Essays in Banking and Risk Management

by

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Abstract

This thesis consists of three essays at the intersection of banking, corporate finance and macroeconomics. Unifying the essays are two themes: firstly a focus on how firms (Chapter 1 and Chapter 2) and individuals (Chapter 3) insure against, and react to, sources of macroeconomic risk; secondly the role of financial institutions in the transmission of macroeconomic shocks.

Turning to specifics, Chapter 1 is a theoretical and empirical examination of risk management behavior amongst small and medium sized firms, in particular firms' choices between fixed and adjustable rate loan contracts. (Although theory suggests small, privately held firms should have strong incentives to engage in risk management, such firms are rarely studied in empirical work.) I develop a simple agency model of risk management behavior, and then present several pieces of empirical evidence that suggest small US firms do use the banking system to help manage interest rate risk, based on microeconomic data on bank dependent US firms.

Chapter 2 presents evidence that banking relationships are most valuable to firms during periods of tight credit, in the extreme during a 'credit crunch'. Relationships alleviate delegated monitoring costs; when banks are credit constrained, these costs are extreme, so the informational advantage of relationships is magnified. I develop these intuitions using a simple agency model. Empirical evidence, based on data from a survey of manufacturing firms during the Asian financial crisis, supports the thesis. Several pieces of evidence also suggest my empirical results are not driven by the endogenous nature of bank relationship formation.

Financial institutions in co-operation with the World Bank and the International Taskforce on Commodity Risk Management have begun implementing strategies to provide commodity price and weather insurance in the developing world. In Chapter 3 (joint with Professor Rob Townsend from the University of Chicago), we examine how shocks to the price of rubber, an important but volatile Thai export commodity, affect the income, consumption and intra-household remittances of rural Thai households. In contrast to related work on rainfall shocks, we find rubber price innovations are not well insured or smoothed – remittances, borrowing and saving play only small roles in ameliorating the effect of these shocks on the consumption of affected households. We argue that differences in the relative persistence of the two types of shocks provide a plausible reason for these divergent findings, drawing on the literature on buffer stock models of consumption behavior and risk sharing with limited commitment.

Thesis Supervisor: Ricardo Caballero
Title: Ford International Professor of Economics

for John and Margaret

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As Professor Caballero once advised me: ‘Writing a thesis is a very non-linear process’. And so it turned out to be. By turns stimulating, exasperating, challenging and rewarding, the final act of writing these words really does feel like the end of an era. First and foremost, I would like to thank my advisers Ricardo Caballero, David Scharfstein and Rob Townsend for their careful insights, valuable criticism and generous encouragement. Each brought a different and fresh perspective to my research endeavors, greatly improving the quality and depth of this thesis. Particular thanks is due to Rob Townsend firstly for inviting me to work with him in Chicago in the summer of 2001, and then for his wonderful and continued energy and hospitality in maintaining that professional relationship despite the tyranny of distance and the demands of his many other research projects.

My research interests and approach to thinking about economics have been greatly influenced by courses from Ricardo Caballero, Bengt Holmstrom, Nobuhiro Kiyotaki, Jeremy Stein, Jean Tirole and Rob Townsend. I also owe a debt of gratitude to Olivier Blanchard for his generous advice at various stages of my doctoral career.

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Contents

Chapter 1

Corporate Risk Management and the Structure of Loan Contracts

Although theory suggests small, young, privately held firms should have strong incentives to engage in corporate risk management, there is currently little evidence of this, in that such firms make almost no use of 'traditional' derivatives-based hedging strategies. In this chapter I examine an alternative margin along which firms manage market risk, by analyzing firms' choices between fixed and variable rate bank loans. First I develop a simple agency model in which both firms and lenders are financially constrained. In equilibrium, banks charge a premium on fixed rate debt to compensate them for assuming the interest rate risk of the loan. Firms who are likely to be financially constrained in future periods will be willing to pay this premium, firms who are likely to be unconstrained will not. I test these and other predictions using microeconomic data on a sample of bank dependent US firms. Small firms and young firms (two measures of financial constraints) as well as firms with higher growth rates, lower current cash flows and less wealthy owners are significantly more likely to choose fixed rate debt. Firms adjust their exposure depending on how interest rate shocks covary with industry cash flows. I provide supporting anecdotal reports from interviews with business lenders, and present evidence that the 'fixed vs variable rate' financing decision is quantitatively important; I also find preliminary evidence that lenders do charge a premium on fixed rate loans. I conclude that small US firms use the banking system to help manage interest rate risk, and discuss implications for the balance sheet and bank lending channels of monetary policy.

1.1 Introduction

Both theory and evidence suggests that the real decisions of firms (investment, hiring and so on) are distorted by financial constraints. Consequently, firms who have difficulty raising external finance may benefit from engaging in 'risk management': activities that reduce the sensitivity of internal funds to external shocks and align funds with investment opportunities. (For example, a firm might use a derivatives contract to hedge against the possibility of rising interest rates or exchange rate fluctuations.)

Based on this view, one might expect that small, young, privately held firms should have the greatest incentive to engage in risk management, since such firms face the most severe financial constraints. There is, however, little evidence of this. Empirical work on corporate risk management has focused on firms' use of financial derivatives; perhaps because of the economies of scale associated with setting up and managing a derivatives hedging program, use of these tools is concentrated amongst large, mature, publicly traded firms.[1,2] For example, in Fenn, Post and Sharpe's (1996) sample of 4000 non-financial public corporations, 52 per cent of firms with greater than \$2500m in assets used interest rate derivatives, compared to only 1 per cent of the firms with less than \$100m in assets. In interviews I have conducted, bank relationship managers report that very few of the small and medium sized enterprises they deal with make any use of derivatives.

Although young, small, credit constrained firms do not use derivatives, they do borrow extensively from financial institutions. This chapter focuses on an alternative setting for examining corporate risk management by analyzing the structure of loan contracts, in particular firms' choices between fixed rate and variable rate loans. This financing decision affects how sensitive the firm's cash flows are to market risk (in this case fluctuations in interest rates) just as does the decision to use derivatives. But it has several advantages as a laboratory for testing risk management theories:

(i) I am able to observe the fixed rate vs variable rate decision for a large sample of small and medium sized firms. Although this class of firms is generally believed to face the most severe financial constraints, it has been little studied within the corporate risk management literature.

(ii) Unlike derivatives, there are no obvious fixed costs of hedging via fixed rate debt that might disproportionately affect small or young firms and produce perverse relationships between agency cost variables and the decision to insure against interest rate risk.

[1] As some direct evidence of these scale economies, Dolde (1993) presents evidence on risk management practices from a survey of Fortune 500 firms showing that almost all firms with active hedging programs employ several full-time risk management professionals to manage their derivatives portfolios. Firm owners and managers may also face substantial fixed cognitive costs in learning enough about derivatives to even make an informed decision about whether such instruments would be beneficial for the firm.

[2] A second possible explanation is that, as the misadventures of Enron, Barings, Procter and Gamble, Orange County and others have highlighted, the use of derivatives is beset with its own set of agency problems. These might might make intermediaries reluctant to lend to small, opaque firms who actively use derivatives-based hedging strategies. This factor may help to explain the sometimes divergent findings of different empirical studies of risk management behavior (see Section 2 for a more detailed review of this literature).

(iii) As I later show, in comparison to 'traditional' derivatives hedging the choice between fixed and variable rate debt has a quantitatively important effect on firms' sensitivity to interest rate shocks. (My point of comparison is the intensity of derivatives use by the largest publicly traded US companies).

The first part of this chapter develops a simple agency model to highlight various costs and benefits of fixed and variable rate debt. As well as providing a clear organizing framework for interpreting my empirical results, the model also makes a new theoretical contribution by analysing risk management behavior in an environment where both the 'buyer' (the firm) and the 'seller' (in this context, a financial institution) are credit constrained. This highlights a potential cost of risk management: when bank credit constraints are also sensitive to interest rate risk - as substantial empirical evidence suggests they are - lenders in equilibrium charge a premium on fixed rate debt to compensate them for assuming the interest rate risk of the loan. Small, young firms who expect to be credit constrained in the future will be willing to pay this premium to avoid interest rate risk; larger, mature firms will not be.

These and other predictions are tested using data from three waves of the Federal Reserve Board Survey of Small Business Finance (SBF). Controlling for firm, loan and ownership characteristics, I find that small firms and young firms (two measures of the degree of financial constraints) are significantly more likely to choose fixed rather than variable rate loans. A doubling of firm size reduces the probability of the firm choosing a fixed rate loan by 5-7 percentage points, while a doubling of firm age reduces this probability by 3-4 percentage points. Firms with greater future investment opportunities (proxied by sales growth) and lower current cash flows (proxied by return on assets) are more likely to use fixed rate debt, also consistent with the hypothesis that firms hedge to reduce the severity of credit constraints in future periods.

The data also supports two of the model's other predictions. Using industry accounts data I estimate the sensitivity of different 2-digit-SIC industries to interest rate shocks; armed with these estimates I find evidence that firms in industries where current cashflows covary positively with interest rates are less likely to use fixed rate debt. This is consistent with theory, since variable rate debt provides such firms a 'natural hedge' against shocks to operating cash flows. Secondly, I find evidence that lenders do charge an interest rate premium on fixed rate debt, after controlling for firm and loan characteristics as well as the slope of the yield curve over the repricing interval of the loan.

In addition, I also find evidence that this corporate finance decision responds to ownership risk characteristics: namely that firms with wealthier owners are less likely to choose fixed rate debt (consistent with either a buffer stock model of consumption, or the idea that risk aversion is decreasing in wealth). Unlike several recent papers, I find only weak evidence of 'market timing' behavior (specifically, the idea that firms switch between fixed and variable rate debt in a predictable way depending on the shape of the yield curve).

Taken together, the results in this chapter provide substantial evidence that small US firms use the banking system to manage interest rate risk, and that this avenue of risk management is quantitatively important. Moreover, the role of banks in influencing firms' interest rate risk is likely to be substantially greater in other parts of the world, especially emerging market economies where interest rate volatility is high and financial intermediaries (as opposed to markets) play a particularly important role as a source of finance for firms.

The model and results presented here also have several interesting implications for macroeconomic fluctuations and for the bank lending and balance sheet channels of monetary policy. A number of papers argue that corporate risk management can help reduce aggregate output volatility: for example Krishnamurthy (2003) shows that hedging can mute the 'financial accelerator' amplification mechanisms in Kiyotaki and Moore (1997). This chapter adds to the body of microeconomic evidence regarding the mechanisms through which such hedging may occur in practice. A different implication is that over time interstate branching, the recent wave of banking mergers, and the increased use of financial engineering by large banks are all likely to improve the US banking system's overall ability to manage interest rate risk. The model and results in this chapter suggest that such developments should then lead to improved interest rate risk management by *firms* and a weakening of the balance sheet channel of monetary policy: ie. as the risk management practices of banks improve, they will be better able to absorb firms' interest rate risk by offering more customized, state-contingent loan contracts on attractive terms.

This chapter proceeds as follows. Section 1.2 places this chapter in the context of the existing risk management literature. Sections 1.3 and 1.4 develop the theoretical framework. Section 1.5 explains the data and empirical methodology, and shows that shows that historically, fixed rate debt is associated not only with more stable nominal interest payments, but also more stable *real* interest payments. Section 1.6 presents the main empirical results. Section 1.7 presents evidence on the quantitative significance of the 'fixed vs variable' risk management channel decision on the firm's cash flows. Section 1.8 concludes.

1.2 Related Literature

The imperfect capital markets view of risk management is discussed in Smith and Stulz (1985) and further developed in Froot, Scharfstein and Stein (1993).[3] In Froot et al., the firm's

[3] Other motivations for risk management (besides those that focus on costly external finance) have also been proposed and tested. Smith and Stulz (1985) argue that since tax losses cannot always be carried forward to future periods, tax payments are convex in firm profits, providing an incentive for firms to hedge. Leland (1998)

production function is concave and raising external finance is costly; these assumptions ensure that fluctuations in internal funds destroy firm value. The intution is that a negative shock to internal funds cannot be costlessly offset by increasing external finance and thus results in lower investment; this has a large impact on firm profit because the marginal product of investment is high when the level of investment is low. The spirit of Smith and Stulz is similar: hedging reduces the probability of financial distress, which increases firm value because of exogenous fixed costs of bankruptcy.

Empirical work to test these ideas has generally focused on firms' use of financial derivatives. Some papers analyse broad cross sections of non-financial firms, while others focus on particular industries (such as gold mining or banking) where derivatives use is particularly prevalent. The table below summarizes results from a representative sample of papers on the relationship between derivatives use and measures of either financial frictions, or cash flows relative to investment opportunities.[4]

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makes a different tax-related argument: effective risk management allows firms to increase their debt capacity, and enjoy the associated debt tax shield. Graham and Rogers (2002) test these two hypotheses, finding evidence for the Leland debt capacity hypothesis, but not the tax convexity hypothesis. That is, firms with active hedging programs have higher debt ratios, but firms with more convex tax schedules are not more likely to engage in derivatives hedging.

Also Smith and Stulz (1985) argue that hedging could be motivated by managerial risk aversion (since managers have a large, non-diversifiable stake in the firm) while DeMarzo and Duffie (1991) develop a career concerns type model in which managers hedge to influence labor market perceptions of their managerial quality. Tufano (1996) finds evidence that managerial variables affect the degree of hedging in the gold mining industry. I also present some evidence consistent with managerial-risk-aversion motivations for insuring against interest rate risk.

[4] Other papers have examined how the decision to hedge affects other aspects of the firm's corporate finance policy. Fenn, Post and Sharpe (1996) find that firms who use interest rate swaps issue more short-term and floating-rate debt, since they are able to better hedge the resulting interest rate risk. Guay (1999) finds that the introduction of a derivatives hedging program is associated with decreases in firm risk, suggesting derivatives are being used for hedging rather than pure speculation. Allayanis and Weston (2001) argue that initiating a deriatives hedging program is associated with a substantial increase in firm market value (as much as 4.8 per cent). However, Guay and Kothari (2003) show that firms' derivatives positions are quite small relative to firm size and cash flows, which suggests that Allayanis and Weston's estimates of the effect of hedging on firm value may be implausibly large.

	dependent variable	Firm size	Investment opportunities	Leverage	Quick ratio	Prob. financial distress
Géczy et. al. (1997)	binary	+++	++	n/s	n/s	
Mian (1996)	binary	+++	- - -			
Haushalter (2001)	binary	++	n/s	n/s		+
	continuous	n/s	n/s	+++		+++
Purnanandam (2003)	binary	+++	n/s	- - -	- - -	- - -
	continuous	++	n/s	- -	- - -	++
Lin and Smith (2003)	continuous	+++	+++	+++	-	
Tufano (1997)	continuous	n/s	-	n/s		
Graham and Rogers (2003)	continuous	+++	- - -	+++		

Binary dependent variable = 1 if the firm uses derivatives, = 0 otherwise. Continuous dependent variable measures the intensity of derivatives use (eg. the proportion of total production hedged using derivatives). +/++/+++ (-/–/—) means the variable is positive (negative) and significant at the 10 per cent/5 per cent/1 per cent level. n/s means the estimated coefficient was not statistically significant. Results are taken from Table 4 of Geczy et. al, Table 4 of Mian, Tables 9 and 7 of Haushalter, Tables 6 and 8 of Purnanandam, Table 5 of Lin and Smith, Table 5 of Tufano and Table 3 of Graham and Rogers.

As the table shows, the estimated sign of these relationships are often not consistent across different studies. Moreover, the most robust finding, that large firms are more likely to use derivatives for risk management, is opposite to that predicted (since smaller firms are generally thought to face greater agency problems). Finally, a recent paper by Guay and Kothari (2003) shows that the magitude of derivatives hedging by large public companies is quantitatively small relative to cash flows and assets.

Taken together, these results are difficult to fully reconcile with theory. As already argued, however, derivatives hedging may be only one of many hedging activities undertaken by firms, and is perhaps not the ideal laboratory for testing risk management theories. As a non-exhausive list, choosing the currency-denomination of external debt, purchasing insurance, holding precautionary cash balances, diversifying the firm's operations across different industries or geographical regions and the formation of long-term banking relationships are all activities substantially motivated by risk management concerns. The margin considered in this chapter (the firm's choice between fixed and variable rate loans) is particularly attractive because it provides a clean test of risk management incentives that sidesteps many of the confounding factors affecting firms' use of derivatives.

The two papers most closely related to this one are Guedes and Thompson (1995) and Faulkender (2003). Guedes and Thompson present a simple signalling model of a firm's choice between fixed rate and adjustable rate debt. They show that high type firms choose variable rate debt in equilibrium, because they are less concerned about the possibility of bankruptcy (which is assumed to impose pecuniary costs on the manager). This prediction is then tested using an event study methodology and data on corporate issuances of fixed-rate and adjustable-rate bonds from the 1980s.[5] Consistent with the model, Guedes and Thompson find that the stock market responded more positively to variable rate debt issuances, except during periods of particularly high inflation volatility These results are extremely interesting, but are addressed towards a somewhat different question to those examined in this chapter. Namely their model makes predictions about the effect of *unobserved* differences between firms (ie. private information) on firms risk management choices. In contrast, the model and empirical analysis below is based on *observed* differences in the degree of agency problems, and is thus able to address questions about the risk management choices of (for example) small or young firms relative to large or older firms, or firms whose cashflows covary with interest rates in different ways.

Faulkender (2003) analyses the determinants of the 'final' interest rate exposure of 275 corporate debt issuances for a sample of firms in the chemical industry. This final exposure reflects the sum of two choices: whether the original loan was issued at a fixed or variable rate, and then whether the firm subsequently used an interest rate swap. Faulkender finds no evidence that firms are hedging when choosing the interest rate exposure of their debt (like other papers in the literature finds a positive association between firm size and the probability of interest rate risk management). However, he finds that firms are 'market timing', in that they are less likely to choose fixed rate debt when the yield curve is upward sloping. Although I too find some weak evidence of market timing, I also find strong relationships between the fixed rate vs variable rate decision and measures of agency costs. This may in part reflect differences in the target sample. I study small, privately held firms (for whom financial frictions are more significant) rather than large public companies. Also, Faulkender's sample is a mix of firms who

[5] Today, almost all corporate bonds are issued at a fixed coupon interest rate. But during the late 1970s and early 1980s, a substantial proportion were in fact issued at a variable rate, because of concerns at the time about high and volatile inflation rates (ie. as long as the Fisher effect operates, variable rate loans provide a hedge against inflation, since the nominal interest rate will go up and down with the inflation rate, leaving the real interest rate constant).

This fits well with the stylized facts discussed in Section 1.5.1 – the years in question are the only period since 1960 in which variable rate loans generated less volatile *real* interest payments (ex post) than did fixed rate loans.

raise debt directly from capital markets and those who issue bank debt, as well as a mix between firms who use derivatives and those who do not; this might potentially obscure relationships between agency cost proxies and the decision to fix or float. (For example, the smaller firms in Faulkender's sample are more likely to use bank debt, while the larger firms are more likely to directly place debt in the corporate fixed interest market. Corporate debt is generally issued at a fixed interest rate, while large bank loans are generally variable rate. These two facts alone suggest a likely positive association between size and the probability of using fixed rate debt).

Finally, Campbell and Cocco (2003) develop and calibrate a model of household mortgage choice. Their analysis is based on a buffer-stock model (ie. a life cycle model with credit constraints), and predicts that households with little wealth should eschew variable rate loans because of the risk that a short run increase in interest rates might force a large decline in current consumption. Thus, their rationale for risk management is quite similar to this chapter, although the benefits of hedging stem from individual risk aversion, rather than corporate finance considerations.

1.3 A simple model

In this section, I develop an agency model of corporate risk management in which a credit constrained firm chooses beween a fixed rate loan and a variable rate loan. Fixed rate debt reduces the volatility of the firm's internal funds; however, banks are also financially constrained and charge a premium on fixed rate debt to compensate them for assuming the interest rate risk of the loan. In equilibrium, borrowers with a low probability of being credit constrained in future periods will be unwilling to pay this premium and will choose a variable rate loan; borrowers who are very likely to be credit constrained will choose a fixed rate. Two other factors also affect the firm's choice: (i) the correlation between interest rates and other shocks to the firm's profitability, and (ii) the fact that shocks to interest rates affect not just the level of internal funds, but also the marginal cost of funds in future periods.

The model makes a number of clear predictions and thus provides a clear organizing framework for interpreting the empirical results in the second half of the chapter. It also develops some new results (i) by analysing risk management in an environment where both the 'buyer' and the 'seller' of risk management are financially constrained, and (ii) by explicitly examining how the 'demand for risk management' varies with the intensity of agency costs. For example, one might expect the critique of Kaplan and Zingales (1997) - who show that investment-cashflow sensitivities are not necessarily monotonic in internal funds or the degree of agency costs - might apply equally well here. I show however that their result applies with somewhat less force in this context (because the willingness to pay for risk management depends on expected future, not current, financial constraints).

1.3.1 Basic setup

There are two periods ($t = 0, 1$) and two types of risk neutral agents: firms and lenders. In the first period, firms invest in a riskless project of fixed size I_0, which produces return R_0. In the second period, firms invest in an variable-scale investment project: an investment of I produces return $f(I)$ if the project succeeds, where $f(.)$ is an increasing concave function. This second project succeeds with probability p_H, and if the project fails it yields a return of 0.

To help finance these projects, firms begin period t with internal funds of A_t[6]. Firms may also borrow additional funds from lenders at a gross risk free rate of $1 + r_t$. The ability of the firm to borrow funds externally at date 1 is however limited by a moral hazard problem. Namely, firms also have access to an alternative project which has a lower probability of success $p_L < p_H$, but produces a stream of private benefits proportional to the size of the project (BI). Lenders observe only whether the project succeeds or fails, not which project is chosen.

