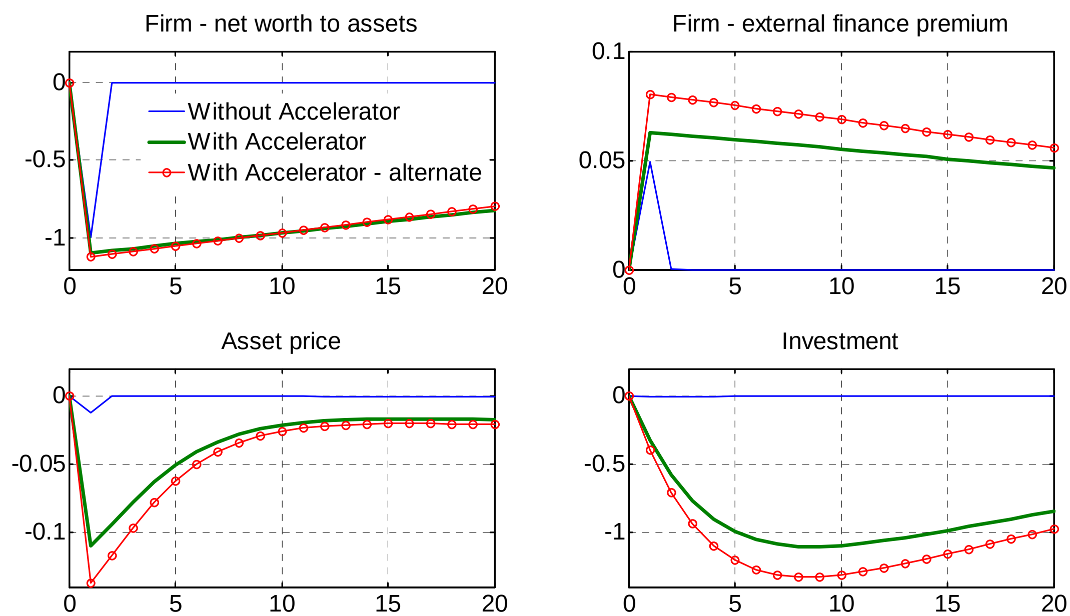


Figure 19: Net Worth Shock—under different elasticities of finance premium to net worth

4.5 Reflections on the recent crises in light of simulations and sensitivity analysis

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 Policy Implication

Given the adverse interplay between a deterioration in the economy and financial stress, and given the potential intensification of such a feedback loop when uncertainty heightens in times of crisis, this section discusses policy responses to and preventive measures for the adverse spiral.

5.1 Policy initiatives designed to stop the feedback loop

Reducing the policy interest rate comes as a natural response to real or financial disturbances that might set off the adverse feedback loop. First, as emphasized by Mishkin (2008), monetary policy must be at least as preemptive in responding to financial shocks as in responding to other types of disturbances to the economy. Second, interest rate cuts shore up borrowers' balance sheets, thereby dampening the external finance premium as implied from the converse of the simulation in Section 4.3.1. Third, by reducing the likelihood of losses, monetary easing also works to reduce uncertainty in the economy, thus helping the markets to accurately determine the fundamental prices of assets. As lenders are less anxious because a clearer picture of borrowers' balance sheets emerges, the sensitivity of the finance premium is likely to shift down from an elevated level, as discussed in the sensitivity analysis of Section 4.4. In short, during the times of crisis when the economy may have undergone structural changes, monetary policy has a greater role than usual in creating a macroeconomic environment that limits the adverse amplification and propagation of negative disturbance.

A question that often surfaces during the recent financial crisis involves the *effectiveness of monetary policy* given that the cost of credit remains high despite aggressive rate cuts. Mishkin (2009) is of the opinion that if the goal of the monetary authority is to offset the contractionary effects of a financial crisis, then it may need to pursue more aggressive monetary policy easing than normal. If the central bank did not aggressively cut rates, the result would be both higher risk-free interest rates and higher credit spreads, which increases the probability that the economy would fall into the adverse feedback loop.

If the scope of monetary easing is somehow limited, *tools other than cutting policy interest rates* are also useful.

- For example, under the *Term Securities Lending Facility* the Federal Reserve lends Treasury securities to primary dealers by a pledge of other securities including certain mortgage-backed securities. Such a strategy allows previously illiquid mortgage-backed securities to be used as collateral and in effect sets a floor on their value, thereby reducing the risk that the balance sheets of the borrowers would further deteriorate, which would have set off the adverse spiral.