The timing of events is shown in Figure 1.1.[7] Firms begin with internal funds of A_0, and

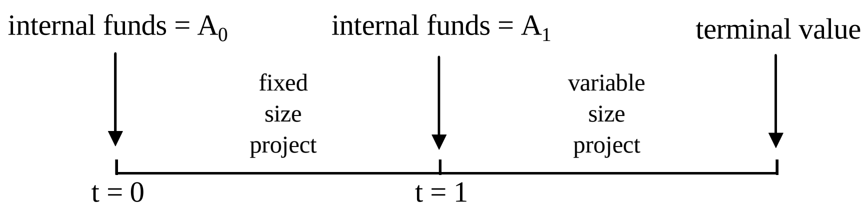

Figure 1-1: Timing

invest these plus any borrowed funds in the project at $t = 0$. At the end of period 0, the firm has internal funds of A_1 (equal to A_0 plus net profits from the project), which it uses to help fund the project at date 1. The firms' objective is to maximize the expected value of its funds at the end of period 1.

The assumptions about the period 0 project (that it is of fixed size and involves no moral hazard problem) are made for simplicity – the substantive conclusions are the same if we assume the period 0 project has the same structure as the period 1 project. The reason for including a second project is that, as I later show, fluctuations in the repayment at the end of period 0

[6] A_t will differ across firms. To save on notation, I suppress the firm i subscript on $A_t(i)$, $I_t(i)$ etc. unless otherwise necessary.

[7] For ease of expression, in the discussion that follows I often refer to the beginning of period i as 'date i'.

affects the value of the firm, because the level of internal funds at date 1 help to mitigate moral hazard problems.

1.3.2 Solving the firm's problem

At $t = 0$, the firm borrows $I_0 - A_0$ and invests I_0 in the riskless project. The firm's internal funds after repaying the lender at the end of period 0 will thus be $A_1 = R_0 - (1 + r_0)(I_0 - A_0)$. The firm's problem at date 1 is:

$$max\ V = f(I_1) - R_1^l \tag{1.1}$$

subject to:

$$p_H R_1^l \geq (1 + r_1)(I_1 - A_1) \quad [lender\ IR]$$

$$p_H V \geq p_L V + BI_1 \quad [firm\ IC]$$

The lender's individual rationality constraint requires the expected payment to the lender ($p_H R_1^l$) is not less than the funds lent to the firm ($I - A_1$), and always binds in equilibrium. The firm's incentive compatibility constraint requires the firm's expected return if it undertakes the high level of effort ($p_H V$) is greater than the sum of the expected return if it shirks ($p_L V$) plus the private benefits from shirking (BI_1). This implies the firm's payment must be at least $\frac{B}{p_H - p_L}$ per unit of investment.

If A_1 is low, the firm's IC constraint binds, and the solution to the program is given by:

$$\left[\frac{B}{p_H - p_L} + \frac{1 + r_1}{p_H}\right] I_1^* = f(I_1^*) + \frac{1 + r_1}{p_H} A_1 \tag{1.2}$$

By implicitly differentiating (1.2), it can be confirmed that $\frac{dI_1^*}{dA_1} > 0$: the higher the level of internal funds, the higher the repayment to the firm (and the smaller the repayment to the lender) for a given project size; this allows the firm to invest in a larger project without violating incentive compatibility. Also, $\frac{d^2 I_1^*}{dA_1^2} < 0$, investment is concave in internal funds as a consequence of the firm's concave production function. See Appendix A.1 for the details of these calculations.

If A_1 is large enough, the firm's IC constraint no longer binds. Assuming that the firm still requires some external finance, the project size is given by:

$$f'(I_1^{**}) = \frac{1 + r_1}{p_H} \tag{1.3}$$

The firm will never invest more, since expanding I_1 beyond I_1^{**} will be profit-reducing even if it is incentive-compatible.

Although the model so far is deterministic, it can be shown that the date 1 expected value of the firm is concave in the level of internal funds (ie. $V_{AA} < 0$ as well as $I_{AA} < 0$; see Appendix A.2 for the calculations). As in Froot, Scharfstein and Stein, this provides the basic motivation for risk management: a negative shock to cash flows has a larger effect on firm value (in absolute value terms) than a positive shock, because the marginal product of investment is higher when investment is low.

1.4 Banks and interest rate risk

I now take the framework from the previous section and introduce an explicit source of interest rate risk. That is, I assume that the interest rate in period 1 is a random variable $r_1 \sim \phi(r_1)$ realized at the end of period 0. I allow the firm's date 0 loan to be one of two types: a fixed rate loan with interest rate δ_f, and a variable rate loan where the interest rate is $\delta_v + r_1$.

1.4.1 Pricing

If lenders are competitive, risk neutral and financially unconstrained, fixed and variable rate loans will be priced so that the expected interest rate is the same on both, that is $\delta_v + \bar{r}_1 = \delta_f$ (where $\bar{r}_1$ is the expected value of r_1).

However, evidence from the literature on the 'bank lending channel' of monetary policy suggests that bank credit constraints are in fact sensitive to interest rates. Following a monetary contraction, various papers have shown that bank lending falls (Bernanke and Blinder 1992), firms substitute away from bank loans towards commercial paper (Kashyap, Stein and Wilcox, 1993), the lending of small banks declines more quickly than lending of large banks (Kashyap and Stein, 1995), and the lending of banks with smaller buffer stocks of government securities falls more quickly (Gibson 1996, Kashyap and Stein, 2000).

In Appendix B I augment the framework developed so far with a simple model of the bank lending channel, a stripped down version of Stein (1998). Banks are able to raise a limited amount of finance from depositors at a riskless rate of 0, but total lending is limited by bank equity. In such an environment, I show that banks are no longer indifferent between issuing fixed and variable rate loans: variable rate debt is more attractive because the repayment on the loan at the end of period 0 covaries positively with the shadow value of date 1 bank internal funds. Consequently, banks charge a premium on fixed rate debt to compensate them for the interest rate risk of the loan. In equilibrium, this premium is given by:

$$\delta_f - (\delta_v + \bar{r}_1) = \frac{\sigma^2}{1 + \bar{r}_1} \tag{1.4}$$

where $\bar{r}_1$ denotes the expected value of r_1, and σ^2 is the variance of r_1.

I now solve for the firm's choice between fixed and variable rate debt at the beginning of period 0. Although several factors affect the decision, one basic tradeoff is a fixed rate loan reduces the volatility of internal funds, but such insurance is costly because the seller of risk management (the bank) is also credit constrained. Whether the firm chooses to pay the fixed rate premium will thus depend in turn on the likelihood the firm is credit constrained in the future. The benefits of fixed rate debt will also be smaller if the firm's operating cashflows covary positively with interest rates.

1.4.2 Solving the firm's problem

Recall from the deterministic model that at date 1 the expected value of the firm ($p_H V$) is an increasing function of A_1 and a decreasing function of r: ie $V = V(A_1, r)$ where $V_{A_1} > 0$ and $V_r < 0$. The firm's problem at date 0 is to choose between fixed or variable rate debt to maximize the value of the firm:

$$\underset{type \in (f,v)}{max} \mathbf{E}_{r_1} V(A_1, r_1)$$

subject to:

$$A_1 = A_0 + R_0 - (1 + \delta_f)(I_0 - A_0) \qquad [lender\ IR : type = fixed]$$

$$A_1 = A_0 + R_0 - (1 + \delta_v + r_1)(I_0 - A_0) \quad [lender\ IR : type = variable]$$

Let $\bar{\mu}$ be the maximum premium the firm is willing to pay for a fixed rate loan. In other words, $\bar{\mu}$ is defined by:

$$\mathbf{E}_{r_1} V(\tilde{A}, r_1) = \mathbf{E}_{r_1} V(\bar{A} - \bar{\mu}, r_1) \tag{1.5}$$

where $\tilde{A}$ is the date 1 level of the firm's internal funds if it chooses variable rate debt (ie $\tilde{A} = R_0 - (1 + \delta_v + r_1)(I_0 - A_0)$), and $\bar{A}$ is the expected value of $\tilde{A}$.

An approximation of this premium can be obtained by taking a Taylor series expansion of both sides of equation (1.5). The maximum interest rate premium ($\bar{\mu}$ divided by the amount borrowed at date 0) the firm is willing to pay is given by:

$$\frac{\bar{\mu}}{I_0 - A_0} \approx \sigma^2 \left[-\frac{1}{2} \frac{V_{AA}}{V_A} (I_0 - A_0) + \frac{V_{rA}}{V_A} \right] \tag{1.6}$$

Whether the firm chooses fixed rate debt or variable rate debt depends on which of several regions the firm is in. This in turn is a function of the level of internal funds at the beginning of period 1 (A_1).

Region 1: Firm requires no external finance at $t = 1$. Since the project is financed entirely from internal funds, the firm's opportunity cost of funds is 0, rather than r_t, since any funds not invested in the project are deposited at the riskless rate of return of 0. There are two cases to consider.

- **Region 1A:** $p_H f'(I_1^*) = 1$**.** In this region, the firm has excess internal funds ($A_1 > I_1^*$), an additional unit of internal funds is simply invested at the riskless rate of return of zero. So $V_A = 1$, and consequently $V_{AA} = V_{rA} = 0$. From (1.5) it can be immediately seen that $\bar{\mu} = 0$. This is very intuitive, the firm is not affected at all by volatility in interest rates, since it always invests the same amount, and the cost of financing the project is independent of the realization of r_1. Since banks charge a premium on fixed rate debt, firms in this region always choose a variable rate loan.

- **Region 1B:** $1 + r_1 > p_H f'(I_1^*) > 1$. In this region, the firm invests only internal funds in the project ($A_1 = I_1^*$), but does not have enough funds to sustain $p_H f'(I_1^*) = 1$. In this region $V_{AA} < 0$ because an incremental unit of internal funds is used entirely to fund higher investment, unlike Region 1A. $V_{rA} = 0$, however, because the firm does not borrow from banks. To the extent that r_1 (which represents the financing wedge of banks) is relatively small on average, the width of region 1B will also be small.

Region 2: Firm requires external finance, IC constraint not binding ($p_H f(I_1^*) = 1 + r_1$)**.** Like region 1A investment is not sensitive to internal funds, so $V_{AA} = 0$. The firm's marginal cost of borrowing is r_1 (that is $V_A = r_1$), thus now V_{rA} is now equal to 1 rather than zero, and the per-unit fixed rate premium reduces to:

$$\frac{\bar{\mu}}{I_0 - A_0} = \frac{\sigma^2}{1 + \bar{r}_1} \tag{1.7}$$

This is exactly the fixed rate premium charged by lenders, leaving the firm indifferent between fixed and variable rate debt. For both firms and banks the shadow value of internal funds is r_1, so both parties prefer high internal funds when r_1 is high.

Region 3: Firm requires external finance, IC constraint binding ($p_H f'(I^*) > 1 + r_1$)**.** In this region, both $V_{AA} < 0$ and $V_{Ar} \neq 0$. $V_{AA} < 0$ because changes in internal funds affect the level of investment (volatility in A_1 reduces the value of the firm because the marginal product of investment is higher when A_1 and I_1 are low)

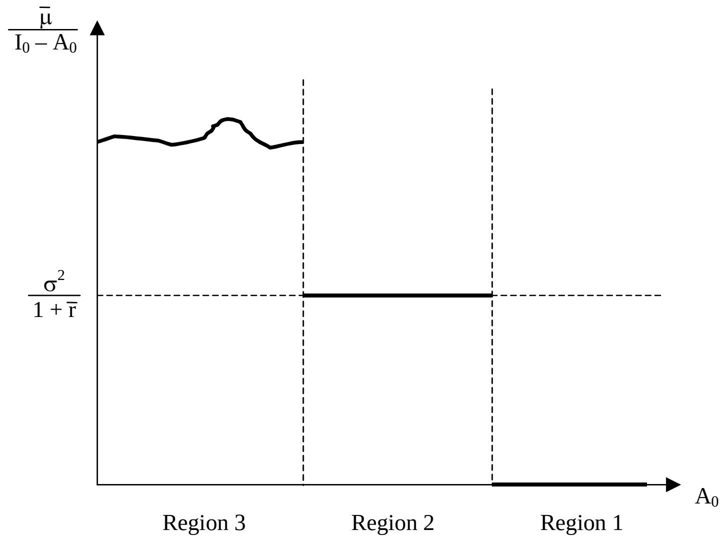

Figure 1-2: Demand for fixed rate debt

As shown in Appendix A.6, V_{rA} can be written as:

$$V_{rA} = k\left[p_H f_{II} I_A I_r + (1 - I_A)\right] \tag{1.8}$$

where $k = \frac{B}{B-(p_H-p_L)\left[f_I - \frac{1+r_1}{p_H}\right]}$. $k > 1$ since $f_I > \frac{1+r_1}{p_H}$.[8]

Although the first term in the square brackets $p_H f_{II} I_A I_r$ is always positive, the second term $1 - I_A$ is not necessarily; so V_{rA} may be positive or negative overall. However, as the size of the loan at date 0 $(I_0 - A_0)$ increases, the costs of volatility in A increase also, causing $\frac{\bar{\mu}}{I_0 - A_0}$ to become larger. This ensures that for a large enough date 0 loan, the willingness to pay for fixed rate debt is highest in Region 3. This result is summarized in Lemma 1.1 below.

Lemma 1.1: *In region 3, the fixed rate premium* $\frac{\bar{\mu}}{I_0 - A_0}$ *is monotonically increasing in the size of the loan at date 0* $(I_0 - A_0)$*.* $\frac{\bar{\mu}}{I_0 - A_0}$ *is independent of* $I_0 - A_0$ *in regions 1 and 2. Thus, the fixed rate premium is highest in region 3 as long as* $I_0 - A_0$ *is sufficiently large.*

Proof: Follows directly from Equation (1.6).■

The results of this section are summarized in Figure 1.2. (The figure is drawn assuming that $\bar{r}_1$ is close to 0, so that region $1B$ is arbitrarily small).

In general, as the amount of internal wealth increases relative to investment opportunities,

[8] Note that this expression nests the expression for V_{rA} in region 2. In region 2, $f_I = \frac{1+r_1}{p_H}$ (so $k = 1$) and $I_A = 0$. So the expression collapses to $V_{rA} = 1$.

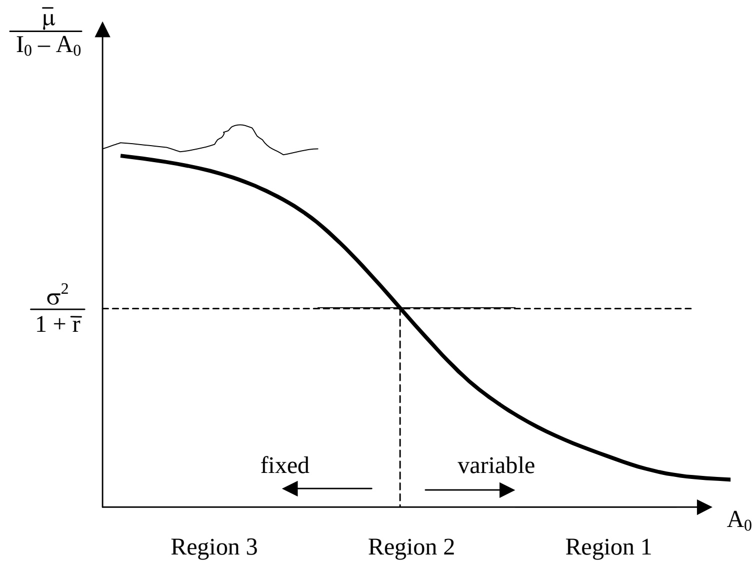

Figure 1-3: Demand for fixed rate debt with stochastic project scale

financial constraints ease and the demand for interest rate risk management declines. Firms able to finance the first-best level of investment (region 1) are not willing to pay any positive premium to avoid interest rate risk. Since interest rate risk is 'priced' at $\frac{\sigma^2}{1+\bar{r}_1}$, in equilibrium such firms will always choose variable rate debt. By contrast, firms in region 3 will always choose fixed rate debt as long as the size of the loan is large enough, as confirmed by Lemma 1.1. Firms in region 2 have the same 'demand for insurance' as financial institutions, and are thus indifferent between the two types of debt once the premium on fixed rate debt is taken into account.

Note that within region 3, the relationship between $\frac{\bar{\mu}}{I_0-A_0}$ and A is drawn as being non-monotonic. In general, there is no reason to necessarily think otherwise. For example, momentarily assume that V_{rA} does not vary with A (or that $I_0 - A_0$ is large enough so that V_{rA} is unimportant in determining the firm's demand for insurance). Then, how $\frac{\bar{\mu}}{I_0-A_0}$ varies with A is determined by the behavior of $-\frac{V_{AA}}{V_A}$ with respect to A, which in turn depends on assumptions about the shape of the firm's production function.[9] Kaplan and Zingales (1997) make a related point when they show in a simple Froot et al. style framework that investment-cashflow sensitivity is generally not monotonic in firms' internal wealth.

[9] The analog from a consumer problem is that a consumer's willingness to pay for insurance against a lottery of fixed size varies with wealth according to how their coefficient of absolute risk aversion varies with wealth.

1.4.3 Variable project scale

In a slightly more general setting, the willingness to pay for interest rate risk management will be downward sloping within regions as well. Consider an extension which captures the simple idea that firms are somewhat uncertain about their future investment opportunities. The model is the same except period 1 output is given by $\theta f(I)$, where θ is not known until the beginning of period 1; in period 0 the firm has a prior distribution over $\theta : \theta \sim g(\theta)$.

The effect of variable project scale is depicted in Figure 1.3. The basic point is that we must average over a range of different project sizes, which smooths out the willingness to pay. For example, when project size is deterministic, all firms in region 2 have the same demand for risk management. But when project size is uncertain, a firm who expects to be near the cusp of region 1 on average will have a lower willingness to pay for insurance, because there is a substantial probability the firm will be able to fund the entire project using internal funds.

Because of this averaging, the critique of Kaplan and Zingales (1997), who show that investment-cashflow sensitivities are not necessarily monotonic in internal funds or the degree of agency costs, applies with somewhat less force in this context. The difference between the two is that the demand for insurance against interest rate shocks depends on expected average future financial constraints, rather than current constraints.

Even in this setting, it is not necessarily true that demand for interest rate insurance is monotonically decreasing in internal wealth.[10] However, $\frac{\bar{\mu}}{I_0 - A_0}$ will always be downward sloping on average over a broad enough range of internal wealth A, and upward sloping on average over a broad enough range of B. This is stated more precisely in Proposition 1.1 below.

Proposition 1.1: *(a) For all A^* there is an $A^{**} > A^*$ such that $\frac{\bar{\mu}_A}{I_0 - A} < \frac{\bar{\mu}_{A^*}}{I_0 - A^*}$ for all $A > A^{**}$.*

(b) For $B = B^*$ there is $B^{**} < B^*$ such that $\frac{\bar{\mu}_{B^*}}{I_0 - A} > \frac{\bar{\mu}_B}{I_0 - A}$ for all $B < B^{**}$.

(c) Two special cases where $\frac{\bar{\mu}}{I_0 - A_0}$ is monotonically decreasing in A_0 (increasing in B) are:

(i) $\bar{r}_1 \approx 0$ and $P(region = 3) \approx 0$ or

(ii) $\bar{r}_1 \approx 0, -\frac{V_{AA}}{V_A}$ is non-increasing in A, and $I_0 - A_0$ is sufficiently large

Proof: See Appendix A.5. ■

The intuition behind these statements is very simple. The higher is A and the lower is B, the more likely the firm will be able to internally finance the period 1 project, in which case the firm is indifferent to interest rate risk. Thus, $\bar{\mu}$ can always be made arbitrarily small by choosing a high enough A or low enough B. The two special cases exploit the fact that the

[10] There are three reasons why. Firstly, depending on assumptions about $f(.)$, it is possible that $\frac{\bar{\mu}}{I_0 - A_0}$ is sometimes upward sloping within region 3. Secondly, unless $\bar{r}$ is close to zero, there will be a 'region 1b' in which the firm does not rely on external finance, but is still willing to pay a positive premium for fixed rate debt. Depending on assumptions this premium may be larger than the willingness to pay in regions 2 or 3. Thirdly, if the loan is small, it is possible that $\frac{\bar{\mu}}{I_0 - A_0}$ is smaller in region 3 than region 2.

benefit of risk management is higher in region 2 than region 3a, and always higher in region 1 than region 2 as long as $I_0 - A_0$ is sufficiently large.

1.4.4 Interest rates and firm cash flows

So far, interest rates has been assumed to be orthogonal to any of the firm's operating activities, but it is straightforward to relax this. Assume that the return on the period 0 project is not R_0, but $R_0 + \epsilon$ where ϵ is a random variable correlated with r_1. Empirically, nominal interest rates are procyclical in the United States (Stock and Watson, 1998), so it seems reasonable to assume $cov(\epsilon, r_1) > 0$.

By taking a Taylor series expansion as before, we can see how introducing this correlation between firm cash flows and interest rates affects the firm's 'demand for insurance' (the premium on fixed rate debt that makes the firm indifferent between fixed and variable rate loans):[11]

$$\frac{\bar{\mu}}{I_0 - A_0} \approx \sigma^2 \left[-\frac{1}{2} \frac{V_{AA}}{V_A} (I_0 - A_0 - 2cov(\epsilon, r_1)) + \frac{V_{rA}}{V_A} \right] \tag{1.9}$$

As equation (1.9) shows, the higher is $cov(\epsilon, r_1)$, the smaller is $\frac{\bar{\mu}}{I_0 - A_0}$, the interest rate premium the firm is willing to pay for insurance against interest rate risk. The intuition is very simple: when $cov(\epsilon, r) > 0$, times where repayments on a variable rate loan are high are also times where the firm is highly profitable: giving the firm a 'natural hedge' against interest rate shocks. Froot et al. (1993) show a similar result: firms attempt to co-ordinate their cash flows and investment opportunities (so that internal funds are high when investment opportunities are plentiful).

In empirical work discussed below, I test this prediction by estimating $cov(\epsilon, r_1)$ across 2-digit SIC industries, and testing whether firms in industries whose output varies procyclically with interest rates are less likely to choose fixed rate debt.

1.4.5 Final remarks

The prediction made here that bank credit constraints affect the pricing of fixed and variable rate loans relies heavily on the assumption that banks are not able to costlessly hedge interest rate risk. Although this might seem unrealistic given the large, liquid swap markets available for such purposes, the literature on the 'bank lending channel' of monetary policy discussed earlier, as well as the striking fact that less that 5 per cent of banks in the United States use

[11] The calculation is similar to before, see Appendix A.4 for details.

derivatives for hedging (Purnanandam 2003), suggests that that in practice banks are not fully insured against interest rate shocks.

Exactly why banks are underinsured is less clear. Transaction costs, imperfect risk measurement systems, concerns by banks regarding the potential misuse of derivatives, and the risk-shifting incentives provided by deposit insurance and are all possible reasons. Another possibility is that since hedging using swaps involves credit risk, such instruments are expensive because of adverse selection; however, the consensus in the literature is that such effects are not a quantitatively important determinant of swap spreads (Duffie and Huang, 1996).[12]

A final question – how robust is the basic result that firms benefit from structuring their loan contracts to reduce fluctuations in internal funds? After all, the risk-shifting result of Jensen and Meckling (1976) seems to suggest the opposite: ie. since equity-holders' claim on the firm is convex in the value of the firm, they will benefit from risky gambles at the expense of debtholders.

Two comments are relevant. Firstly, risk shifting is likely to be less important as a determinant of the structure of loans to small and medium-sized firms, because of the importance of lending relationships to small business finance. Why is this? Risk-shifting entails gambling at the expense of prior debt holders. But if the intermediary providing any new loans also holds a substantial portion of any existing debt, the risk-shifting externality will be largely or entirely internalized: the intermediary will take into account the effect of risk-shifting on the value of the lender's prior debt claims when pricing new loan contracts.

Secondly, risk-shifting, if important, should be most relevant in the region where net equity is close to zero: ie. for firms in or near financial distress. In empirical work discussed below, I use various measures of financial distress to test whether firms in this region are less likely to choose fixed rate debt (ie. that there is a U-shaped relationship between financial health and incentives to manage risk). I find little evidence of such behavior. (This is probably not surprising given the large personal costs that bankruptcy imposes on the owner of the firm.)

1.5 Data and empirical strategy

Do small and medium sized firms use the banking system to help manage interest rate risk, consistent with the costly-external-finance view of risk management developed above? To begin to answer this question, I use loan-level data drawn from the Federal Reserve Board Survey of Small Business Finance (SBF) to examine three of the model's empirical predictions:

[12] This is partially because of the high credit quality of market participants, and partially due to 'netting', credit triggers and other credit enhancement mechanisms used in the swaps market.

(i) Firms more likely to face future credit constraints ie. those with greater informational problems (high B), or less internal funds (low A) will be more likely to choose fixed rate debt. [Proposition 1.1].

(ii) Firms whose cashflows covary positively with interest rates will be less likely to choose fixed rate debt. [Equation 1.9].

(iii) Credit constrained financial institutions charge a premium on fixed rate loans relative to variable rate loans to compensate them for the interest rate risk of the loan. [Equation 1.6].

The SBF is a cross-sectional survey that contains detailed information on firm characteristics and financing behavior for a sample of US small and medium sized enterprises (defined as private non-financial firms with less than 500 employees at the end of the reference year).[13] Three surveys have been carried out to date, covering businesses in operation at the end of 1987, 1993 and 1998 respectively.

As well as firm, owner and balance sheet characteristics, the SBF provides information on each of the firm's loans, and very detailed information on the firm's most recent loan, including the size of the loan, interest rate paid, category of loan (eg. line of credit, business mortgage etc.), maturity, and what (if any) type of collateral was posted against the loan. Most importantly for the purposes of this chapter, the SBF also records whether the most recent loan was issued at a fixed or variable interest rate.

Table 1.1 provides information about the total number of firms in each survey, and the number who had applied for and/or been granted external debt finance. For the 1993 and 1998 surveys, firms were only asked about their most recent loan if they had filed a loan application in the past three years. Many firms had not applied for credit during that period, others had made loan applications but had always been denied credit. For the 1987 survey, firms provided information about their most recent loan regardless of which year that loan was granted. Across all surveys, information on the most recently granted loan is provided by 4673 of the total of 11422 firms. Of these, 484 of the firms from the 1987 survey either (i) did not not disclose the year of the loan, (ii) did not state whether the loan was fixed or floating, or (iii) had not taken out a loan since 1980. Excluding these 484 firms yielded a 'final' sample of 4189 firms.

Table 1.2 provides descriptive information about these 4189 firms. Since the SBF oversamples large firms and minority-owned firms within the target population, I present averages weighted using the sample weights provided in the SBF, as well as unweighted statistics for comparison. Approximately 70 per cent of the firms are S- or C-corporations. The firms have an average size of \$840 000 (\$2.4 million on an unweighted basis), with substantial variation

[13] For the 1987 survey, the relevant population is the universe of US firms with less than 500 *full time equivalent* employees. For the 1993 and 1998 survey the population is firms with less than 500 *full-time plus part-time* employees. Other things equal, this would tend to make firms in the 1993 and 1998 surveys smaller on average smaller than those in the 1987 survey.

across firms: the largest 1 per cent of firms have assets of $28 million or more, the smallest 1 per cent have assets of $3800 or less. Loans in the sample have an average maturity of around 4 years. Most importantly for my purposes, there is substantial variation in firms' choice between fixed and variable rate loans: 51 per cent of loans in the sample were drawn at a fixed rate (58 per cent weighting by the SBF sampling weights), the rest at a variable rate.

Table 1.3 presents a more detailed breakdown between fixed and variable rate loans, sorted by the category and source of the loan. There is substantial variation in the proportion of fixed rate loans across different loan types. Importantly though, there is also substantial variation *within* loan types; in other words most categories include substantial proportions of both fixed and variable rate debt. At the extremes, lines of credit are generally (71 per cent) granted at a variable rate, while vehicle mortgages are most likely (88 per cent) to be at a fixed rate. Bank loans are less likely to be issued at a fixed rate (44 per cent compared to 76 per cent for non-bank loans).

The most basic implication of the model is that firms' choices between fixed and variable rate debt are correlated with proxies for financial constraints (ie. high B and low A). Using a binary dependent variable equal to 1 if the firm's most recent loan was at a fixed rate, and 0 if the loan was at a variable rate, I estimate probit regressions of the form:

$$\begin{aligned} P(FIXED = 1) = \quad & \Phi(\text{agency costs, cash flows,} \\ & \text{investment opportunities,} \\ & \text{firm, loan and macroeconomic controls, } \varepsilon) \end{aligned}$$

I consider three main proxies for agency costs:

1. Size. Small firms are generally thought to face more severe financial constraints than large firms. This result is implied by the theoretical model presented earlier (small firms have less internal funds relative to investment opportunities, worsening moral hazard problems), but there are other reasons to believe it also. Small firms have less ability to access alternative sources of finance, such as public debt and equity markets. And within the class of bank-dependent firms there are substantial economies of scale, both in monitoring by financial intermediaries, and in firm activities that might reduce informational problems (such as the preparation of detailed financial accounts).[14] Consistent with these arguments, Gertler and Gilchrist (1994) argue that financial constraints explain why small manufacturing firms shrink more following monetary contractions, while Perez-Quiros and Timmerman (2000) show that small firms' stock returns are more sensitive to measures of credit market conditions. Also

[14] A simple probit regression using the SBF sample reveals that large firms are much more likely to regularly prepare sets of accounts, and use computer accounting software for financial recordkeeping.

consistent with this view, Petersen and Rajan (1994) using the SBF find that small firms pay a premium on loans from financial institutions.

2. Age. Over time, profitable firms accumulate capital and internal funds to finance investment. Unless the firm's investment opportunities increase proportionately, this implies older firms are likely to face less severe financial constraints than young firms. Hall (1987) and Evans (1987) show that older firms grow more slowly than young firms, consistent with the view that firms' investment opportunities do not increase as quickly as the firm's ability to finance them. Also, the actions of the firm over time can help to reveal private information and build a reputation (Diamond, 1991), and develop relationships with financial institutions (Sharpe 1990, Rajan 1992, Petersen and Rajan 1994).

3. Banking relationship variables. As well as the age of the firm, the SBF contains variables that directly measure the strength of the firm's banking relationships, namely the length of the relationship with current or primary lenders, and measures of lending concentration (how many banks or lenders the firm borrows from, or the proportion of finance from the firm's primary lender). Petersen and Rajan (1994) show that firms with long or concentrated banking relationships rely less on overdue trade credit, a costly alternative form of external finance, suggesting that relationships ameliorate financing problems.

In addition to this set of variables, conditional on future investment opportunities, firms with higher current cash flows will be able to borrow and invest more, and (by the argument made in the model) be less likely to face financial constraints in the future. Such firms will have a lower demand for risk management. Conversely, conditional on current cash flows, firms with greater future investment opportunities will have a greater demand for risk management.

I use current profitability scaled by assets as a measure of current cash flows, and sales growth as a proxy for investment opportunities. It should be noted that the interpretation of these variables is subject to some caveats. Sales growth, as a backward looking variable, is an imperfect measure of future investment opportunities. Moreover, current profitability may instead reflect future investment opportunities rather than being a useful proxy for current liquidity.

A summary of the main variables of interest and their predicted signs is provided below:

Measures of:	Predicted sign	Variables
Size	-	ln(assets), ln(sales)
Age	-	ln(1+age)
Banking relationships	-	ln(1+relationship length), no. of lenders
Cash flows	-	return on assets (net profit/assets)
Investment opportunities	+	sales growth

The probit regression also includes a number of firm, loan and macroeconomic controls. The set of firm controls includes regional dummies, survey dummies, 1-digit SIC industry dummies, firm leverage (total debt/total assets) and a dummy for whether the firm is incorporated.

The set of macroeconomic controls include the current prime interest rate, the spread between the yield on 10 year government bonds, a corporate bond yield spread (Baa yields minus Aaa yields).

The complete set of loan controls includes dummy variables for the type of lender (bank, non-bank financial institution and non-financial-institution), dummies for the type of loan (line of credit, business mortgage, vehicle loan etc.), dummies for the type of collateral required on the loan, the maturity of the loan, and the size of the loan (scaled by firm size).

It is in fact unclear whether including all the loan controls is the most appropriate empirical strategy. Many of these variables (such as maturity, or the size of the loan) are clearly endogenous. Furthermore, no obvious instruments are available: any variable that affects one characteristic of the loan is likely to influence all other characteristics as well. The argument for excluding the loan controls is that the best we can hope for is an estimate of the reduced form effect of agency cost variables on the decision to fix or float. Including loan characteristics (eg. maturity) biases these estimates on the agency cost variables towards zero, because the loan controls are determined by the same factors as the dependent variable.

Cognizant of this problem, I test the sensitivity of my results to the set of loan controls used. I begin with a 'baseline' specification that includes some loan controls for which the endogeneity problem outlined above is likely to be less important (eg. the type of loan: vehicle loan, operating lease, business mortgage etc.), but exclude others (maturity, size of the loan etc.). I then in turn estimate specifications that include all, then none, of the loan characteristics. Fortunately, as described below, the results are quite robust to the set of loan controls used.

1.5.1 Real interest rate volatility

My empirical strategy assumes a fixed rate loan reduces the interest rate sensitivity of the firm's real debt repayments. But is this assumption reasonable? Interest rates on commercial loans are almost never held fixed in real terms: the rate is either tied to an index like the prime interest rate, or set at a fixed nominal rate. Since inflation rates are volatile, a loan at a fixed nominal interest rate may not necessarily be associated with less volatile real interest payments.

To investigate this further, I estimate the variance of $(R_{t+k} - R_t)$ (where R_t denotes the real interest rate at time t) at different horizons, using historical US data from January 1960 until December 1999. This variance is a summary statistic of the extent to which the future real interest rate on a loan is likely to differ from its current rate. (For a loan whose interest rate is fixed in real terms, this variance would be zero.) I perform this exercise for loans linked to the bank prime rate, the Federal funds rate, and to a fixed nominal rate, over several different time horizons ($k = 1, 2, 3$ and 5 years).[15] Results are presented in Table 1.4.

As the table shows, over the past 40 years loans fixed in nominal terms have on average been associated with smaller fluctuations in real interest rates. Over the entire sample, the variance of the change in the real prime rate over a 1-year period is 3.34, for the Federal funds rate, 4.00. For a fixed nominal interest rate, this variance is only 1.70. The proportionate difference is more pronounced over the period since 1982 (after the Volcker disinflation); over this span, the 1-year variance is 0.49 for a fixed nominal rate, but 2.28 for the prime rate and 2.19 for the Federal funds rate. Results are similar at longer horizons.

Moreover, to the extent that nominal price and wage rigidities are important, this comparison is likely to understate the volatility benefits of fixed rate debt. If the firm's output and input prices are set in nominal terms, firms may actually be more concerned about the volatility of nominal, rather than real, interest rates, at least for shocks that last a few years or less. Of course, as previously discussed, some firms may prefer variable rate debt as a 'natural hedge' because their other cashflows also covary positively with interest rates – I find some empirical support for this hypothesis in the results presented below.

[15] ie. For the fixed rate, variability in the real interest rate in future periods is due entirely to changes in the inflation rate between t and $t + k$. For the prime rate and the federal funds rate, fluctuations in the real rate may be due to fluctuations in inflation or fluctuations in the nominal rate.

1.6 Results

1.6.1 Which firms choose fixed rate debt?

The basic probit results are presented in Table 1.5. Coefficients are normalized to show the marginal effect of a change in variable x on the probability of choosing fixed rate debt at the point of means of the data.

Results are presented for a baseline specification (Column 1) as well as a number of alternatives. Column 2 includes two ownership characteristics, whether the owner of the firm also manages the firm, and whether the firm is owned by a single family. Neither are statistically significant, a point discussed in more detail below. Following the above discussion, columns 3 and 4 test how sensitive the results are to the inclusion or exclusion of potentially endogenous loan controls: maturity, dummies for the type of collateral used to secure the loan, the size of the loan, category of loan (eg. line of credit, business mortgage, vehicle loan etc.), and two dummies for the source of the loan (whether the lender was a bank, and whether the lender was not a financial institution). Column 5 excludes loans granted before 1985. For the 1998 and 1993 SBF, firms were only asked about loans made in the previous three years; in 1987 firms were asked about their most recent loan regardless of which year it was granted. So Column 5 checks whether the results are driven by these 'stale' observations from the 1987 sample. Column 6 restricts the sample to incorporated firms. Since the model discussed earlier assumes limited liability (as do most models in corporate finance), it is important to test whether the results are robust to removing partnerships and sole traders from the sample. Column 7 excludes the control for the sales growth of the firm. Although sales growth is generally significant when included in the probit regression, several hundred firms did not report this information, so excluding it allows us to use a larger sample of firms.

Turning to the key agency cost variables, I find that small firms (measured by *log(assets)*) and young firms (measured by *log(1+age)*) are substantially more likely to choose fixed rate loans. My central estimates suggest that at the mean of the data, a doubling of firm size is associated with around a 6-7 percentage point decline in the probability of choosing fixed rate debt, while a doubling of firm age is associated with a decline of around 4 percentage points. The coefficient on firm size is significant at all conventional levels of size (p values < 0.0001), while the coefficient on firm age is generally significant at the 5 per cent level. These results lend prima facie support to the idea that firms who have more difficulty raising external finance are more likely to use fixed rate debt to insure against interest rate shocks.

I also find evidence that firms with lower current cashflows (measured by profits/assets), and higher investment and growth opportunities (measured by sales growth) are more likely to choose fixed rate debt. As discussed above, this too is consistent with costly external finance motivations for risk management, firms with greater growth opportunities are more likely to require future external finance, while firms with higher current cashflows are more easily able to finance operations through retained earnings. Two caveats are worth noting regarding the profits/assets coefficient, however. Firstly, an argument can be made that cash flows are really a proxy for investment opportunities (Tobin's q) rather than current liquidity, in which case one might expect the opposite sign on the profitability coefficient. Secondly, the results for return on assets in particular are somewhat less robust than for firm age and size; although always correctly signed and generally significant, this variable not is significant in every specification. The critique mentioned above is one possible reason for this, data quality is another. Because many of the firms in the SBF do not produce regular accounting statements except for tax purposes, the quality of accounting information may be somewhat lower than for publicly traded firms.

Table 1.5 also presents results for three banking relationship variables. 'Number of lenders' measures the breadth of banking relationships (the presumption being that firms who deal with fewer lenders develop stronger relationships, lowering agency costs). The coefficient is never statistically significant. Two variables measure the length of relationships: the length of time the firm has dealt with its primary financial institution, and the length of time the firm dealt with the particular lender who provided the most recent loan. Coefficients on these two variables have opposite signs. The coefficient on 'time with most recent lender' is negative, consistent with a costly external finance view of risk management: firms with short lending relationships face more obstacles obtaining external finance, and thus have a greater incentive to manage internal funds. However, the coefficient is generally not statistically significant, except in Column 4 (1 per cent level) and Column 3 (10 per cent level). Moreover, the coefficient on 'years with primary lender' is positive, not negative as predicted, and always statistically significant.

What explains these results on the 'length of relationship' variables? One possibility is that the results reflect switching between lenders. Given the specificity in banking relationships, the decision to switch to an alternative intermediary after many years with a primary bank may be a signal of financial difficulties. To test this possibility, I split the 'years with primary lender' variable in two by interacting it with a dummy variable equal to 1 if the primary lender provided the most recent loan. Re-estimating the model in Column 1 including these two interacted variables, I find:

	coefficient	s.e.
log(1+years with current lender)	0.033	0.024
log(1+years with primary lender) $\mid$ *primary = current*	-0.008	0.024
log(1+years with primary lender) $\mid$ *primary* $\neq$ *current*	0.053	0.017***

The results appear consistent with this 'switching' hypothesis. The significant positive coefficient on '*years with primary lender*' is entirely driven by firms who have switched from their primary lender to an alternative lender in obtaining finance for the most recent loan. For firms whose primary lender is also their most recent lender, the coefficient is negative although not statistically significant.

A second possibility is that these results reflect the interaction of two confounding effects, firstly that banking relationships reduce agency costs, but second that relationships involve an implicit insurance contract between the bank and the firm. It is well-known that banks smooth firms' cost of funds over the interest rate cycle (eg. Berger and Udell, 1992); perhaps one aspect of this interest rate insurance is the provision of fixed rate loans on favorable terms.

A third possible explanation is that, although measures of lending relationships are often found to be correlated with access to finance, research has not yet fully explained why some firms choose to change their primary lender or to use multiple financial institutions while others do not. Thus, the relationship between relationship length and fixed rate debt may reflect omitted firm characteristics. For example, firms who choose to never to change their primary lender may be more conservative or risk averse, and in turn also more likely to choose fixed rate debt.

To conserve space, individual coefficient estimates for a number of the firm, ownership, loan and macroeconomic controls are omitted from Table 1.5; however they are presented instead in Table 1.14. Most notably, leverage (total debt / total assets) is associated with a lower probability of choosing fixed rate debt. When the size of the loan is controlled for (Column 3 of Table 1.14) the coefficient on leverage becomes insignificantly different from zero, but the coefficient on (loan size / assets) is negative. That is, larger loans are more likely to be at a variable rate, while smaller loans are more likely to be at a fixed rate. The expected sign of this coefficient is unclear, firms may take out larger loans either because they are a better credit risk and thus are able to obtain finance more easily, or because they are less able to finance operations and growth using internal finance. The results in the second part of Table 1.14 show that larger loans are associated with lower interest rates, providing some evidence consistent with the first of these two explanations.

1.6.2 Operating cashflows and interest rates

A second implication of the model is that firms should take into account the correlation of interest rate shocks with other cashflows when choosing between fixed and variable rate loans. If states of nature where repayments on a variable rate loan are high are also times where the firm is highly profitable and has a lot of internal funds: (ie. $cov(\epsilon, r) > 0$ in terms of equation (1.9)) the firm has a natural hedge against interest rate shocks,and will prefer variable rate debt.

As part of this project, I interviewed a number of bank business lending managers in the Washington DC and Boston MA metro areas (the interviews are described in more detail in Appendix C). This 'natural hedge' view of variable rate debt is explained succinctly in the following quote from one of the managers I surveyed:

A variable rate loan tends to follow the overall economy. During good economic times interest rates have a tendency to rise, most businesses will have increased revenues and can afford increased debt service. During economic downturns interest rates tend to decrease, most businesses need a lower debt service payment to compensate for lack of revenues at this time. Because the debt service on a fixed rate loan does not change it would cause undo (sic) *stress on the firm during a depressed economic cycle.*

– Survey respondent #4 (Washington DC business banking manager, midsize bank)

A two-step procedure is undertaken to test this idea. Firstly, I collect 2 digit SIC industry data for the period 1960-2000, and regress the output share of 2-digit industry i on a constant, a time trend, and the 12-month nominal riskless interest rate (contemporaneous and lagged one period):[16]

$$\ln(\frac{y_{it}}{y_t}) = \alpha_{i,0} + \alpha_{i,1}t + \sum_{k=0,1}\beta_{i,k}r_{t-k} + \varepsilon_{it} \tag{1.10}$$

This regression is used to produce estimates of how correlated industry cash flows are with interest rates. That is, $\Sigma\beta_i$ is the empirical counterpart to $cov(\epsilon, r)$.