- Furthermore, given that when a firm is forced to sell, other firms would rush to sell too to avoid holding those assets with declining prices. Such fire sale externalities further depress asset prices, and in this situation the government has an important role to rectify such adverse third-party effects. According to Geanakoplos (2009), a crash can be reversed in part by having the government step in and do some buying to replace "optimistic buyers." This is the essence of the *Troubled Assets Relief Program*. Such government intervention when externalities are present prevents the assets from falling into pessimistic buyers who, by valuing the assets less, would otherwise drive down asset prices and deteriorate balance sheets further.

- Another unconventional tool is the *stress tests*. This assessment was to ensure that the equity capital held by bank holding companies was sufficient to withstand a worse-than-expected macroeconomic environment and subsequently resume lending to creditworthy borrowers. Moreover, in times of crisis, institutions may be reluctant to realize losses in their balance sheets, thereby impeding information revelation and the process of price discovery. From this perspective, Krishnamurthy (2009) views that a benefit of the stress tests is that they force information revelation and reduce uncertainty regarding balance sheets.

Once the crisis comes to pass, the authorities should pay particular attention to *countercyclical regulations*. Brunnermeier et al. (2009) argue that in the upturn of the business cycle—during which asset values rise, risks fall, and competition intensifies—most financial institutions respond by expanding their balance sheets, using short-term funding as it is cheaper, and increasing leverage. Those that do not do so risk being viewed as underutilizing their equity. Consequently, it is recommended that capital requirements be countercyclical: imposing a capital cost that is increasing during booms when credit expands and leverage rises, and vice versa. The most straightforward rationale for the build-up of buffers in good times is that they can be drawn down as strains materialize. Furthermore, such a countercyclical capital requirement allows agents to absorb the shock better and helps to limit incipient financial distress, thereby working to forestall the amplification effects of the financial accelerator.

5.2 The case of Thailand

Given that Thailand is not at the center of the financial crisis but nonetheless affected by its repercussions, policy responses are naturally different from those adopted by the authorities in a more serious environment. However, an important feature of policy formulation common to both the core and peripheral economies is the practice of what Mishkin (2008) terms as "policy flexibility"—optimal policy may involve much more rapid adjustment in times of crisis.

In December 2008 the *Monetary Policy Committee* (MPC) decided to lower the policy interest rate by 100 basis points from 3.75 percent. Given that the most likely projection of the economic outlook pointed toward a marked slowdown in activities, with a substantial increase in the downside risks going forward, and given that risks to inflation subsided significantly, the MPC promptly reacted with special vigor to ensure that economic disruptions were minimal and so as to avert a potential negative feedback loop. The extensive monetary easing continued into 2009 until around mid-year. In the first three MPC meetings of the year the policy rate was cut in a series of 75, 50, and 25 basis points. It was in May when the MPC viewed that monetary policy had been substantially eased and the policy rate of 1.25 percent was sufficiently low, and it was only in the August MPC meeting that a sustained improvement in economic activity appeared to be forthcoming.

On the *financial stability* front, although loan growth was slowing down and lending standards remained somewhat tight, overall financial conditions did not especially constrict a sustainable economic recovery, as the financial position of commercial banks continued to be well capitalized. That after the 1997 Asian financial crisis the balance sheets of banks have been in good form owes partly to prudential measures by the central bank. Until recently, the Bank of Thailand stipulated financial institutions to cap the loan-to-value ratio for residential property with transaction exceeding 10 million baht at 70 percent (increased to 80 percent in March 2009). In Thailand the property sector's performance has a significant bearing on financial stability; overinvestment in this sector prior to 1997 brought about considerable nonperforming loans that threatened the soundness of the commercial banking system. The central bank has also strengthened its financial institutions supervisory role, adopting risk-based supervision, scenario analyses, and an early warning system.

The *fiscal authority* has played a crucial part in providing short-term stimulus to the economy. It put forward a mid-year supplementary budget, most of which were direct transfers to the public, and, when the economic downturn was in full swing, introduced another stimulus package with a focus on public investment. Interpreted in the context of our paper, this stimulus packages were first intended to support domestic demand, thereby preventing a contraction in the real economy that could trigger an adverse feedback loop. Second, such stimulus packages also work to reduce macroeconomic uncertainty and "undo the effects of the wait-and-see attitudes" of the private sector as emphasized by Blanchard (2009). Third, to reduce uncertainty in the credit market, the authorities have also designed policies to limit damages to the real economy caused by credit crunch by taking over the role of the insurance markets, introducing measures such as loan guarantees—a scheme by which the government will assume a private debt obligation if the borrower defaults. In short, fiscal stimulus measures not only replaces private demand but also reduce uncertainty of a bottomless recession so as to get consumers and firms to spend again.