In the second stage, I replace the SIC dummies from the basic 'fixed vs variable' probit regression with the estimate $\Sigma\hat{\beta}_i$. Evidence that the coefficient on $\Sigma\hat{\beta}_i$ is negative would be consistent with the 'natural hedge' view outlined above.

The first stage estimates of $\hat{\beta}_{ik}$ are quite precise: of 48 2-digit industries for which industry output data is available and for which there is at least one 'most recent loan' observation in the SBF, the $\hat{\beta}_{ik}$'s are jointly significant at the 5 per cent level in 36 cases, and jointly significant at the 1 per cent level in 26 cases. The five largest and five smallest betas from the first stage

[16] I also tried using $ln(y_{it})$ rather than the log output share as the dependent variable in this first stage estimation of the $\beta's$. The second stage results are almost identical.

interest rate sensitivity regression are presented below. Industries with negative βs include non-deposit financial institutions (whose profits are directly affected by high interest rates), and several industries whose output is not strongly procyclical (such as motion pictures). The high βs for coal mining and oil and gas extraction reflects the high interest rates during the energy crisis of the late 1970s and early 1980s.

SIC code	Industry	$\mathbf{\Sigma}\hat{\boldsymbol{\beta}}_{ik}$
61	Non-depositary financial institutions	-0.122
62	Security and commodity brokers	-0.046
41	Local and interurban passenger transit	-0.041
72	Personal services	-0.031
78	Motion pictures	-0.028

SIC code	Industry	$\mathbf{\Sigma}\hat{\boldsymbol{\beta}}_{ik}$
35	Industrial machinery and equipment	0.027
12	Instruments and related products	0.038
67	Holding and other investment offices	0.110
12	Coal mining	0.114
13	Oil and gas extraction	0.120

Results from the second stage probit regression are presented in Table 1.6. The coefficient on *industry interest rate sensitivity* (ie. $\mathbf{\Sigma}\hat{\boldsymbol{\beta}}_{ik}$) is negative as predicted and significant at either the 5 per cent or 10 per cent level. In other words firms in industries where $cov(\epsilon, r) > 0$ do in fact hedge less aggressively against interest rate shocks. The magnitude of the effect can be interpreted as follows: a firm whose share of output increases by 1 per cent when interest rates increase by 1 percentage point (ie $\Sigma\hat{\beta}_i = 0.01$) is around 1.5 percentage points less likely to choose fixed rate debt, compared to a firm whose share of output is independent of interest rate shocks.

Moreover, this point estimate is likely an underestimate of the true coefficient. To the extent that the estimated $\hat{\beta}_i$ are a noisy measure of the correlation between firm operating cash flows and interest rates, the coefficient on *industry interest rate sensitivity* is likely to be substantially attenuated.

A potential criticism of these results: one could argue that correlations between output and interest rates actually highlight differences in investment opportunities, rather than differences in cash flows. Under this view, industries whose output varies procyclically with interest rates actually have particularly high investment oppportunities when interest rates are high, and thus actually need more cash during these times (not less). In which case, the predicted sign of the second-stage coefficient on *industry interest rate sensitivity* is positive, not negative.[17]

Although it is difficult to rule this possibility out entirely, various pieces of evidence argue against it. For example, Almeida, Campello and Weisbach (2003) show that the 'cash flow sensitivity of cash' (a measure of the degree of financial constraints) of constrained firms increases markedly when output is low, and falls when output is high. Eisfeldt and Rampini (2003) present evidence that the liquidity of capital is procyclical. And firms in the SBF dataset were less likely to cite financial constraints as being a concern in the 1998 survey (when growth was especially high) than in the previous two surveys. All this suggests that financial constraints (which reflect the availability of finance relative to investment opportunities) are more binding during times when output is low.

1.6.3 Interest rates on fixed and variable rate loans

The theoretical part of this chapter highlights the fact that if bank credit constraints become tighter following increases in interest rates (as the literature on the bank lending channel suggests is true in practice), then lenders should optimally charge a premium on fixed rate debt after controlling for firm and loan characteristics as well as the state of the yield curve.

In future work, I plan to test this implication of the model directly, using data from Bank Call Reports and the Federal Reserve Board's Survey of the Terms of Business Lending. In particular, I plan to test the hypothesis that cross-sectionally, those banks which research on the bank lending channel has shown are more sensitive to interest rate shocks (ie. small banks and banks with smaller buffer stocks of government securities) should price fixed rate debt more conservatively.

Here I present some preliminary evidence from the SBF on the interest rates charged on fixed and variable rate loans. Amongst the loan characteristics in the SBF is the initial interest rate paid on the loan; I use this to test whether fixed rate debt is relatively expensive, controlling for borrower characteristics and the state of the yield curve.

The set of borrower controls is essentially the same as for previous regressions. I include both the Federal funds rate and the prime interest rate as controls for the bank's cost of funds. Also, to reflect the fact that fixed and variable rate loans are priced off different parts of the yield curve, I construct a variable that reflects the term spread over the repricing interval of

[17] A simple way to incorporate this idea into the model would be to change the production function at date 1 to $\theta f(I)$, where θ is stochastic and has the property that $cov(\theta, r) > 0$. In this case, even if $cov(\epsilon, r) > 0$, the firm will still be willing to pay a high premium to avoid interest rate risk if $cov(\theta, r) >> cov(\epsilon, r)$.

the loan. For a variable rate loan, I assume the loan is repriced continuously, so this variable is simply equal to zero. For a fixed rate loan, the repricing interval is the maturity of the loan (so the variable is set equal to the Treasury yield over the loan maturity minus the federal funds rate). Finally, I include a dummy variable equal to one if the loan was taken out at a fixed interest rate. If fixed and variable rate loans are priced symmetrically, then the coefficient on the fixed rate dummy variable will be equal to zero.

Results for this regression are presented in Table 1.7. As the table shows, the fixed rate dummy variable is significant and positive in all the specifications. The point estimates suggest a fixed rate loan is associated with a premium of between 35-50 basis points over an equivalent maturity variable-rate loan, after controlling for the shape of the yield curve.

Looking at the rest of the results, I find that large firms pay lower interest rates, consistent with the idea that firm size is a reasonable proxy for agency costs. Young firms also on average pay a higher rate, although this is not statistically significant except in column (3). Petersen and Rajan (1994) estimate a similar regression to this one using the 1987 SBF only. Although they do not use the SBF survey weights, Petersen and Rajan find similar results (they also find a premium on fixed rate debt of around 40 basis points).

How does this estimated premium of 35-50 basis points compare quantitatively to the calibrated predictions of the model? The predicted premium is $\frac{\sigma^2}{1+\bar{r}}$, where σ^2 represents the variance of the holding period return on a variable rate loan conditional on current interest rates. As a proxy of this, I calculate the variance of $(ff_{t,t+36} - 3\ year_t)$ where $ff_{t,t+36}$ is the 36-month cumulative federal funds rate, and $3\ year_t$ is the cumulative return on holding a 3 year treasury bond over the same 36 month period. I calculate this variance over the post-Volcker period as well as a longer time span (since 1960). These variances are 40 basis points and 57 basis points. $1+\bar{r} \approx 1.06^3$ over both these periods, so the two estimates of $\frac{\sigma^2}{1+\bar{r}}$ expressed on an annual basis are $\frac{1}{3}\frac{39.6}{1.06^3} = 11$ basis points and $\frac{1}{3}\frac{56.8}{1.06^3}$ =16 basis points respectively.

Although these estimates are lower than my empirical estimates, one factor which would tend to decrease the premium generated by the model is my simplifying assumption that the bank is not able to raise non-deposit finance between periods. In my model, when banks are credit constrained a one-unit increase in bank equity causes a 1 unit increase in lending next period. But in a model like Holmstrom and Tirole (1997) or Stein (1998), when banks are credit constrained a one-unit increase in bank equity causes a greater-than-1-unit increase in lending, because the additional equity provides pledgeable internal wealth that can be used to raise further external finance. In practice the debt/equity ratios of financial instititions are high (around 10), so this multiplier effect could be quite large. (σ^2 really represents the variance in the shadow value of bank internal wealth, which is might be lower or higher than the variance of interest rates themselves, depending on assumptions).

Another possibility is that the SBF estimates are too high because of selection bias. Firms choose endogenously whether to take a fixed or variable rate loan. If this choice is correlated with unobserved firm characteristics that also affect the interest rate on the loan (as is almost certainly the case) the coefficient on the fixed rate debt dummy variable will be biased. Unfortunately, there is no obvious instrument available: theory suggests that any variable that affects the fixed vs variable decision is also likely to affect the interest rate on the loan.

Subject to this important caveat, results from the SBF provide some tentative evidence that, at least in this sample, fixed rate debt is relatively expensive compared to variable rate debt. This finding is also consistent with several responses by business lenders I interviewed, responding to the question "What are the disadvantages of a fixed rate loan relative to a variable rate loan?":[18]

'Fixed rate loans are more expensive. As a Bank we are taking greater risk with a fixed rate loan; therefore, cannot offer as desirable terms for a fixed rate as we can for a variable rate loan'

– Interviewee #5

'Depending on the term of the loan and the general interest rate environment, variable rate loans are much cheaper than fixed rate loans'

'Fewer banks will be willing to do a fixed rate loan versus variable'

– Interviewee #6

'*Interest rates on variable rate loans are lower initially, and probably over the life of the loan (I do not expect interest rates to spike)'*

– Interviewee #2

Also, interviewee #2 also described how his bank made an explicit effort to 'push' clients towards choosing variable rate loans as a method of reducing his bank's exposure to interest rates. Of the other three respondents, interviewee #1 suggested variable rate loans would often be cheaper depending on the interest rate environment, while interviewees #3 and #4 did not report that the interest rates on fixed rate loans were systematically higher than on variable rate loans. None of the survey respondents claimed that fixed rate debt was cheaper on average than variable rate debt.

1.6.4 Robustness checks

Tables 1.8, 1.9 and 1.10 present various alternative specifications to test the robustness of the results in Table 1.5. Columns 1 and 2 of Table 1.8 test for the significance of a number of

[18] These interviews are discussed in more detail in Section 1.7.

additional ownership variables: the age, years of business experience, and ownership share of the principal owner, a dummy for whether the owner of the firm also manages the firm, and a dummy for whether the firm is owned by a single family (these last two were also included in the specification in Table 1.5 column 2). The first three of these ownership variables were only collected in the 1993 and 1998 SBF surveys, and were not reported by all firms, so we are left with a smaller sample than before, between 2000 and 2400 observations depending on the specification.

As the F-test displayed in Table 1.8 shows, this set of ownership variables has little explanatory power in explaining the choice between fixed and variable rate debt. I am never able to reject the null hypothesis that the coefficients on these five variables are jointly equal to zero. None of the individual coefficients are significant either, with the exception of the coefficient on 'principal owner also manages firm', which is significant in Column 2, but not in Column 1.

Given that most of the firms in the SBF are small and closely held, this lack of explanatory power is perhaps surprising. It is possible though, that ownership preferences and characteristics are important, but along dimensions that are not very correlated with the the ownership variables measured in the SBF. A more powerful test would test for the significance of ownership fixed effects using a panel data set (this approach is not possible with the SBF data, which consists of a series of cross-sectional surveys). Bertrand and Schoar (2002) using this approach find that CEO fixed effects are statistically significant in explaining financing decisions by publicly traded firms.

The next part of Table 1.8 (Columns 3-5) restricts the sample to bank loans only. As mentioned earlier, bank loans are less likely to be at a fixed rate than non-bank loans. But the relationship between the fixed-variable choice and firm characteristics is similar to before. The standard errors are somewhat larger, because of the smaller sample size.

Column 7 includes two additional variables, where the size and age of the firm are interacted with the maturity of the loan. One might argue that the determinants of the choice between fixed and variable rate loans should be particularly good predictors for longer maturity loans, where the difference between fixed and variable loan contracts is more important. Neither of these interaction terms is statistically significant. Finally, the last column of Table 1.8 uses an alternative measure of firm size (log sales instead of log assets). The results are essentially identical to before – the coefficient on log sales is -0.062 and significant at the 1 per cent level.

Table 1.9 presents model estimates after breaking down the sample by survey year. There are some fairly substantial differences in the coefficient point estimates across surveys. Some, but not all of these differences can be explained by sampling error.[19] One striking feature of

[19] To test whether the differences across surveys are due to sampling error, I estimate the model across all years, interacting the main variables of interest (log firm age, log assets, sales growth, return on assets and the

the table is that the point estimates and statistical significance of the key agency cost variables is substantially less in the 1998 SBF than in the previous two surveys. For example, point estimates on firm age, firm size, return on assets and sales growth are all smaller in magnitude in 1998 than 1993.

What explains these differences? A speculative but plausible reason is that financial constraints were much less binding in 1998 than earlier surveys (1993 in particular). Firms in 1998 were in general highly profitable, and did not rank access to finance as an important problem.[20] Interest rate and inflation volatility was low, reducing the probability that an interest rate shock could severely affect a firm's balance sheet. Because of these factors, the consequences of sub-optimally choosing variable rather than fixed (or vice versa) were relatively small. Conversely, most loans in the 1993 sample were taken out during the early-90s recession, a recession also associated with a shortage of bank credit (Bernanke and Lown, 1991), which might help explain why the point estimates drawn from this survey are larger and more significant.

Finally, Table 1.10 divides the sample by type of loan, presenting separate estimates for lines of credit and non-lines of credit. There are reasons to believe the results might look quite different between the two subsamples. Unlike the other types of loan, the interest rate risk of a variable rate line of credit is 'contingent' in the sense that the firm faces risk only to the extent that it subsequently draws down the credit line in the future. Furthermore, most lines of credit are variable rate (71 per cent), while a majority of other loans are fixed.[21] Examining Table 1.10, the results for lines of credit do look somewhat different than for other loans. The coefficient on firm size is somewhat larger, on firm age and ROA somewhat smaller (and no longer statistically different from zero). However, I am unable to reject that the null that these

banking relationship variables) with survey dummies. I then test for equality across the coefficients on each set of survey-interaction variables. I reject the null of equality at the 10 per cent level for two of the four: log firm age (p = 0.088) and sales growth (p = 0.059).

[20] The most important problem cited by firms in the 1998 survey was a shortage of labor! Reliance on internal finance is also reflected in the small proportion of firms from the 1998 survey who had taken out a recent loan (only 19 per cent of the 'most recent loan' observations come from the 1998 SBF). The strong economy at the time seems like a plausible explanation for this: firms in 1998 were much more profitable (median ROA of 26.6 per cent compared to 14.2 per cent in 1993) and thus more able to fund operations and investment from retained earnings. [The low number of 1998 loan observations also reflects a change in survey design; unlike the previous two surveys data on the most recent loan was not collected in 1998 for firms whose only new loan was the renewal of a pre-existing line of credit. But this is only a partial explanation, since there was a decline in the numbers of all types of loans, not just lines of credit.]

[21] That lines of credit are generally variable-rate is a direct consequence of the fact that the amount drawn down on the line is at the discretion of the firm. The main problem with a fixed rate line is that a subsequent change in market rates will affect the wedge between market rates and the cost of funds on the credit line. If rates fall substantially, the credit line becomes very expensive. If rates rise, the firm can potentially exploit an arbitrage opportunity by aggressively drawing on the line of credit and investing the proceeds at the new higher market rate. These scenarios are possible only because, unlike the other types of loan in my sample, credit lines give the firm discretion *ex post* to vary the actual amount borrowed contingent on how interest rates evolve. I thank Allen Berger for bringing these issues to my attention.

differences in coefficient point estimates are due to sampling error.[22]

1.6.5 Risk aversion

All the regression results presented so far suggest that small firms are substantially more likely to choose fixed rate debt. I have interpreted this result as evidence that firms are hedging in response to credit constraints: small firms have less access to capital markets and face more severe informational problems, and thus have a greater incentive to smooth fluctuations in internal funds.

But there is another plausible explanation, rooted in the risk aversion of the owner rather than in corporate finance. If the firm is closely held (as most of the firms in the SBF are) and risk aversion is declining in wealth or the owners' consumption behaves according to a buffer-stock style model, the premium that the owner will be willing to pay for insurance against interest rate shocks will also be declining in wealth. If large firms have wealthier owners, this mechanism could generate a negative correlation between firm size and the probability of choosing fixed rate debt.

I am able to most directly test this hypothesis using data from the 1998 survey, which includes a direct measure of the wealth of the firm's primary owner.[23] If the fixed rate vs variable rate choice is driven by risk aversion and both firm size and owner wealth are included as explanatory variables, only the second of these should be statistically significant.

I employ three different specifications; in each case I present estimates from a regression that excludes the owner wealth variable, then an otherwise identical specification in which the natural logarithm of owner wealth is included as a regressor. A comparison of the two sets of results shows directly how controlling for wealth affects the coefficient on log assets.

Results from this exercise are shown in Table 1.11. Inferences are somewhat less precise than for the entire sample because of the small number of observations in the 1998 survey relative to 1993 and 1987. However, the results show the finding that small firms choose fixed rate loans is quite robust to controlling for owner wealth. In each case, the coefficient on log assets in each case is around 25-30 per cent smaller, but still correctly signed, and still statistically significant at either the 5 per cent or 10 per cent level.

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[22] Using the same strategy as for Table 8, I estimate a model which uses all the data but includes an additional set of variables generated by interacting each of the main variables of interest (log firm age, log assets, sales growth, return on assets and the banking relationship variables) with a dummy for line of credit. None of these variables were significant at the 10 per cent level.

[23] The survey asks the owner about her total wealth outside of her stake in the firm. This consists partially of home equity, and partially non-home wealth. My measure of total owner wealth is the sum of these two non-firm wealth variables plus the owner's stake in the firm (ie. the net equity of the firm multiplied by the proportion of equity owned by the firm's primary owner).

Notably, the coefficient on log wealth *is* negative as predicted, and statistically significant at the 5 per cent level in two of the three specifications. This suggests that firm risk management behavior for this class of firms *is* in part determined by the risk preferences of the firm's owner. Moreover, the magnitude of the elasticities is quite similar, around 0.03. Given the small number of observations for 1998, these conclusions are somewhat tentative, it would be interesting to re-estimate these specifications once the fourth wave of SBF data is available.

1.6.6 Market timing

Several recent papers have found evidence of 'market timing' in corporate finance decisions. For example, Baker and Wurgler (2002) show that listed firms are more likely to issue equity when market values are high relative to book values or past market values, and that this has a persistent effect on firms' capital structures. Baker, Greenwood and Wurgler (2003) show that for publicly traded firms, the maturity of new debt issues is systematically related to factors that also predict excess bond returns. Finally, Faulkender (2003) finds that the final interest rate exposure of a sample of corporate debt issuances is strongly affected by the shape of the yield curve – firms are more likely to choose variable rate debt (or swap fixed rate debt) when the yield curve is upward sloping (and thus current interest rates are low relative to expected future rates).

I use two different variables to test for market timing effects. Firstly, in virtually all the regressions presented so far I have included a measure of the yield curve spread (10 year - 1 year) amongst the macroeconomic controls. As an alternative variable, I replace the 10/1 year yield spread with variable measuring the yield spread over the life of the loan. The advantage of this second variable is that, conditional on the maturity of the loan, it captures the exact interest rate timing decision faced by the firm (since the fixed interest rate will reflect the expected interest rate over the life of the loan, while the corresponding variable rate will reflect instead the current Federal funds rate or prime rate). The disadvantage of the second measure is that the loan maturity (which is endogenous) is required to construct it.

Results using both variables are presented in Table 1.12. Columns 1-3 use the 10/1 year yield spread variable. Column 1 exactly reproduces Column 1 from the basic table of regression results, Table 1.5. Here, the 10/1 year yield spread is negatively signed but not statistically significant. Although this suggests market timing effects are not present, this specification also includes survey dummies, which removes much of the time-series variation in the 10/1 year yield spread. Column 2 replicates Column 1 except the survey fixed effects are dropped. In this specification, the coefficient on the 10/1 year yield spread is negative and significant at the 10 per cent level. Column 3 includes additional loan controls, when these are added the coefficient becomes significant at the 5 per cent level. Columns 4 and 5 take the specifications from Column 2 and 3 but replace the 10/1 year yield spread with the yield spread measured over the maturity of the loan in question. This 'loan yield spread' variable is negative in both cases; in Column 4 it is significant at the 10 per cent level, while in Column 5 it is not statistically significant.

These results provide some weak evidence for market timing as measured in Faulkender (2003). As an aside, although evidence of debt market timing can be interpreted as firms attempting to exploit market inefficiency (Baker, Greenwood and Wurgler 2003) or as evidence of myopic behavior, there is also a possible rational explanation; namely, if the firm is currently very short of cash, it may make sense for the firm to 'backload' interest payments on its debts, so that payments are low immediately, but then higher in the future when the firm has more disposable funds. In other words, it might make sense for such a firm to choose whichever of fixed or variable rate debt minimizes current interest payments. To test this possibility, I took the specification from column 3 and interacted the 10/1 yield spread with the size of the firm (the prediction being that small firms should benefit more from shifting cash across periods in this way). The coefficient on this interaction term is positive as predicted, although not statistically significant.

1.6.7 Risk shifting

As mentioned at the end of Section 1.4, not all theories of corporate finance suggest that firms should optimally choose to reduce cashflow volatility. In particular, since equity represents a call option on the value of the firm, for firms nearing financial distress equity-holders may benefit (at the expense of debt-holders) from undertaking risky gambles.