In sum, given that sufficiently severe financial disruptions raise the probability of particularly adverse outcomes, which subsequently have the potential to feed into each other in a downward spiral, policymakers must look forward and be ready to forestall a likely feedback loop, and, if it sets off, must react with sufficient vigor in a timely manner to arrest such a corrosive self-reinforcing mechanism.

6 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.

References

[1] Altunbas, Y., L. Gambacorta, and D. Marqués (2007), "Securitization and the Bank Lending Channel." ECB Working Papers 838.

[2] Altunbas, Y., L. Gambacorta, and D. Marqués (2009), "Bank Risk and Monetary Policy." ECB Working Papers 1075.

[3] Arellano, M., and S. Bond (1991), "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations." *Review of Economic Studies* 58: 277–97.

[4] Aysun, U., R. Brady, and A. Honig (2009), "Financial Frictions and Monetary Transmission," University of Connecticut, Department of Economics Working Paper 2009–24.

[5] Bayoumi, T., and O. Melander (2008), "Credit Matters: Empirical Evidence on U.S. Macro-Financial Linkages." IMF Working Paper WP/08/169.

[6] Bernanke, B.S. (2007), "The Financial Accelerator and the Credit Channel." Speech given at a conference on "The Credit Channel of Monetary Policy in the Twenty-First Century," Federal Reserve Bank of Atlanta, Atlanta, June 15, 2007.

[7] Bernanke, B.S., and A.S. Blinder (1988), "Credit, Money, and Aggregate Demand." *American Economic Review* 78: 435–39.

[8] Bernanke, B.S., and M. Gertler (1995), "Inside the Black Box: The Credit Channel of Monetary Policy Transmission." *Journal of Economic Perspectives* 9: 27–48.

[9] Bernanke, B. S., M. Gertler, S.G. Gilchrist (1996), "The Financial Accelerator and the Flight to Quality." *Review of Economics and Statistics* 78: 1–15.

[10] Bernanke, B.S., M. Gertler, and S.G. Gilchrist (1999), "The Financial Accelerator in a Quantitative Business Cycle Framework." *Handbook of Macroeconomics* Vol. 1C, Amsterdam: Elsevier.

[11] Black, F., and M.S. Scholes (1973), "The Pricing of Options and Corporate Liabilities." *Journal of Political Economy* 81: 637–654.

[12] Blanchard, O. (2009), "Perils of Uncertainty: (Nearly) Nothing to Fear but Fear Itself." *The Economist*, January 30, 2009.

[13] Borio, C., and H. Zhu (2008), "Capital Regulation, Risk-Taking and Monetary Policy: A Missing Link in the Transmission Mechanism?" BIS Working Papers 268.

[14] Brunnermeier, M.K., A. Crockett, C.A.E. Goodhart, A. Persaud, and H. Shin (2009), "The Fundamental Principles of Financial Regulation." Geneva Reports on the World Economy 11, International Center for Monetary and Banking Studies, Geneva, Switzerland.

[15] Canzoneri, M., R. Cumby, and B. Diba (2007), "Euler Equations and Money Market Interest Rates: A Challenge for Monetary Policy Models." *Journal of Monetary Economics* 54: 1863–1881.

[16] Cavallo, E.A., and P. Valenzuela (2007), "The Determinants of Corporate Risk in Emerging Markets: An Option-Adjusted Spread Analysis." IMF Working Papers IMF/07/228.

[17] Chatelain, J., and A. Tiomo (2001), "Investment, the Cost of Capital, and Monetary Policy in the Nineties in France: A Panel Data Investigation." ECB Working Paper No.106.

[18] Chatelain, J., A. Generale, I. Hernando, U. Kalckreuth, and P. Vermeulen (2001), "Firm Investment and Monetary Transmission in the Euro Area." ECB Working Paper No.112.

[19] Chuenchoksan, S. and D. Nakornthab (2008), "Past, Present, and Prospects for Thailand's Growth: A Labor Market Perspective." Bank of Thailand Discussion Paper DP/06/08.

[20] Christiano, L.J., M. Eichenbaum, and C.L. Evans (2005), "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy." *Journal of Political Economy* 118: 1–45.

[21] Collin-Dufresne, P., R.S. Goldstein, and S.J. Martin (2001), "The Determinants of Credit Spread Changes," *Journal of Finance* 56: 2177–2207.

[22] Durbin, E., and D. Ng (2005), "The Sovereign Ceiling and Emerging Market Corporate Bond Spreads," *Journal of International Money and Finance* 24: 631–649.

[23] Erceg, C.J., D.W. Henderson, and A.T. Levin (2000), "Optimal Monetary Policy with Staggered Wage and Price Contracts." *Journal of Monetary Economics* 46: 281–313.