As explained, such risk-shifting may be substantially internalized in this context, precisely because the provider of the potential 'gamble' will often also be one of the existing debtholders. But to test empirically whether such effects are important, I identified several potential proxies for financial distress: the square of any percentage decline in sales from the previous year, the square of firm losses, and the square of the percentage of trade credit paid late. The last two of these were not statistically significant. The first, (the squared percentage decline in sales) was negatively signed, and statistically significant in some of the specifications. This is perhaps consistent with a 'risk-shifting' prediction, although it is also consistent with the interpretation that, conditional on current profits, firms with low sales growth have less investment opportunities, and thus less need for external finance.

1.6.8 Out of sample evidence

A potential criticism of the results presented here is that the SBF contains insufficient cross sectional variation: all the firms in the sample are in some sense 'small' since even the largest have only 500 employees. Consequently firm size differences are perhaps not large enough to provide a meaningful proxy for differences in financial constraints.

The exclusive focus on small and medium sized firms in the SBF is in one sense an advantage; since these firms are overwhelmingly reliant on private sources of funding, we do not need to consider the 'fixed or variable' decision jointly with the firm's decision to borrow from banks or directly from capital markets (or the decision whether or not to use derivatives). It is, however useful to conduct out-of-sample comparisons: how does the proportion of fixed and variable rate debt in the SBF compare to the proportion of fixed rate debt for much larger firms?

One such source of evidence is Booth and Chua (1995), who examine a sample of large bank loans from Loan Pricing Corporation's Dealscan database. The loans are much larger than those in the SBF with a mean loan size of \$184m, and median loan size of \$36m. Booth and Chua report that well over 90 per cent of the loans in their sample involve a variable interest rate (most commonly linked to the prime rate or Federal funds rate). Hubbard, Kuttner and Palia (2002) also collect a sample of Dealscan loans; 97 per cent of the loans in their sample are variable rate. Finally, 90 per cent of the large bank loans in the sample of Faulkender (2003) were originally issued at a variable rate (a further 19 per cent were subsequently swapped to a fixed rate using interest rate derivatives).

By comparison, less than half of the loans in the SBF sample were issued at a fixed rate. The comparison is even more stark if we exclude lines of credit (which are generally floating) from the SBF average.[24]

These comparisons provide some external validation for the regression results presented above. Firms in the SBF sample, taken as a whole, are both smaller and more likely to choose fixed rate debt than comparison samples of much larger firms. This is consistent with my in-sample results that larger SBF firms are less likely to choose fixed rate loans. Also, although Booth and Chua do not specifically regress firm size or loan size on the propensity to fix, they do report (by different size classes) the proportion of loans that fall into an 'Other' category which bundles together fixed rate loans as well as some other relatively uncommon loan types. This 'Other' category makes up 43 per cent of the loans in the smallest size category (loans $<$ \$250 000), but close to zero per cent of the loans in the largest size category

[24] Only 32 per cent of the non-line-of-credit loans in my sample involve a variable interest rate. Even for firms with more than \$1m in assets, the percentage is only 45 per cent. (By comparison, even after taking into account the final exposure those loans that are subsequently swapped to a fixed rate, 71 per cent of Faulkender's (2003) sample consists of variable rate loans). As discussed, the contingent nature of lines of credit make it more difficult to issue such commitments at a fixed rate of interest.

(loans >$500m). Although not the cleanest test, this is suggestive that the propensity to fix is negatively correlated with size *within* Booth and Chua's sample, as well as *between* Booth and Chua's sample and the SBF.

1.7 Quantitative exercise

As a final exercise, I examine how important (in a quantitative sense) the choice between fixed and variable rate debt is for the firms in my sample. In particular, how important is the decision relative to the magnitude of 'traditional' derivatives-based risk management activities undertaken by large firms?

A natural point of comparison are estimates produced by Guay and Kothari (2003). They calculate the magnitude of the average cash flow generated by the derivatives portfolios of the largest 1000 US public companies following a 3.6 percentage point change in interest rates. (These cash flow estimates are then scaled by various firm characteristics, such as total assets, interest rate expenses etc.)

To produce comparable estimates for my sample, I calculate the additional interest expense that would be incurred by the firm on its most recent loan following a 3.6 percentage point change in interest rates, assuming the loan was taken at a variable rate. I then scale these by the same firm characteristics as Guay and Kothari.

Results of this comparison are presented in Table 1.13. The difference in interest rate sensitivity induced by the firm choosing a variable rather than fixed interest rate on its most recent loan is much larger than the effects of derivatives use by large publicly traded firms. The 'fixed vs variable' sensitivity associated with the most recent loan is larger by a factor between 2 and 8 relative to the subsample of firms that use interest rate derivatives, and even larger again in comparison to the entire sample.

Moreover, if we considered the overall 'fixed vs variable' composition of the firm's debt in the SBF, rather than just looking at the most recent loan, these differences would be larger still.

The basic lesson of this table is that use of derivatives represents only one aspect of a firm's risk management policies, and for many firms may be relatively unimportant compared to other channels. The risk management margin considered in this chapter (fixed vs variable rate loans) appears to be quantitatively significant relative to the use of derivatives by even the largest non-financial firms.

1.8 Conclusions

This chapter presents new evidence on corporate risk management by analyzing firms' choices between fixed and variable rate loans. In contrast to papers that focus on hedging using deriviatives, I find strong evidence that small, young, privately held firms have a substantial 'demand for risk management'. I also find evidence that firms choices varies systematically with industry sensitivity to interest rate shocks, and that financial institutions charge a premium on fixed rate debt to compensate them for interest rate risk. Finally, I present preliminary evidence from interviews with business lenders, and show that the 'fixed vs variable' decision is a quantitatively important component of firms' risk management strategies.

The theoretical part of this chapter analyses risk management in an environment when both the buyer (the firm) and seller (the bank) are credit constrained. Although both parties are risk neutral, credit market imperfections mean that both have a demand for interest rate risk management, and that insurance against interest rate risk is priced. This introduces a new cost of hedging relative to most papers; whether the firm chooses to insure against particular shocks depends on how credit constrained the firm is relative to the provider of the insurance. In this respect, there are interesting parallels to the literature on consumption risk sharing[25], and also with Froot (1998) who shows that the availability and pricing of insurance in the reinsurance market is affected by shocks to reinsurer capital. This raises several interesting questions: for example in future research I plan to test whether the fixed rate premium is higher amongst the types of financial institutions which previous research has shown are more sensitive to periods of rising interest rates.

The theory and evidence in this chapter also has implications for literatures on the 'financial accelerator', and the bank lending and balance sheet channels of monetary policy. My evidence is consistent with the predictions of Krishnamurthy (2003), who shows in a general equilibrium framework that hedging helps to mute the collateral-driven multiplier effects identified by Kiyotaki and Moore (1997). Evidence from this chapter that small firms are more likely to use fixed rate debt also fits with Gertler and Gilchrist's (1994) findings that small manufacturing firms are more affected by tight monetary policy (if small firms are more sensitive to tight money they should be more likely to hedge against it). It also suggests however, that the use of fixed rate debt does not provide sufficient insurance, since otherwise Gertler and Gilchrist's results would not have been observed in the first place.

Finally the model in this chapter has some interesting implications for the effect of financial innovation on the transmission of monetary policy. Several economists have noted that improved interest rate risk management practices by banks are likely to weaken the importance of the bank

[25] eg. Cochrane (1991), Townsend (1994).

lending channel. For example Cecchetti (1996) notes [in a discusion of the relative importance of the balance sheet and bank lending channels] that '*with the introduction of interstate banking and the development of more sophisticated pools of loans, it is only the balance sheet effects that will remain*'. The model presented in this chapter predicts that, given the interaction between the risk management activities of firms and financial institutions, improved risk management by banks will lead to a transfer of risk away from firms and towards banks (since banks have an improved ability to bear that risk). Thus, financial innovation may weaken both the bank lending *and* balance sheet channels (even if small firms never directly make use of the new hedging instruments). The recent proliferation of more flexible and customized types of business and consumer loans is perhaps evidence of this 'risk sharing' effect in action.

1.9 References

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1.10 Appendix A: Proofs and Calculations

I use the notation X_y to signify the partial derivative of X with respect to y evaluated at the optimum, X_{yz} to represent the second derivative of X with respect to y and then z etc.

A.1. Date 1 investment is concave in internal funds:
Suppressing all the time subscripts, I_1^* is defined by:

$$\left[\frac{B}{p_H - p_L} + \frac{1+r_1}{p_H}\right] I^* = f(I^*) + A\frac{1+r_1}{p_H} \tag{1.11}$$

Differentiating with respect to A :

$$\left[\frac{B}{p_H - p_L} + \frac{1+r_1}{p_H} - f_I\right] I_A = \frac{1+r_1}{p_H} \tag{1.12}$$

Since $f'(I^*)I^* < f(I^*)$, $I^*\left[\frac{B}{p_H-p_L} + \frac{1+r_1}{p_H} - f_I\right] > \left[\frac{B}{p_H-p_L} + \frac{1+r_1}{p_H}\right] I^* - f(I^*) = A\frac{1+r_1}{p_H} > 0$. Thus $I_A > 0$. Taking the second derivative and substituting for $\frac{B}{p_H-p_L} + \frac{1+r_1}{p_H} - f_I$ from (1.12) yields:

$$I_{AA} = \frac{p_H}{1+r_1} I_A^3 f_{II} < 0 \tag{1.13}$$

A.2. Period 1 profit is concave in internal funds:
The value of the firm if the project succeeds is given by:

$$V = f(I^*) - \frac{1+r_1}{p_H}(I^* - A_1) \tag{1.14}$$

The first-order and second-order conditions are:

$$V_A = [f_I - \frac{1+r_1}{p_H}]I_A + 1 \tag{1.15}$$

$$V_{AA} = \underbrace{[f_I - \frac{1+r_1}{p_H}]}_{>0}\underbrace{I_{AA}}_{<0} + \underbrace{f_{II}}_{<0}\underbrace{I_A^2}_{>0} \tag{1.16}$$

As can be seen from the equation, $V_{AA} = \frac{d^2V}{dA_1^2}$ is unambiguously negative.

A.3. Proof of Lemma 1.2: $cov(R_1, r_1) < 0$.

The market clearing condition for loanable funds at date 1 is given by:

$$\int_0^1 I_{1,i} - A_{1,i} di \leq \frac{1-\varphi}{\varphi} R_1 + E_1 \tag{1.17}$$

If the inequality is strict if there is an excess of loanable funds, in which case $r_1 = 0$. Note that $E_1 + \int_0^1 A_{1,i} di = E_0 + A_0 + (R_0 - I_0)$, that is, the sum of the total equity held by banks and firms at date 1 is a constant, equal to the sum of date 0 bank and firm equity $(E_0 + A_0)$ plus net returns from the period 0 project $(R_0 - I_0)$.

Thus, we can write:

$$\int_0^1 I_{1,i}(\underset{-}{r_1}) di = \frac{1-\varphi}{\varphi} R_1 + [E_0 + A_0 + R_0 - I_0] \tag{1.18}$$

Therefore a negative shock to R_1 must reduce total investment $\int_0^1 I_{1,i}(r)$. Since I_1 is decreasing in r_1 for all firms, this implies dr_1/dR_1 and thus $cov(r_1, R_1) < 0$. ■

A.4. Taylor series expansion

The premium $\bar{\mu}$ that makes the firm indifferent between fixed and variable rate debt is given by:

$$\mathbf{E}_{r_1} V(\tilde{A}, r) = \mathbf{E}_{r_1} V(\bar{A} - \bar{\mu}, r) \tag{1.19}$$

where $\tilde{A}$ is the level of internal wealth if the firm chooses a variable rate loan (ie $\tilde{A} = R_0 - (1 + \delta_v + r_1)(I_0 - A_0)$), and $\bar{A}$ is the expected value of $\tilde{A}$.

The second-order Taylor series expansion of the left hand side around $(\bar{A}, \bar{r})$ is:

$$\begin{aligned} V(\tilde{A}, r) - V(\bar{A}, \bar{r}) \quad &\approx \quad (\tilde{A} - \bar{A})V_A + (r - \bar{r})V_r + (\tilde{A} - \bar{A})(r - \bar{r})V_{rA} \\ &+\frac{1}{2}(r - \bar{r})^2 V_{rr} + \frac{1}{2}(\tilde{A} - \bar{A})^2 V_{AA} \end{aligned} \tag{1.20}$$

The Taylor series expansion of the right hand side around $(\bar{A}, \bar{r})$ is:

$$V(\bar{A} - \bar{\mu}, r) - V(\bar{A}, \bar{r}) \approx -\bar{\mu} V_A + \bar{\mu}^2 V_{AA} + (r - \bar{r})V_r + \frac{1}{2}(r - \bar{r})^2 V_{rr} - \bar{\mu}(r - \bar{r})V_{Ar} \tag{1.21}$$

Putting these two together, recalling that $\tilde{A}_r = -(I_0 - A_0)$, taking the expectation with respect to r and simplifying yields:

$$\frac{\bar{\mu}}{I_0 - A_0} \approx \sigma^2 \left[-\frac{1}{2} \frac{V_{AA}}{V_A}(I_0 - A_0) + \frac{V_{rA}}{V_A} \right] \tag{1.22}$$

which is equation (1.6) from the main text.

For the extension in Section 1.4.4 (where the returns on the period zero project are correlated with interest rates), $\bar{\mu}$ is still found from the same condition (1.19), except that $\tilde{A}$ is replaced by $\tilde{A} = R_0 + \epsilon - (1 + \delta_v + r_1)(I_0 - A_0)$, and $\bar{A}$ is replaced by $\bar{A} = R_0 + \epsilon - (1 + \delta_v + \bar{r}_1)(I_0 - A_0)$. Taking the Taylor series expansion of each side as before yields:

$$\frac{\bar{\mu}}{I_0 - A_0} \approx \sigma^2 \left[-\frac{1}{2} \frac{V_{AA}}{V_A} (I_0 - A_0 - 2cov(\epsilon, r_1)) + \frac{V_{rA}}{V_A} \right] \tag{1.23}$$

A.5. Proof of Proposition 1.1.

Denote firm $A^*, B^{*\prime}s$ premium on fixed rate debt by $\bar{\mu}_{A^*,B^*}$. Remember that this premium is given by:

$$\frac{\bar{\mu}}{I_0 - A_0} = \sum_{i \in \{1a, 1b, 2, 3\}} P_\theta(Region = i) \times E_\theta \left[\frac{\bar{\mu}}{I_0 - A_0} | Region{=}i \right] \tag{1.24}$$

As $B \to 0$ or $A \to \infty$, $P(region = 1a) \to 1$ and $\frac{\bar{\mu}}{I_0 - A_0} \to 0$. Therefore it is always possible to choose a $B = B^{**}$ small enough, or $A = A^{**}$ large enough so that $\bar{\mu}_{A^*,B} < \bar{\mu}_{A^*,B^*}$ for all $B < B^{**}$ or $\bar{\mu}_{A,B^*} < \bar{\mu}_{A^*,B^*}$ for all $A > A^{**}$. This proves Part (a). Part (b) follows from the facts that (1) as $\bar{r}_1 \to 0$, $P_\theta(Region{=}1b) \to 0$ (2) $\frac{\bar{\mu}}{I_0 - A_0} | Region{=}2 > \frac{\bar{\mu}}{I_0 - A_0} | Region{=}1a$, and (3) when $-\frac{V_{AA}}{V_A}$ is non-increasing in A, $\frac{\bar{\mu}}{I_0 - A_0}$ is non-increasing in A within region 3. ■

A.6. Derivatives

Recall that optimal date 1 investment I_1^* is found implicitly from $\left[\frac{B}{p_H - p_L} + \frac{1+r_1}{p_H} \right] I_1^* = f(I_1^*) + \frac{1+r_1}{p_H} A_1$, and the value of the firm if the project succeeds is given by $V(A_1, r_1) = f(I_1^*) - \frac{1+r_1}{p_H}(I_1^* - A_1)$. For convenience the first, second and cross derivatives of I_1 and $V(A_1, r_1)$ with respect to A_1 and r_1 are summarized in the below tables:

derivative of $\mathbf{I}_1$ w.r.t.	
$\mathbf{A}_1$	$\frac{1+r_1}{p_H} \left[\frac{B}{p_H - p_L} + \frac{1+r_1}{p_H} - f_I \right]^{-1}$
$\mathbf{r}_1$	$\frac{A_1 - I_1}{1+r_1} I_A$
$\mathbf{A}_1\mathbf{A}_1$	$\frac{p_H}{1+r_1} f_{II} I_A^3$
$\mathbf{A}_1\mathbf{r}_1$	$\left[f_{II} I_A I_r + \frac{1}{p_H}(1 - I_A) \right] \left[\frac{B}{p_H - p_L} + \frac{1+r_1}{p_H} - f_I \right]^{-1}$
$\mathbf{r}_1\mathbf{r}_1$	$-\left[f_{II} I_r^2 - \frac{2}{p_H} I_r \right] [\frac{B}{p_H - p_L} + \frac{1+r_1}{p_H} - f_I]^{-1}$

derivative of $\mathbf{V}(\mathbf{A}_1, \mathbf{r}_1)$ w.r.t.	
$\mathbf{A}_1$	$I_A[f_I - \frac{1+r_1}{p_H}]$
$\mathbf{r}_1$	$I_r\left[f_I - \frac{1+r_1}{p_H}\right] - \frac{I_1 - A_1}{p_H}$
$\mathbf{A}_1\mathbf{A}_1$	$f_{II}I_A^2 + I_{AA}\left[f_I - \frac{1+r_1}{p_H}\right]$
$\mathbf{A}_1\mathbf{r}_1$	$k\left[p_H f_{II} I_A I_r + (1 - I_A)\right]$
$\mathbf{r}_1\mathbf{r}_1$	$f_{II}I_r^2 + \left[f_I - \frac{1+r_1}{p_H}\right] I_{rr} - \frac{2}{p_H} I_r$

where: $k = \frac{B}{B-(p_H-p_L)\left[f_I - \frac{1+r_1}{p_H}\right]}$. $k > 1$ since $f_I > \frac{1+r_1}{p_H}$.

1.11 Appendix B: Model of Banks

The model of financial intermediation is a stripped-down version of Stein (1998). Each bank has the following balance sheet identity:

$$\text{Loans } (L_t) + \text{Reserves } (R_t) = \text{Deposits } (D_t) + \text{Non-deposit finance } (E_t) \tag{1.25}$$

For simplicity, it is assumed depositors require a risk free rate of return of 0.[26] Deposit finance is limited by a fractional reserve requirement which must be satisfied at the beginning of each period:

$$R_t \geq \varphi D_t \tag{1.26}$$

Combining these two equations yields:

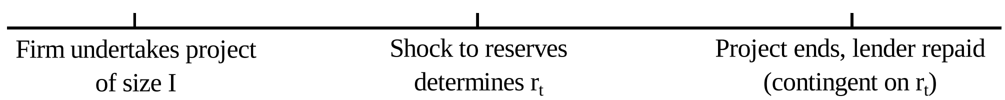
$$L_t \leq \frac{1-\varphi}{\varphi} R_t + E_t \tag{1.27}$$

[26] The assumption that deposit rates are exogenous is not at all crucial. The key price in the analysis that follows is the *wedge* between deposit and lending rates. In a more realistic setup we could assume imperfect substitutability between money and bonds, in which case shocks to bank reserves will affect the interest rate on both deposits and loans. But the key result, that a reduction in reserves tightens bank credit constraints and raises intermediation spreads, will remain, as the model in Stein (1998) shows.

In words, bank lending must be financed by either deposits or non-deposit finance. Deposits in turn are limited by the level of bank reserves. The key point of Stein (1998) is that when raising non-deposit finance (E_t) is costly, monetary policy shocks which drain reserves from the banking system (a reduction in R_t) will reduce lending by banks and raise intermediation spreads. This is the bank lending channel of monetary policy.

In Stein, raising external funds is possible, but is costly because of adverse selection. Here, I make a starker assumption: that no additional non-deposit finance can be raised between periods. Non-deposit finance at date 1 will thus be equal to non-deposit finance at date 0 plus any profits from lending to firms at date 0.

The timing of the model is the same as before, except that at the end of $t-1$, there is a random monetary policy shock, which determines the level of reserves in the following period R_t and consequently next period's interest rate on bank loans to firms r_t. Importantly, the value of R_t is revealed *before* the firm repays the lender in period $t-1$, so the date $t-1$ contract can be made contingent on r_t.



The relationship between R_t and r_t is determined by the market clearing condition

$$\int I_{t,i} - A_{t,i} di \leq \frac{1-\varphi}{\varphi} R_t + E_t. \tag{1.28}$$

A fall in R_t reduces the total amount of loanable funds available for borrowing, and thus reduces investment. Since investment is decreasing in the cost of funds for all firms, this means a negative shock to R_t is matched by an increase in the market clearing interest rate r_t. See Lemma 1.2 below.[27]

Lemma 1.2: $cov(R_t, r_t) < 0$.
Proof, see Appendix A.3.■

Below, I solve the firm's problem allowing the repayment from the bank to the firm at the end of $t-1$ to be contingent on the realization of r_t. I restrict contracts to be one of two types: a fixed rate loan with interest rate δ_f, and a floating rate loan where the interest rate is $\delta_v + r_t$.

I focus on the shock to reserves at the end of period 0. Because firms and lenders are risk neutral and period 1 is the terminal period, both parties will be indifferent to the realization of r_2. Firms *do* care whether the date 0 contract is contingent on r_1, because internal funds at the end of period 0 are used to help finance the project at date 1.

[27] As shown in the proof of Lemma 2 in Appendix A, $cov(R_t, r_t) < 0$ regardless of whether debt contracts between banks and firms at date $t-1$ are made contingent on the realization of r_t. Making the repayment to the lender contingent on r_t shifts funds between banks and firms, but does not affect $A_t + E_t$ (the total amount of total non-deposit funds available for investment by firms).

Since banks are risk-neutral and can choose freely between lending fixed or floating, the equilibrium expected rate of return on the two types of loans must be equal. The expected return on a fixed rate loan is the product of $1 + \delta_f$ (the rate of return in period 0), and $\mathbf{E}[1+r_1]$ (the expected rate of return in period 1). The expected return on a variable rate loan is $\mathbf{E}[(1+\delta_v+r_1)(1+r_1)]$. Note that the period 0 return $1+\delta_v+r_1$ and period 1 return $1+r_1$ appear together inside the expectation operator. This highlights the key benefit of variable rate debt. Variable rate loans produce a high rate of return exactly in the states of nature where the period 1 rate of return on bank capital is high. In other words, variable rate loans provide a hedge against shocks to loanable funds.

Setting these two expected rates of return equal, using the fact that $E(ab) = E(a)E(b) + cov(a, b)$ and rearranging yields an expression for the interest rate premium on fixed rate debt relative to variable rate debt:

$$\delta_f - (\delta_v + \bar{r}_1) = \frac{\sigma^2}{1+\bar{r}_1} \tag{1.29}$$

where $\bar{r}_1$ denotes the expected value of r_1, and σ^2 is the variance of r_1. This premium is strictly positive, and increasing in the volatility of interest rates.

To recapitulate, banks charge an interest rate premium on fixed rate debt, because variable rate debt hedges the bank against shocks to reserves (R_t). The repayment on a period 0 variable rate loan covaries positively with r_1, the shadow value of date 1 bank internal funds.

Finally, having determined the spread between fixed and variable rate debt, the interest rate on fixed rate debt (δ_f) is pinned down by the market clearing condition (1.28) at date 0, and is decreasing in the supply of loanable funds ($E_0 + R_0$) relative to demand ($\int I_{t,i} - A_{t,i} di$). If there are excess loanable funds, $\delta_f = 0$, ensuring that banks earn a net expected rate of return of zero on lending to firms.

1.12 Appendix C: Anecdotal evidence from business lenders

As mentioned above, to complement the large-sample evidence presented above, I also conducted a series of interviews with business lending professionals from various banks in the Washington, DC and Boston, MA metro areas.

One motivation for conducting these interviews was to collect additional information not provided in the SBF. For example, the SBF does not explicitly ask firms whether or not they use derivatives for hedging. In principle this could be important for the results – perhaps the larger firms in my sample choose variable rate loans, but then switch them to a fixed rate using interest rate swaps. By asking business lenders what proportion of the firms they deal with make use of derivatives, I was able to obtain a rough estimate of how serious a problem this might be.

A second purpose was to improve my institutional knowledge, and learn about additional factors bearing on the fixed vs variable rate decision.

A third purpose was simply to find out how consistent my empirical results are with anecdotally reported industry practice.

I conducted eight interviews (in two cases the respondent completed a written survey in lieu of granting a face-to-face interview), and asked nine questions in each interview, falling into five main categories. The categories are listed below, along with a brief summary of the tenor of the responses :

I. What are the advantages and disadvantages of fixed vs variable rate loans; is the 'cost' (the expected total interest expense plus any transactions costs) higher or lower for fixed rate debt? (Q1,Q2,Q4)

All respondents cited the lack of uncertainty about future interest rates as being the main benefit of fixed rate debt. As already discussed, several interviewees reported that fixed rate debt involves higher total interest costs 'on average'.

Respondents also cited prepayment penalties as being a disadvantage of fixed rate debt (there are generally no prepayment penalties on variable rate commercial loans, but there are on fixed rate loans). Answers to this section also partially seemed to reflect individual respondents' views about the future path of interest rates. Finally 5 of the 8 respondents told me that they were sometimes given directives by senior management to favor variable or fixed rate debt.

II. What type of firms are more likely to choose fixed rate debt or variable rate debt, and what proportion of loans are issued at a fixed rate? (Q3).

Respondent #6 cited small firms as being more likely to use fixed rate loans. Respondent #1 did not believe there were many obvious trends, although doctors 'did not care' while construction companies 'love fixed rate loans'. Respondent #2 suggested more risk-averse firms were more likely to choose fixed rate loans. Respondent #4 suggested more conservative firms, as well as those in the non-profit sector (who generally face a fixed budget constraint).

III. What is the average and largest size of the firms you deal with? (Q5,Q6)

The maximum loan size ranged from maximum $2.5m (respondent #1), to maximum $20m (respondent #2, #6 and #8)

IV. What proportion of the firms you deal with make use of derivatives? (Q9)

5 out of 8 interviewees reported that none of the firms they dealt with used derivatives. Respondents #1 and #8 suggested a small proportion do, while respondent #2 estimated 2 of 50 client firms used derivatives.

V. Generally, how prevalent is refinancing in the commercial lending market? (Q7)

Respondents generally replied that there had been a substantial amount of refinancing in recent years because of the large decline in interest rates, but less common in general (especially for shorter maturity loans) than the household mortgage market.

Table 1.1
Sample selection: firms' applications for and receipt of external finance

This table provides descriptive information on the number of firms in each wave of the SBF, and whether they applied for and/or had been granted external finance. The 'final sample' for each survey is the number of firms who met the following criteria (i) received a loan within the timeframe specified, (ii) reported the year the loan was approved, and (iii) reported whether the loan was fixed or floating. Note that for the 1987 survey, no information was reported on the number of firms who sought but had not received finance within particular time periods.

	SBF survey year			
	1987	1993	1998	*TOTAL*
No. firms in original sample	3224	4637	3561	*11422*
No. firms sought external finance	*	2007	962	*
No. firms granted external finance				
within 3 years	1509	1695	796	*4000*
>3 years, since 1980	236			*236*
before 1980	128			*128*
year not identified	309			*309*
TOTAL	*2182*	*1695*	*796*	*4673*
Final sample: fixed vs floating				
finance <3 years ago	1466	1695	796	*3957*
finance >3 years ago, since 1980	232			*232*
TOTAL	*1698*	*1695*	*796*	*4189*

Table 1.2
Descriptive statistics

The first three columns present summary statistics by survey years for the subsample of firms for whom information is recorded on whether the most recent loan was fixed or floating. The fourth column presents summary statistics for this subsample across all three surveys. The fifth column does the same, but observations are weighted using sampling weights provided with the SBF. The sixth column presents weighted summary statistics for the entire sample of firms across all three surveys (not just those who had taken out a recent loan and recorded whether it was fixed or floating).

	Individual surveys			Combined		
	1987	1993	1998	subsample, not weighted	subsample, weighted	all firms, weighted
Number of firms	1698	1695	796	4189	4189	11422
Assets (mean, $000s)	1623	3401	2291	2469	841	468
Assets (median, $000s)	238	650	326	359	159	72
Assets (std. dev., $000s)	4331	9911	6198	7434	3345	2497
Employment (mean, #)	34.2	55.1	36.9	43.2	14.2	8.8
Corporate form (%):						
Sole trader	0.30	0.18	0.26	0.24	0.34	0.45
Partnership	0.08	0.07	0.07	0.07	0.08	0.08
S-corp	0.16	0.28	0.35	0.24	0.22	0.20
C-corp	0.47	0.46	0.33	0.44	0.36	0.28
Firm age (mean, years)	13.1	16.3	13.9	14.6	12.8	13.7
Characteristics of most recent loan:						
Loan is fixed rate (%)	0.53	0.42	0.66	0.51	0.58	0.58
Maturity of loan (years)	4.16	3.29	4.91	3.94	4.07	4.19
Lender is a bank (%)	0.77	0.84	0.73	0.79	0.76	0.26
Loan is line of credit (%)	0.32	0.60	0.32	0.43	0.38	0.13

Table 1.3
Descriptive statistics: proportions of fixed rate loans by category

The first part of the table presents information on the number of 'most recent loans' of different types, and the source of those loans (bank or non-bank). The 'non-bank' source includes non bank intermediaries such as finance companies, credit unions etc. as well as lenders who were not financial institutions. The second part of the table presents (by source) the proportion of each type of loan for which the interest rate on the loan was fixed, rather than floating.

	Number of observations, by lender type			**Proportion of fixed rate loans, by lender type**		
	Bank	Non-bank	All	Bank	Non-bank	All
New line of credit	1631	176	1807	0.28	0.41	0.29
Capital lease	26	59	85	0.62	0.97	0.86
Business mortgage	404	88	492	0.44	0.63	0.47
Vehicle mortgage	434	275	709	0.84	0.96	0.88
Equipment Loan	410	176	586	0.58	0.86	0.66
Other	412	98	510	0.55	0.66	0.57
All loans	**3317**	**872**	**4189**	**0.44**	**0.76**	**0.51**

Table 1.4
Variance of real interest rates: alternative loan indexes

Presents calculations of the variance of (R_{t+k} - R_t) (where Rt denotes real interest rate at time t) for: the bank prime rate, the federal funds rate, and a nominal fixed rate. Real interest rates were calculated on an ex post basis (ie. if the realized inflation rate was x per cent, and the prime rate was *y* per cent, then the real prime rate was calculated as *x - y*). The first two parts of the table used a smoothed measure of the inflation rate (obtained by applying a two-sided moving average filter with binomial weights) to minimize high-freqency fluctuations in the inflation series caused by measurement error. The last part of the table uses the original unsmoothed inflation data. Sample from 1/1960 to 12/1999. GDP deflator used to construct inflation rate (linearly interpolated to produce monthly data).

	Horizon (k)			
	1 year	2 years	3 years	5 years
Full sample (1960 onwards)				
Fixed rate	1.70	3.80	5.11	6.96
Prime rate	3.34	5.68	7.93	12.22
Federal funds rate	4.00	6.07	7.98	11.84
1982 onwards				
Fixed rate	0.49	0.72	1.07	1.09
Prime rate	2.28	3.42	4.45	5.30
Federal funds rate	2.19	3.72	4.93	5.50
1982 onwards (raw inflation series)				
Fixed rate	0.92	1.07	1.53	1.49
Prime rate	2.71	3.82	4.86	5.74
Federal funds rate	2.59	4.13	5.37	5.97

Table 1.5

Which firms choose fixed rate loans?

Dependent variable = 1 if the firm's most recent loan is a fixed rate loan, and = 0 if it is a variable rate loan. Probit regression. Coefficients are normalized to display the marginal effect of a change in the RHS variable at the point of sample means. Standard errors in parentheses. For F-tests, table presents the p-value for the null that estimated coefficients are jointly equal to zero.

	(1)	(2) include some ownership variables	(3) include all loan characteristics	(4) include no loan characteristics	(5) exclude loans before 1985	(6) corporations only	(7) no sales growth
Firm size and age variables							
Log(book value of assets)	-0.065	-0.067	-0.086	-0.081	-0.066	-0.063	-0.059
	(0.008)***	(0.008)***	(0.009)***	(0.008)***	(0.008)***	(0.011)***	(0.008)***
Log(firm age + 1)	-0.041	-0.041	-0.041	-0.037	-0.041	-0.046	-0.029
	(0.019)**	(0.019)**	(0.019)**	(0.017)**	(0.020)**	(0.025)*	(0.017)*
Profitability & growth opportunities							
Sales growth	0.068	0.068	0.055	0.060	0.058	0.084	
	(0.028)**	(0.028)**	(0.029)*	(0.028)**	(0.028)**	(0.036)**	
Profits/assets	-0.018	-0.019	-0.010	-0.022	-0.019	-0.008	-0.010
	(0.009)*	(0.009)**	(0.011)	(0.009)**	(0.009)**	(0.015)	(0.009)
Lending relationship variables							
No. of fin.institutions firm borrows from	0.003	0.003	-0.002	0.010	-0.001	0.010	0.005
	(0.009)	(0.009)	(0.010)	(0.009)	(0.009)	(0.012)	(0.009)
Log(years with current lender + 1)	-0.021	-0.020	-0.030	-0.067	-0.022	-0.016	-0.022
	(0.017)	(0.017)	(0.018)*	(0.015)***	(0.017)	(0.021)	(0.016)
Log(years with primary lender + 1)	0.048	0.048	0.044	0.092	0.041	0.058	0.049
	(0.019)***	(0.019)**	(0.020)**	(0.017)***	(0.019)**	(0.024)**	(0.017)***
Firm controls	all	all	all	all	all	all	all
Ownership controls	no	some	no	no	no	no	no
Loan controls	some	some	no	all	some	some	some
Macroeconomic controls	all	all	all	all	all	all	all
Pseudo R2	0.224	0.224	0.252	0.102	0.219	0.227	0.214
Number of observations	3546	3546	3422	3546	3334	2454	4064

***, ** and * represents significance at 1%, 5% and 10% levels respectively.

Table 1.6

Interest rate shocks and industry cash flow shocks

Dependent variable = 1 if the firm's most recent loan is a fixed rate loan, and = 0 if it is a variable rate loan. Probit regression. Coefficients are normalized to display the marginal effect of a change in the RHS variable at the point of sample means. Standard errors in parentheses. For F-tests, table presents the p-value for the null that estimated coefficients are jointly equal to zero.

	(1)	(2) include some ownership variables	(3) include all loan characteristics	(4) corporations only	(5) exclude loans before 1985	(6) no sales growth
Industry interest rate sensitivity	-1.535	-1.558	-1.180	-1.350	-1.563	-1.109
(2 digit SIC)	(0.679)**	(0.686)**	(0.709)*	(0.787)*	(0.719)**	(0.674)*
Firm size and age variables						
Log(book value of assets)	-0.068	-0.069	-0.089	-0.067	-0.068	-0.062
	(0.008)***	(0.008)***	(0.009)***	(0.011)***	(0.008)***	(0.008)***
Log(firm age + 1)	-0.040	-0.041	-0.040	-0.045	-0.038	-0.029
	(0.019)**	(0.019)**	(0.019)**	(0.025)*	(0.020)*	(0.017)*
Profitability & growth opportunities						
Profits/assets	-0.018	-0.019	-0.010	-0.008	-0.019	-0.010
	(0.009)*	(0.009)**	(0.011)	(0.015)	(0.009)**	(0.009)
Sales growth	0.067	0.067	0.055	0.085	0.059	
	(0.028)**	(0.028)**	(0.029)*	(0.036)**	(0.028)**	
Firm controls	all	all	all	all	all	all
Ownership controls	no	some	no	no	no	no
Loan controls	some	some	all	some	some	some
Macroeconomic controls	all	all	all	all	all	all
Pseudo R2	0.222	0.223	0.249	0.225	0.217	0.212
Number of observations	3546	3546	3422	2454	3334	4064

***, ** and * represents significance at 1%, 5% and 10% levels respectively.

Table 1.7
Cost of fixed and variable rate debt

Dependent variable = interest rate on most recent loan in percentage points. Standard errors in parentheses.

	(1)	(2) include all loan characteristics	(3) no sales growth	(4) interact with firm size
Dummy for fixed rate loan	0.524	0.413	0.433	1.373
	(0.141)***	(0.143)***	(0.140)***	(0.761)*
Fixed rate loan dummy * log assets				-0.070
				(0.061)
Firm size and age variables				
Log(book value of assets)	-0.272	-0.327	-0.294	-0.235
	(0.041)***	(0.045)***	(0.041)***	(0.038)***
Log(firm age + 1)	-0.103	-0.093	-0.142	-0.104
	(0.076)	(0.077)	(0.070)**	(0.076)
Profitability & growth opportunities				
Sales growth	0.215	0.186		0.215
	(0.144)	(0.142)		(0.144)
Profits/assets	-0.066	-0.036	-0.017	-0.067
	(0.043)	(0.043)	(0.037)	(0.043)
Debt / (debt + equity)	-0.195	-0.075	0.015	-0.197
	(0.096)**	(0.107)	(0.094)	(0.096)**
Selected interest rate controls				
Federal funds rate	0.470	0.397	0.496	0.467
	(0.349)	(0.349)	(0.327)	(0.349)
Prime rate	-0.013	0.032	-0.062	-0.014
	(0.295)	(0.295)	(0.279)	(0.296)
Firm controls	all	all	all	all
Ownership controls	no	no	no	no
Loan controls	some	all	all	some
Macroeconomic controls	all	all	all	all
Pseudo R2	0.26	0.27	0.27	0.26
Number of observations	2985	2933	3406	2985

***, ** and * represents significance at 1%, 5% and 10% levels respectively.

Table 1.8

Which firms choose fixed rate loans? Additional results

Dependent variable = 1 if the firm's most recent loan is a fixed rate loan, and = 0 if it is a floating rate loan. Probit regression. Coefficients are normalized to display the marginal effect of a change in the RHS variable at the point of sample means. Standard errors in parentheses. For F-tests, table presents the p-value for the null that estimated coefficients are jointly equal to zero.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Additional owner characteristics		Bank loans only			Interact with maturity	Alternative size measure
		No sales growth		All loan controls	Addit. owner characteristics		
F-test on ownership variables: P value	0.832	0.508			0.896		
Firm size and age variables							
Log(book value of assets)	-0.056	-0.053	-0.066	-0.090	-0.053	-0.061	
	(0.011)***	(0.010)***	(0.010)***	(0.011)***	(0.012)***	(0.009)***	
maturity * Log(book value of assets)*10^{-2}						-0.046	
						(0.048)	
Log(sales)							-0.062
							(0.008)***
Log(firm age + 1)	-0.064	-0.043	-0.039	-0.039	-0.084	-0.045	-0.041
	(0.031)**	(0.026)*	(0.022)*	(0.022)*	(0.035)**	(0.023)**	(0.019)**
maturity * Log(firm age)*10^{-2}						0.022	
						(0.227)	
Profitability & growth opportunities							
Sales growth	0.079		0.065	0.044	0.069	0.065	0.075
	(0.045)*		(0.033)*	(0.035)	(0.053)	(0.029)**	(0.028)***
Profits/assets	-0.019	-0.012	-0.021	-0.011	-0.020	-0.019	0.003
	(0.011)*	(0.010)	(0.010)**	(0.011)	(0.012)*	(0.010)*	(0.009)
Firm controls	all	all	all	all	all	all	all
Ownership controls	all	all	no	no	all	no	no
Loan controls	some	some	some	all	some	some	some
Macroeconomic controls	all	all	all	all	all	all	all
Pseudo R2	0.200	0.191	0.177	0.206	0.163	0.233	0.221
Number of observations	2080	2465	2834	2743	1699	3452	3546

***, ** and * represents significance at 1%, 5% and 10% levels respectively.

Table 1.9

Which firms choose fixed rate loans? By survey

Dependent variable = 1 if the firm's most recent loan is a fixed rate loan, and = 0 if it is a floating rate loan. Probit regression. Coefficients are normalized to display the marginal effect of a change in the RHS variable at the point of sample means. Standard errors in parentheses. For F-tests, table presents the p-value for the null that estimated coefficients are jointly equal to zero.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	1987 SBF		1993 SBF		1998 SBF		
		Additional loan controls		Additional loan controls		Additional loan controls	Parsimonious specification
Firm size and age variables							
Log(book value of assets)	-0.087	-0.104	-0.069	-0.095	-0.037	-0.043	-0.038
	(0.015)***	(0.017)***	(0.013)***	(0.015)***	(0.014)***	(0.016)***	(0.013)***
Log(firm age + 1)	-0.021	-0.017	-0.117	-0.094	-0.037	-0.043	-0.039
	(0.027)	(0.027)	(0.042)***	(0.042)**	(0.034)	(0.033)	(0.026)
Profitability & growth opportunities							
Sales growth	0.059	0.047	0.459	0.491	0.031	0.000	
	(0.037)	(0.038)	(0.143)***	(0.138)***	(0.040)	(0.040)	
Profits/assets	-0.015	-0.004	-0.026	-0.015	-0.009	0.006	-0.007
	(0.019)	(0.021)	(0.017)	(0.017)	(0.012)	(0.012)	(0.012)
Lending relationship variables							
No. of fin.institutions firm borrows from	0.044	0.041	-0.027	-0.027	-0.002	-0.007	
	(0.017)**	(0.018)**	(0.017)	(0.017)	(0.013)	(0.013)	
Log(years with current lender + 1)	-0.049	-0.049	-0.028	-0.039	0.018	-0.012	
	(0.026)*	(0.027)*	(0.034)	(0.035)	(0.026)	(0.026)	
Log(years with primary lender + 1)	0.081	0.071	0.049	0.047	-0.018	-0.007	
	(0.029)***	(0.030)**	(0.039)	(0.040)	(0.028)	(0.027)	
Firm controls	all	all	all	all	all	all	some
Ownership controls	no	no	no	no	no	no	no
Loan controls	some	all	some	all	some	all	some
Macroeconomic controls	all	all	all	all	all	all	some
Pseudo R2	0.287	0.305	0.206	0.227	0.221	0.262	0.202
Number of observations	1464	1393	1329	1329	750	698	794

***, ** and * represents significance at 1%, 5% and 10% levels respectively.

Table 1.10

Which firms choose fixed rate loans? Broken down by type of loan

Dependent variable = 1 if the firm's most recent loan is a fixed rate loan, and = 0 if it is a floating rate loan. Probit regression. Coefficients are normalized to display the marginal effect of a change in the RHS variable at the point of sample means. Standard errors in parentheses. For F-tests, table presents the p-value for the null that estimated coefficients are jointly equal to zero.