[24] Fuhrer, J. (2000), "Optimal Monetary Policy in a Model with Habit Formation." *American Economic Review* 90: 367–390.

[25] Gapen, M.T., D.F. Gray, C.H. Lim, and Y. Xiao (2004), "The Contingent Claims Approach to Corporate Vulnerability Analysis: Estimating Default Risk and Economy-wide Risk Transfer." IMF Working Paper WP/04/121.

[26] Geanakoplos, J. (2009), "The Leverage Cycle." Paper presented at the Bank of Korea International Conference on "The Credit Crisis: Theoretical Perspectives and Policy Implications," Seoul, Korea, June 2–3, 2009.

[27] Gilchrist, S., and C.P. Himmelberg (1995), "Evidence on the Role of Cash Flow for Investment." *Journal of Monetary Economics* 36: 541–572.

[28] Gray, D., and S. Malone (2009), *Macrofinancial Risk Analysis*. West Sussex, England: John Wiley & Sons.

[29] Gray, D., R.C. Merton, and Z. Bodie (2006), "A New Framework for Analyzing and Managing Macrofinancial Risks of an Economy." NBER Working Paper 12637.

[30] Hänsel, D. and J.P. Krahnen (2007), "Does Credit Securitization Reduces Bank Risk? Evidence from the European CDO Market." Mimeo, Goethe University Frankfurt.

[31] Hoshi, T., A.K. Kashyap, and D. Scharfstein (1991), "Corporate Structure, Liquidity, and Investment: Evidence from Japanese Industrial Groups." *Quarterly Journal of Business and Economics* 106: 33–60.

[32] Hubbard, R.G., A.K. Kashyap, and T.M. Whited (1995), "Internal Finance and Firm Investment." *Journal of Money, Credit & Banking* 27: 683–701.

[33] Instefjord, N. (2005), "Risk and hedging: Do credit derivatives increase bank risk?" *Journal of Banking and Finance* 29: 333–345.

[34] Ivaschenko, I. (2003), "How Much Leverage Is Too Much, or Does Corporate Risk Determine the Severity of a Recession." IMF Working Paper WP/03/03.

[35] Kashyap, A.K., J.C. Stein, and D.W. Wilcox (1993), "Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance." *American Economic Review* 83: 78–98.

[36] Kim, D., M. Loretan, and E. Remolona (2009), "Contagion and Risk Premia in the Amplification of Crisis: Evidence from Asian Names in the Global CDS Market." Bank for International Settlements.

[37] Krishnamurthy, A. (2009), "Amplification Mechanisms in Liquidity Crises." NBER Working Paper No. 15040.

[38] Levin, A.T., F.M. Natalucci, and E. Zakrajšek (2004), "The Magnitude and Cyclical Behavior of Financial Market Frictions." Finance and Economics Discussion Series 2004–70. Washington: Board of Governors of the Federal Reserve System.

[39] Merton, R.C. (1973), "Theory of Rational Option Pricing." *Bell Journal of Economics and Management Science* 4: 141–83.

[40] Mishkin, F.S. (2008), "The Federal Reserve's Tools for Responding to Financial Disruptions." Speech given at the Tuck Global Capital Markets Conference, Tuck School of Business, Dartmouth College, Hanover, New Hampshire.

[41] —– (2009), "Is Monetary Policy Effective During Financial Crises?" NBER Working Paper No. 14678.

[42] National Statistical Office (2006), *Business Trade and Services Survey 2006*. Bangkok, Thailand.

[43] —– (2007), *Industrial Census 2007*, Bangkok, Thailand.

[44] Papke, L.E., and J.M. Wooldridge (2005), "A Computational Trick for Delta-method Standard Errors." *Economics Letter* 86: 413–417.

[45] Rajan, N. (2005), "Has Financial Development Made the World Riskier?" NBER Working Paper No. 11728.

[46] Ravn, M.O., S. Schmitt-Grohe, and M. Uribe (2006), "Deep Habits." *Review of Economic Studies* 73: 195–218.

[47] Reynard, S. and A. Schabert (2009), "Modeling Monetary Policy." Working Paper, Swiss National Bank.

[48] Sunirand, P. (2002), "The Role of Bank Capital and the Transmission Mechanism of Monetary Policy." Financial Markets Group Discussion Paper No. 433, London School of Economics.

[49] Sutthasri, P. (2007), “Parameter Calibration for the Bank of Thailand DSGE Model” (in Thai). Unpublished manuscript, Bank of Thailand.

[50] Tanboon, S. (2008), “The Bank of Thailand Structural Model for Policy Analysis.” Bank of Thailand Discussion Paper DP/12/2008.