	(1)	(2)	(3)	(4)	(5)	(6)
	Lines of credit			Bank loans only		
		Additional loan characteristics	Corporations only		Additional loan characteristics	Corporations only
Firm size and age variables						
Log(book value of assets)	-0.077	-0.090	-0.071	-0.046	-0.063	-0.040
	(0.012)***	(0.014)***	(0.014)***	(0.009)***	(0.010)***	(0.012)***
Log(firm age + 1)	-0.027	-0.031	-0.003	-0.040	-0.040	-0.059
	(0.030)	(0.031)	(0.037)	(0.020)**	(0.020)**	(0.027)**
Profitability & growth opportunities						
Sales growth	0.091	0.084	0.082	0.038	0.024	0.061
	(0.044)**	(0.045)*	(0.055)	(0.029)	(0.029)	(0.037)*
Profits/assets	-0.014	0.002	0.014	-0.018	-0.015	-0.019
	(0.013)	(0.014)	(0.019)	(0.010)*	(0.011)	(0.015)
Lending relationship variables						
No. of fin.institutions firm borrows from	0.014	0.011	0.026	-0.002	-0.004	0.001
	(0.014)	(0.015)	(0.016)	(0.010)	(0.010)	(0.012)
Log(years with current lender + 1)	0.005	0.004	-0.006	-0.027	-0.037	-0.008
	(0.030)	(0.032)	(0.033)	(0.016)*	(0.017)**	(0.020)
Log(years with primary lender + 1)	0.040	0.029	0.032	0.036	0.033	0.051
	(0.032)	(0.034)	(0.037)	(0.018)**	(0.019)*	(0.024)**
Firm controls	all	all	all	all	all	all
Ownership controls	no	no	no	no	no	no
Loan controls	some	all	some	some	all	some
Macroeconomic controls	all	all	all	all	all	all
Pseudo R2	0.115	0.158	0.100	0.176	0.207	0.174
Number of observations	1519	1450	1163	2027	1972	1291

***, ** and * represents significance at 1%, 5% and 10% levels respectively.

Table 1.11

Do the results reflect owner risk-aversion? (1998 SBF only)

Dependent variable = 1 if the firm's most recent loan is a fixed rate loan, and = 0 if it is a floating rate loan. Probit regression. Coefficients are normalized to display the marginal effect of a change in the RHS variable at the point of sample means. Standard errors in parentheses. For F-tests, table presents the p-value for the null that estimated coefficients are jointly equal to zero.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	All loan controls		Some loan controls		Parsimonious specification		
	excluding owner wealth variable	including owner wealth variable	excluding owner wealth variable	including owner wealth variable	excluding owner wealth variable	including owner wealth variable	alternative wealth variable
Firm size and owner wealth							
Log(book value of assets)	-0.043	-0.035	-0.037	-0.027	-0.038	-0.030	-0.038
	(0.016)***	(0.017)**	(0.014)***	(0.015)*	(0.013)***	(0.014)**	(0.013)***
Log(total owner wealth)		-0.017		-0.033		-0.029	
		(0.015)		(0.015)**		(0.015)**	
Owner equity / total wealth							-0.001
							(0.002)
Age, profitability & growth opportunities							
Log(firm age + 1)	-0.043	-0.037	-0.037	-0.026	-0.039	-0.030	-0.041
	(0.033)	(0.034)	(0.034)	(0.034)	(0.026)	(0.026)	(0.026)
Sales growth	0.000	-0.001	0.031	0.028			
	(0.040)	(0.040)	(0.040)	(0.039)			
Profits/assets	0.006	0.007	-0.009	-0.006	-0.007	-0.005	-0.007
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Firm controls	all	all	all	all	some	some	some
Ownership controls	no	no	no	no	no	no	no
Loan controls	all	all	some	some	some	some	some
Macroeconomic controls	all	all	all	all	some	some	some
Pseudo R2	0.262	0.264	0.201	0.210	0.202	0.209	0.203
Number of observations	698	698	750	750	794	794	794

***, ** and * represents significance at 1%, 5% and 10% levels respectively.

Table 1.12

'Market timing'?

Dependent variable = 1 if the firm's most recent loan is a fixed rate loan, and = 0 if it is a floating rate loan. Probit regression. Coefficients are normalized to display the marginal effect of a change in the RHS variable at the point of sample means. Standard errors in parentheses. For F-tests, table presents the p-value for the null that estimated coefficients are jointly equal to zero.

	(1) Same as column (1) from table 5	(2) No survey dummies	(3) As (2), additional loan characteristics	(4) As (2), alternative spread measure	(5) As (4), additional loan characteristics
Measure of term structure spread					
Term spread: 10 year vs spot rate	-0.012	-0.024	-0.030		
	(0.017)	(0.013)*	(0.014)**		
Term spread over loan maturity				-0.023	-0.014
				(0.013)*	(0.015)
Firm size and age variables					
Log(book value of assets)	-0.065	-0.065	-0.086	-0.063	-0.090
	(0.008)***	(0.008)***	(0.009)***	(0.009)***	(0.009)***
Log(firm age + 1)	-0.041	-0.041	-0.041	-0.050	-0.046
	(0.019)**	(0.019)**	(0.019)**	(0.020)**	(0.020)**
Profitability & growth opportunities					
Sales growth	0.068	0.077	0.063	0.089	0.077
	(0.028)**	(0.027)***	(0.028)**	(0.028)***	(0.029)***
Profits/assets	-0.018	-0.018	-0.010	-0.015	-0.005
	(0.009)*	(0.009)*	(0.011)	(0.010)	(0.011)
Firm controls	all	all but surv. dum.	all but surv. dum.	all but surv. dum.	all but surv. dum.
Ownership controls	no	no	no	no	no
Loan controls	some	some	all	some	all
Macroeconomic controls	all	all	all	all	all
Pseudo R2	0.224	0.223	0.251	0.226	0.252
Number of observations	3546	3546	3422	3207	3185

***, ** and * represents significance at 1%, 5% and 10% levels respectively.

Table 1.13: Cash flows and interest rates

Sensititivity of firm cash flows to a 3.4 percentage point change in interest rates, scaled by various firm characteristics

	Interest rate derivatives, Fortune 500 firms		**Most recent loan, SBF sample**
	All firms	Users only	
mean sensitivity of cash flows to shock, as proportion of:			
Mean interest expense	< 0.039	< 0.069	0.205
Mean assets x10^{-2}	< 0.091	< 0.161	0.956
Mean cash flows from operations	< 0.009	< 0.016	0.029
median sensitivity of cash flows to shock, as proportion of:			
Median interest expense	0.0	< 0.046	0.235
Median assets x10^{-2}	0.0	< 0.112	0.876
Median cash flows from operations	0.0	< 0.013	0.030

Table 1.14
Additional results from Table 1.5 and Table 1.7

Results for those regressors for which results were not presented as part of Table 5 and Table 7. To conserve space, results are not presented for columns (4), (5) and (6) of Table 5, and Column (2) of Table 7 [results are similar to columns that have been included in the table]. Also to conserve space, individual results for collateral dummies (not generally significant), and industry dummies are not included in this table (available on request).

	Table 1.5				Table 1.7		
	(1)	(2)	(3)	(7)	(1)	(3)	(4)
Firm and loan controls							
Dummy for unincorporation	0.037	0.040	0.026	0.039	0.152	0.314	0.149
	(0.027)	(0.028)	(0.029)	(0.025)	(0.128)	(0.121)***	(0.128)
Total debt / total assets	-0.071	-0.072	-0.017	-0.065	-0.195	0.015	-0.197
	(0.021)***	(0.021)***	(0.024)	(0.020)***	(0.096)**	(0.094)	(0.096)**
Location = North-east	0.044	0.043	0.046	0.040	-0.129	-0.109	-0.130
	(0.037)	(0.037)	(0.039)	(0.035)	(0.202)	(0.183)	(0.202)
Location = North-central	0.065	0.065	0.072	0.066	-0.264	-0.274	-0.270
	(0.034)*	(0.034)*	(0.035)**	(0.032)**	(0.175)	(0.161)*	(0.174)
Location = South	0.068	0.066	0.070	0.071	-0.233	-0.215	-0.238
	(0.034)**	(0.034)*	(0.035)**	(0.032)**	(0.173)	(0.159)	(0.173)
Dummy: Owner manages firm		-0.048					
		(0.036)					
Dummy: Firm family owned		-0.007					
		(0.032)					
1 digit SIC dummies	yes	yes	yes	yes	yes	yes	yes
Loan controls							
Lender = bank	-0.173	-0.174	-0.176	-0.175	0.215	0.140	0.221
	(0.032)***	(0.032)***	(0.033)***	(0.030)***	(0.219)	(0.198)	(0.219)
Lender = not fin.inst.	0.001	0.000	0.057	0.006	0.268	-0.031	0.266
	(0.086)	(0.085)	(0.088)	(0.077)	(0.474)	(0.433)	(0.474)
Loan = line of credit	-0.260	-0.261	-0.241	-0.244	-0.802	-0.651	-0.805
	(0.036)***	(0.036)***	(0.038)***	(0.034)***	(0.241)***	(0.210)***	(0.241)***
Loan = capital lease	0.256	0.257	0.269	0.252	-0.026	0.112	-0.034
	(0.054)***	(0.054)***	(0.054)***	(0.050)***	(0.477)	(0.406)	(0.477)
Loan = business mortgage	-0.108	-0.109	-0.066	-0.111	-0.862	-0.475	-0.852
	(0.048)**	(0.048)**	(0.064)	(0.044)**	(0.255)***	(0.228)**	(0.254)***
Loan = line of credit	0.258	0.258	0.229	0.277	-1.162	-1.205	-1.158
	(0.037)***	(0.037)***	(0.048)***	(0.034)***	(0.279)***	(0.259)***	(0.278)***
Loan = line of credit	0.069	0.070	0.035	0.085	-0.564	-0.520	-0.559
	(0.042)	(0.042)*	(0.054)	(0.039)**	(0.294)*	(0.263)**	(0.293)*
Loan size			-0.166			-0.359	
			(0.029)***			(0.104)***	
Maturity			-0.001			-0.013	
			(0.003)			(0.012)	
Collateral dummies			yes			yes	
Macroeconomic controls							
Survey = 1987	-0.026	-0.029	-0.053	-0.029	0.883	0.805	0.855
	(0.061)	(0.061)	(0.067)	(0.058)	(0.590)	(0.545)	(0.591)
Survey = 1993	-0.054	-0.057	-0.067	-0.071	0.404	0.317	0.391
	(0.053)	(0.053)	(0.056)	(0.048)	(0.318)	(0.304)	(0.319)
Federal funds rate					0.470	0.496	0.467
					(0.349)	(0.327)	(0.349)
Term structure spread					-0.095	-0.073	
					(0.095)	(0.092)	
10 year bond spread	-0.012	-0.012	-0.016	-0.018	0.039	0.011	0.041
	(0.017)	(0.017)	(0.017)	(0.016)	(0.106)	(0.106)	(0.106)
Corporate bond spread	-0.222	-0.220	-0.224	-0.212	0.494	0.399	0.526
	(0.079)***	(0.079)***	(0.085)***	(0.076)***	(0.383)	(0.375)	(0.381)
Prime interest rate	0.000	0.000	0.005	-0.001	-0.013	-0.062	-0.014
	(0.010)	(0.010)	(0.010)	(0.009)	(0.295)	(0.279)	(0.296)

Chapter 2

Banking Relationships and the Credit Cycle

This chapter presents evidence that banking relationships are most valuable to firms during periods of tight credit, in the extreme during a 'credit crunch'. Relationships help alleviate delegated monitoring costs; when banks are credit constrained, these costs are extreme, so the informational advantage provided by relationships is magnified. The first part of this chapter develops these intuitions using a simple agency model (and also highlights some cases where they do not apply). The second part of the chapter presents empirical evidence, based on data from a survey of manufacturing firms during the Asian financial crisis. Controlling for firm characteristics, I find that at the onset of the crisis firms who dealt exclusively with one financial institution or had long-standing banking relationships became conditionally less likely to be refused a loan, less likely to report that bank credit conditions had worsened, and less likely to cite lack of bank finance as a cause of declining output. Weak relationships were not correlated with changes in the availability of other sources of credit (such as trade credit, or loans from family and friends), suggesting the relationship variables are not simply proxies for unmeasured dimensions of firm quality. Finally, firms with exclusive relationships did not have significantly greater access to credit prior to the decline in borrowing conditions, emphasising the link between the value of bank relationships and the state of the 'credit cycle'.

2.1 Introduction

Financial intermediaries, particularly banks but also finance companies, venture capital firms and so on, are an important source of finance for all but the largest firms. Moreover lending *relationships*, in which firms borrow repeatedly from a small number of institutions, are the norm in most countries.[1] For example, in the 1998 US Survey of Small Business Finance, only 14 per cent of firms reported borrowing from more than two financial institutions, and firms had been dealing with their primary institution for an average of 8 years. By reducing informational problems, lending relationships hold the promise of cheaper and more plentiful finance for firms. On the other hand, they may also can lead to holdup and soft-budget constraint problems (and thus distorted investment choices) when firm-lender contracts are incomplete.

Various costs and benefits of banking relationships have been recognized and studied by a substantial theoretical and empirical literature (see Boot (2000) and Freixas and Rochet (1997) for references to many of the most important papers). This chapter is directed at a related but less-explored question; I instead ask '*when* are relationships valuable?' In particular, during periods when bank lending is constrained (in the extreme, during a 'credit crunch'), do banks cut back lending to all firms proportionately, or do they maintain lending to firms with whom they have broad, long-lasting relationships?

This question is of interest to economists for several reasons. From a macroeconomic perspective, many papers have found that small firms and young firms are disproportionately affected during episodes of depleted bank capital and low credit availability.[2]. But the underlying channels that generate these patterns are only partially understood (in part because of the paucity of micro-level panel data for bank dependent firms), and several different stories relating to the role of relationships are possible. One is that banks explicitly maintain lending to 'relationship' firms during such episodes and cut back lending to other firms; since the youngest or smallest firms have not had time to develop strong bank relationships, this helps explain why such firms do worse during periods of tight credit. Another is that relationships are a wash: perhaps all firms are proportionately rationed by financial institutions but small

[1] Boot (2000) in his review of the literature, identifies two key features of banking relationships: (i) The firm and the financial institution interact repeatedly, either over time or across a range of services (ii) As a result of past interactions, the financial institution obtains superior information (broadly defined) about the firm, and thus has an informational advantage over potential outside lenders.

Ongena and Smith (2000) provide cross-country evidence on the surprising diversity in the concentration of bank relationships across European countries.

[2] Gertler and Gilchrist (1994) argue that financial constraints explain why small manufacturing firms shrink more following monetary contractions. Perez-Quiros and Timmerman (2000) show that small firms' stock returns are more sensitive to measures of credit market conditions. Ding, Domaç and Ferri (1998) present evidence of a 'flight to quality' in lending during the Asian financial crisis (including a disproportionate decline in lending to small firms). Hancock and Wilcox (1998) show using data from the period of the US credit crunch of the early 1990s that declines in bank capital of small banks (who lend disproportionately to small businesses) had a larger effect on economic activity than declines in the capital of larger banks, and provide some statistically weaker evidence that the output and payrolls of small firms declined more substantially following the decline in bank capital.

Less directly, Hall (1987) and Evans (1987) show that older firms grow more slowly than young firms, consistent with the view that firms' investment opportunities do not increase proportionately with the firm's ability to finance them. Also, actions of the firm over time can help to reveal private information and build a reputation (Diamond, 1991), and build relationships with financial institutions (Sharpe 1990, Rajan 1992).

and young firms are less able to draw on alternative sources of finance because they are less well-capitalized, have less wealthy owners or are unable to draw finance directly from capital markets. Yet another is that conditional on age, relationships actually help small firms (relative to large firms) during such episodes, because small firms tend to have more concentrated lending relationships (thus there must have been some offsetting reason why small firms contract more than large firms). Distinguishing between these alternatives adds to our understanding of how 'credit crunches' and the bank lending channel of monetary policy affect real economic activity. As I show in a simple model, these are empirical questions to which standard theoretical models do not provide unambigous answers.

Secondly, the question is interesting from a microeconomic corporate finance perspective; since lending relationships are pervasive it is important to understand why banks and firms choose to form them. Perhaps they are more of an 'insurance policy' against times when banks cut back lending and raise lending standards than has been understood to date.

Finally, there are potential implications for the conduct of prudential policy: evidence that relationship capital becomes very valuable during times of tight bank credit perhaps strengthens the case for bailing out failing financial institutions (at least in the short run) during such episodes. (This is separate and in addition to the argument for aggresive prudential policy during times of banking system stress as a response to the heightened possibility of bank runs.)

The first part of the chapter examines the role of banking relationships using a simple model of credit-constrained bank lending, adapted from Holmstrom and Tirole (1997, hereafter HT). The value of relationships stems from a 'learning by lending' assumption: banks become more efficient monitors of the firm the more they lend to it.

This framework is then used to ask what happens following changes in credit conditions (a decline in bank equity which consequently increases the return on bank equity and widens intermediation spreads). As for several of the comparative statics results in HT's original paper, the answers are somewhat ambiguous. Under a wide range of assumptions, firms with exclusive relationships or a long history of borrowing from a single financial institution do experience a smaller increase in the cost of debt, and smaller declines in output, investment and profitability when credit conditions worsen. But these predictions are not completely robust, they depend to some extent on the form of the firm's production function (for example, if the production function is linear instead of concave, all firms experience a proportionate decline in credit availability when lending conditions worsen).

The somewhat ambiguous flavor of these theoretical predictions makes it is particularly important to provide empirical evidence on the link between relationships and credit conditions. The second part of this chapter presents such evidence, based on data from a World Bank survey of manufacturing firms during the Asian financial crisis of 1997-1998.

The estimation strategy is essentially a version of difference-in-differences. The Asian crisis especially in its early stages represented a substantial exogenous decline in the availability of credit. I am able to directly test the hypothesis that this decline in credit disproportionately affects firms with weak relationships since the World Bank survey includes several measures of the change in credit conditions experienced by the firm, as well as a variable measuring whether the firm was refused credit during three different time periods, one of which is before the onset of the crisis. The data also allows me to conduct a 'false positive' test of whether relationship variables were strong predictors of the availability of other forms of credit (such as trade credit, or loans from family and friends), allowing me to disentangle whether measured relationship variables do really reflect the intensity of bank-firm informational problems or rather are general proxies for unmeasured dimensions of firm quality or creditworthiness. As well as these reasons, the dataset is also attractive in that it surveys mainly small and medium sized unlisted enterprises for whom detailed data is not generally available, and provides two different measures of relationship strength (the number of financial institutions the firm deals with - a measure of the concentration of lending relationships, and the length of time the firm had been dealing with its relationship banks).

To preview my empirical results, I find that along several dimensions banks did indeed shift the availability of credit towards firms with strong relationships at the onset of the Asian financial crisis. In particular firms with strong banking relationships became substantially less likely to be refused a loan, less likely to self-report that availability of credit from banks had declined, and less likely to report that lack of bank finance had contributed to output declines. These findings are economically significant; for example, my central estimates suggest that during the early part of the crisis, loan refusal rates increased by 3 percentage points for firms who dealt exclusively with a single FI, but by between 9 and 17 percentage points for firms who dealt with multiple dispersed lenders. (In contrast, there was no significant difference in loan refusal rates before the crisis).

The rest of the chapter proceeds as follows. Section 2.2 of the chapter develops the theoretical model. Section 2.3 describes in more detail the empirical strategy, while Section 2.4 describes the World Bank dataset I use, and briefly reviews literature on the origins and consequences of the Asian financial crisis. Section 2.5 presents the main empirical results. Section 2.6 concludes.

2.2 Model

This section develops a simple theoretical framework for thinking about how the benefits and costs of banking relationships vary with bank credit conditions. The model highlights several basic points:

1. Under a fairly broad range of assumptions, a deterioration in borrowing conditions (modelled through an exogenous decline in bank capital) disproportionately impacts firms with weak banking relationships. The intuition is that lending relationships help alleviate financial frictions between banks and firms, making it easier and/or cheaper for banks to monitor the firms' activities. When financial institutions are credit constrained the cost of bank monitoring becomes extremely large. Consequently, the informational advantage provided by lending relationships is magnified.

2. Although fairly general, these conclusions are still, however, somewhat sensitive to the structure of the model. They depend, for example, on the sign of the third derivative of the firm's production function (for reasons similar to why, in the context of a consumer problem, precautionary savings depend on the third derivative of the utility function). Also, when firms' production functions are linear (rather than concave as I generally assume) an increase in the cost of funds reduces the availability of credit to all firms proportionately. This partial ambiguity highlights the importance of empirically testing the predictions examined in this section.

3. Most of the results developed below (predictions about the behavior of firm investment and output following a decline in credit conditions) are, at least in a one period framework, independent of the extent to which lenders are able to hold up the firm *ex post* (holdup problems have been highlighted in the literature as a primary cost of forming strong lending relationships). The reason is that, under Nash bargaining, the ex post division of rents between the bank and firm is Pareto optimal; thus, it is in the bank's interest to set marginal interest rates to maximize the firm's total profit (which under Nash bargaining also maximizes the bank's relationship rents).

A related theoretical contribution to the analysis presented here is Dell'Ariccia and Marquez (2000), who analyse how the degree of adverse selection in the credit market affects how banks reallocate lending following exogenous shocks. The main comparative static result they find is that incumbent banks are more likely to retain firms who are less able to signal their type. They consider the example of an incumbent bank facing competition from a low-cost foreign bank: the model predicts the foreign bank will draw away large transparent firms who can easily signal their type, but will retain more opaque firms who because of adverse selection the foreign bank will not accept. To make the link between the model here and theirs, the degree of adverse selection could be interpreted as a measure of relationship length or breadth between the firm and its financial institution.

2.2.1 Basic setup

The basic structure of the model is adapted from Holmstrom and Tirole (1997), hereafter HT. There are three types of risk neutral agents in the economy, firms, banks and uninformed investors. Firms raise capital for an investment project which matures at the end of the period. This project is partially financed by the firm's internal capital. Firms can also borrow money from uninformed investors, who demand an expected rate of return of 0. However, because of agency problems (described in more detail later) uninformed investors do not lend directly to the firm, but instead deposit funds in a bank, who then invests these deposits as well as some of its own capital in the project.

Structure of project. The firm's project is of variable size I and succeeds with probability p_H. The project produces gross return $f(I)$ if it succeeds, and 0 if it fails. This project is partially financed by the internal funds of the firm (A) and partially by external borrowing. The firm's ability to borrow is, however, limited by a moral hazard problem: firms have access to an alternative, negative net present value project which has a lower probability of success (p_L), but produces a stream of private benefits for the entrepreneur. Project choice is not contractible (outsiders can only observe whether the project succeeds or fails, not which project is chosen).

To ameliorate these moral hazard problems, the firm borrows through a bank, which has access to a monitoring technology: by spending an amount cI during the course of the period, the bank can reduce the private benefits sufficiently so that the firm chooses the positive net present value project.

Relationships. Holmstrom and Tirole (1997) assume the rationale for banks is that, through monitoring, they are able to reduce the degree of private benefits available to entrepreneurs. As a simple extension of this idea, I assume that the bank gets better at monitoring the firm more it monitors. In particular, as a simple, reduced-form way of modelling exogenous variation in banking relationships, I assume there are two types of firms. The first type have had long relationships with a single lender, for these firms $c = c_L$ but only when they borrow from that lender. The second type have less strong relationships with two different lenders. For these firms $c = c_M > c_L$ when they borrow from either lender. If firms borrow instead from an institution other than their current relationship banks, monitoring costs are higher again: $c = c_H > c_M$.

The idea is that banks undertake a variety of monitoring activities − examining financial statements, ensuring that loan covenants are being respected, checking on pledged collateral, and so on. The cost of such activities is substantially front-loaded, involving high costs initially as the bank makes contact with the firm, learns about the nature of its business, gets to know its management and accounting systems and so on. Over time, the bank learns more about the firm, and can monitor the firm's activities more efficiently. Higher monitoring costs with multiple lenders can also be viewed as a reduced-form reflection of congestion externalities and moral-hazard-in-teams problems associated with having multiple delegated monitors. Diamond and Rajan (2001), using a very different framework, make a similar type of assumption - namely that the relationship lender can liquidate the firm's assets for a higher amount than outside parties. In both cases, the superior skills of the relationship lender give them an improved bargaining position over outside lenders.

This modelling assumption, although simple, captures two key features of relationships:.(i) strong relationships improve the efficiency of delegated monitoring and thus reduce informational problems, but (ii) exclusive relationships introduce the possibility of *ex post* holdup.[3] For firms with a single bank, relationship rents are generated because of the fact it is costly for firms with exclusive relationships to shift to a new bank (due to the high up-front monitoring costs). It is assumed the bank captures a share ϕ of these relationship rents as per a Nash bargaining solution. On the other hand, for firms with two bank relationships, lenders compete *a la* Bertrand competition, driving each banks' share of the relationship rents to zero. Correspondingly, there are no holdup problems *ex-post*.

Banks. As mentioned above, through monitoring, banks are able to dissuade the firm from shirking and choosing the low probability project. The bank, however, also faces a moral hazard problem: since monitoring is costly and the bank's monitoring activities are not observable to outsiders, the bank must receive a large enough share of the project's returns to incentivize it to pay the cost of monitoring.

Exactly as in HT, banks partially compensate the firm for receipt of this share of project returns by investing some of their own capital in the project. I denote by β the equilibrium gross rate of return that banks earn on these funds invested in or spent monitoring the firm. ($\beta \geq 1$, since bank funds can always be lent to uninformed investors). As HT show, β is determined by the demand for and supply of bank capital, and is a decreasing function of the level of bank capital. A 'credit crunch' in this setup is an exogenous decline in the level of bank capital, which correspondingly increases the market clearing β.

[3] A number of papers have emphasized the role of banking relationships as implicit long-term contracts, and consequently the benefits of such relationships in reducing informational problems between lenders and firms. Sharpe (1990) presents an asymmetric information model in this vein, while Diamond (1991) shows how multiperiod bank-firm relationships help reduce project-choice moral hazard problems. Petersen and Rajan (1995) emphasize how ex-post market power can encourage banks to provide finance to allow small businesses to expand (the idea being that high profits earned from subsequent loans more than offset any losses made on the initial loan to the new small business).

Rajan (1992) emphasises hold-up problems associated with exclusive lending relationships. Von Thadden (1994) notes that these problems can be ameliorated by using multiple lenders; while Detragiache et al (2000) provide an alternative rationale for multiple banking relationships as insurance against the possibility of bank failure.

Timing. The timing of events is as follows:

(1) Banks' cost of funds (β) is revealed. HT show that shocks to bank equity will make financial institutions more credit constrained, and increase β. (In addition, the literature on the 'bank lending channel' shows that changes in monetary policy can also be a source of shocks to β.)

(2) Funds are lent to the firm, who invests in the variable scale project.

(3) Project succeeds (with probability p_H) or fails.

The firm's problem. The firm solves:

$$\max_{I} \pi_f = f(I) - R_b - R_u \tag{2.1}$$

subject to the following constraints:

$$\begin{array}{ll} [B-IC] & p_H R_b - \beta c I \geq p_L R_b \\ [B-IR] & p_H R_b \geq \beta[I_b + cI] \\ [U-IR] & p_H R_u \geq I_u \\ [feasibility] & I_b + I_u + A \geq I \end{array}$$

In words, the firm maximizes the output of the project $f(I)$ less payments to the bank (R_b) and uninformed depositors (R_u). Firstly, payments to the bank must satisfy the bank's incentive-compatibility constraint $[B - IC]$: ie. the expected payoff to the bank minus the opportunity cost of monitoring the firm must be at least as great as the bank's expected payoff if it does not monitor. The banks participation constraint $[B - IR]$ says R_b must also be large enough to provide an expected gross rate of return of β on the bank's inital outlay of funds (the amount invested in the project plus the amount spent monitoring the firm). Uninformed investors require an expected return of 0 on their investment of I_u, this is $[U - IR]$. The feasibility constraint simply states that all investment must be financed out of bank funds, the funds of uninformed investors or the firm's retained earnings A.

Each of the four constraints binds in equilibrium. Combining the equations and solving, the first-order condition for equilibrium investment I^* is:

$$f'(I^*) = \frac{1}{p_H} + \frac{c}{p_H - p_L}\left(\beta - \frac{p_L}{p_H}\right) \tag{2.2}$$

Note that $f'(I^*)$ is increasing (and therefore investment is decreasing) in c and β.

Profits, investment and holdup. As previously mentioned, firms with a single relationship bank are subject to the possibility of holdup. The expected return on an incremental unit of investment is $p_H f'(I)$, while the opportunity cost of the incremental funds lent to the firm by the bank and by uninformed investors.is $\frac{1}{p_H} + \frac{c}{p_H - p_L}\left(\beta - \frac{p_L}{p_H}\right)$. Following a Nash bargaining rule, the difference between these two on each incremental unit of investment are split between the bank (share ϕ) and the firm (share $1 - \phi$). Note that on the last unit of investment, the expected return from extra investment is exactly equal to the cost, so these rents will be zero. Since bargaining is ex-post efficient, it does not affect the profit maximizing level of investment from equation (2.2).

The profits of firms with a single exclusive lending relationship may be higher or lower than for firms eith multiple relationships. Let π_0 be the profits of the firm if it does not borrow from any of its current relationship lenders (ie. when monitoring costs are c_H). The profit of a firm with a single exclusive relationship is given by $\pi = \pi_0 + (1 - \phi)[\pi_{\max} - \pi_0]$, where $\pi_{\max}$ is the profit of the firm if there is no holdup. If the firm has a single relationship, $c = c_L < c_M$, so the surplus from the relationship is higher. But because part of this surplus is expropriated by the relationship bank (ie. ϕ is positive), the firms' net profits may be lower than for firms with two weaker relationships.

2.2.2 'Credit crunch'

We now consider the comparative statics effects of an increase in the credit constrainedness of banks: ie. a fall in bank capital and concomitant increase in β. HT show that such a shock leads to lower investment and profitability and an increase in interest rate spreads, here we examine how it differentially affects firms with strong and weak relationships.

This exercise can be conducted for several firm outcomes at date 1: output, investment, profitability and the firm's marginal and average cost of debt. These cases are discussed below, along with a discussion of whether and how the model's predictions are affected by the degree of ex-post holdup.

It turns out that for several of these measures, the model produces ambiguous predictions regarding whether 'strong relationship' or 'weak relationship' firms are more affected by the decline in the supply of credit. To build further intuition in these cases, I discuss sufficient conditions under which 'strong relationships' firms unambiguously perform better, and examine the parametric example $f(I) = I^\alpha$.

Cost of debt. The firm's marginal cost of debt $1 + r$ can be broken down into two components:

$$1 + r = \underbrace{\frac{1}{p_H}}_{1+r_{fb}} + \underbrace{\frac{c}{p_H - p_L}\left(\beta - \frac{p_L}{p_H}\right)}_{r_p} \tag{2.3}$$

$1 + r_{fb}$ is the first-best marginal cost of debt, the interest rate that would determine the firm's optimal level of investment in the absence of contracting problems. r_p is the deadweight cost of external finance. It reflects two factors: first, the physical cost of the bank having to spend resources monitoring the firm; and second that the rate of return on bank capital β is greater than one.[4]

What happens to the marginal cost of debt when β increases? The relevant derivative is:

$$\frac{dr}{d\beta} = \frac{c}{p_H - p_L} \tag{2.4}$$

This is unambigously increasing in c, implying that firms with multiple weaker relationships (c_M relative to c_L) experience a larger increase in the cost of debt.

Holdup does not affect this marginal cost of debt; since the Nash-bargaining over profits is Pareto optimal, this result is independent of the degree of holdup (ie. whether $\phi < 1$). On the other hand, holdup will however increase the *average* cost of debt for a firm with only one relationship bank; this is just the flip side of the fact that holdup reduces the firm's profits.

Investment. As the return on bank capital and the cost of funds increases, investment declines. The relevant derivative is:

$$\frac{dI}{d\beta} = \frac{c}{p_H - p_L} . \frac{1}{f''(I)} \tag{2.5}$$

Unlike the cost of funds, the second derivative $\frac{d}{dc}\left[\frac{dI}{d\beta}\right]$ cannot be signed unambiguously. Appendix A.1 shows that a weak sufficient condition for $\frac{d}{dc}\left[\frac{dI}{d\beta}\right] < 0$ (which would imply that firms with weak relationships experience a larger decline in investment) is $f'''(I) < 0$.

The intuition for this ambiguity in $\frac{d}{dc}\left[\frac{dI}{d\beta}\right]$ is as follows: even though the marginal cost of funds changes more for firms with weak relationships, the change in investment may still be larger for firms with strong relationships if the marginal product of investment is very insensitive to changes in investment in the relevant region for such firms. The condition $f'''(I) < 0$ rules out this possibility.

Even if $f'''(I) > 0$, in many cases firms with weak relationships will still be more sensitive

[4] If bank monitoring was contractible, the deadweight cost would be reduced to $\frac{c}{p_H}$, if firm effort was also contractible r_p would fall to zero.

to increases in the required rate of return on bank capital. In Appendix A.2 I work through the parametric example $f(I) = I^{\alpha}$. With this production function, the percentage decline in investment is always larger for firms with weak relationships (c_M instead of c_L), while the *absolute* decline in investment is larger for firms with weak relationships under the condition $\frac{p_H - p_L}{\beta p_H - p_L} + c > \frac{2-\alpha}{1-\alpha}$. This condition is satisfied as long as α is not too close to 1.

Output. Taking the derivative of output with respect to the bank's required rate of return yields the following expression:

$$\frac{df(I)}{d\beta} = \frac{c}{p_H - p_L} . \frac{f'(I)}{f''(I)} \tag{2.6}$$

Again the sign of the second derivative $\frac{d}{dc}\left[\frac{df(I)}{d\beta}\right]$ is ambiguous without further restrictions on the shape of $f(.)$. As before, assuming that $f'''(I) < 0$ is a sufficient but not necessary condition for the decline in output to be larger for firms with weak relationships to suffer a larger decline in output. However, in this case, the sufficient condition is even weaker than before (see Appendix A.2 for a discussion).

Again, in Appendix A.3 I consider the parametric example $f(I) = I^{\alpha}$, and as in the case for investment, find that the percentage change in output is unambiguously larger for 'weak relationship' firms. The absolute decline in output is larger as long as $\frac{p_H - p_L}{\beta p_H - p_L} + c > \frac{1}{1-\alpha}$. As in the case of investment, this condition is satisfied as long as α is not too close to 1, but is not satisfied as $\alpha \longrightarrow 1$.[5]

Note as well that because *ex post* bargaining is Pareto optimal, these results for both investment and output are independent of the degree of holdup (ϕ). This just directly follows from the fact that holdup only affects the firm's average cost of funds, not the firm's marginal cost of funds.

2.2.3 Summary and Discussion

The first basic conclusion of this section is that across a fairly broad range of assumptions about the shape of the firm's production function, firms with weak relationships (or equivalently by assumption, higher delegated monitoring costs) experience larger increases in the cost of funds and a larger fall in output, investment and profitability following a decline in the lending capacity of banks. The basic intuition is that when banks become credit constrained, monitoring resources are rationed and become expensive; since relationships help to minimize monitoring

[5] This condition is less stringent than the corresponding condition for investment (it is possible for firms with higher output to experience a proportionately larger fall in investment but proportionately smaller fall in output, since the firm's production function is concave).

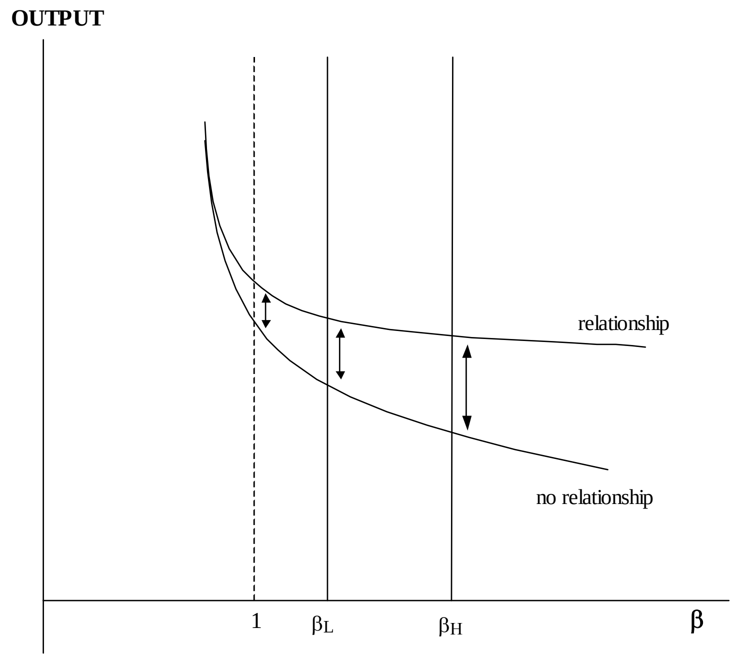


Figure 2-1: Effects of credit fluctuations

costs, they become more important during such episodes.

This is illustrated in a stylized way in Figure 1; 'relationship' represents a firm with a strong lending relationship (one lender with low monitoring costs). 'no relationship' is a firm with less strong lending relationships (two lenders with higher monitoring costs).

Ultimately, however, as the framework developed in this section highlights, whether or not relationships help more during periods of tight credit is an empirical question; partially because the framework sketched here may be an inperfect abstraction of reality, but also because, even in the model, the comparative statics results are somewhat ambiguous.

Consequently, the second part of this chapter is directed towards empirically estimating the link between credit conditions and the availability of credit to firms with different types of lending relationships.

2.3 Empirical Strategy

In this part of the chapter, I use firm-level data on a sample of privately held, bank-dependent firms to test the hypothesis that firm-lender relationships become more important during times of constrained bank credit, in the extreme, during a 'credit crunch'.

The primary data source (described in more detail below) is a series of World Bank surveys of manufacturing firms conducted in Thailand, Korea, Indonesia and the Philippines during the Asian financial crisis. The idea is that the crisis represented an exogenous decine in the availability of credit to firms (a summary of the case for this view is presented below). According to the framework just presented, this decline is likely to have affected firms with strong and weak relationships differently. In some sense, then, the estimation approach is a version of difference-in-differences.[6]

The model presented above implies a non-linear relationship between the amount of loanable funds and the benefits (in terms of loan size, investment, profits, cost of funds etc.) of relationship lending. Rather than estimating the non-linear equation as derived, I work with the following log-linear approximation (2.7) (See Appendix B for the derivation of this equation):

$$credit_{it} = \tau_t + \alpha.relation_i + \delta.borrow.cond_t + \gamma[relation_i.borrow.cond_t] + \Gamma X_{it} + \varepsilon_{it} \qquad (2.7)$$

$credit_{it}$ is a measure of the difficulty the firm has in obtaining loans from financial institution; the higher the index the more difficult or expensive it is to obtain finance. By log-linearizing, I can obtain equations in which $credit_{it}$ is the level of credit obtained by the firm, the inverse of the firm's cost of funds, or firm output or profitability.

$relation_{it}$ is an index of the strength of firm-lender relationships agency costs associated with lending to the firm. (ie. the stronger the relationship, the higher is $relation_{it}$). I use two different variables for this purpose: firstly the length of time the firm has been dealing with its primary bank, and secondly the extent to which the firm's relationships with banks are concentrated amongst a small number of institutions (ie. the number of financial institutions with which the firm deals). These variables are discussed in more detail in the next section.

$borrow.cond_t$ is the empirical analog of the inverse of β, the return on bank capital, and measures aggregate availability of credit from financial institutions (the higher the lending capacity of the financial sector, the higher is $borrow.cond_t$).

Finally, X_{it} is a vector of firm characteristics, τ_t a time-t fixed effect and ε_{it} a zero-mean error term.

The key prediction we want to test is $\gamma < 0$. That is, a decline in credit conditions has a greater effect on credit availability for firms without lending relationships (or with less strong relationships). Of some independent interest, the model also predicts $\alpha > 0$ and $\delta > 0$, ie that credit problems increase the worse the firm's lending relationships or or the worse the aggregate supply of credit; some results on this are also presented in the section that follows.

For some measures of credit availability, the survey contains both pre- and post-crisis data.

[6] See Meyer (1995) for a summary of difference in differences estimation.

This allows us to estimate equation (2.7) directly. In a number of other cases, the survey instead provides measures of the *change* in credit conditions, without providing pre-treatment and post-treatment data on the level of credit availability. For example: firms self report on a 1 to 5 scale whether credit from domestic banks became more restrictive during the crisis.

I can still use this type of data to recover an estimate of γ, by estimating the equation:

$$\Delta credit_{it} = \phi_0 + \phi_1 . relation_i + \eta \Delta X_i + \varepsilon_i \tag{2.8}$$

This is simply the first difference of the difference-in-differences equation [equation (2.7)]. Matching parameters, $\phi_1 = \gamma . \Delta borrow.cond_t$. So as before, as long as I take a stand on the sign of '$\Delta borrow.cond_t$' (ie, whether credit conditions worsened or improved), γ, the parameter that measures the relative performance of 'strong' and 'weak' relationship firms, can still be estimated.

2.3.1 Identification: 'Bad relationships' or 'bad firms'?

What factors determine the cross-sectional variation in banking relationships? And to what extent do differences in the strength of relationships simply proxy for unmeasured dimensions of firm quality?

These questions are crucially important to the validity of any causal interpretations of observed correlations between credit availability and the strength of relationships. On the one hand, there are plausible reasons why otherwise similar firms may differ substantially in the strength of their lending relationships. For example, in the game-theoretic framework developed in Sharpe (1990), banks optimally play randomized strategies when choosing whether to continue to extend credit to client firms, providing an immediate source of exogenous cross-sectional variation in relationship strength. Or the number of relationships may reflect idiosyncratic differences in the range of services offered by individual financial institutions in the firm's local banking market.

On the other hand, consider a scenario in which there are two types of firms, one of whom is for some reason less creditworthy than the other. The first class of firms will have greater difficulty obtaining loans; they are also likely to have shorter-lived, more dispersed lending relationships (ie. as incumbent lenders learn about the firm's type, they are unlikely to renew lines of credit or make new loans to the firm). Such a scenario could easily generate strong correlations between the intensity of lending relationships and the availability of credit, even if no causal relationship is present.[7]

[7] Cognizant of this problem, one strand of the literature eg. Slovin et al (1993) and Bae et al (2002) focuses

Few papers in the banking relationships literature have convincingly addressed these endogeneity problems. Although the data at hand does not offer any obvious instruments for either measure the intensity of banking relationships, I do pursue two different strategies that at least partially help to disentangle 'bad relationships' vs 'bad firms' explanations of my empirical results.

Firstly, as described above, I estimate correlations between relationships and credit relationships either in first differences or using a differences in differences approach (in contrast to most papers, who estimate these relationships in levels). The advantage of the former is that if there is some fixed difference between the supply of credit to firms with strong and weak relationships, it will be netted out upon first differencing.

Secondly, the survey data is sufficiently detailed to allow me to estimate the effect of banking relationships not just on the supply of bank credit, but the availability of other types of credit as well. For example, firms provide an estimate of the change in the availability of credit during the crisis not just from banks, but also from a variety of other sources: trade credit, moneylenders and family and friends. If relationships are simply a proxy for general informational problems, one would expect that weak relationships (ie. dealing with many lenders rather than one, or having a short relationship with the firm's primary bank) will be correlated with a decline in the availability of all sources of credit. If on the other hand, the relevant variables do actually measure the strength of *banking* relationships, firms with weak relationships should experience a decline in the availability of bank credit, but not necessarily other sources of credit.

2.4 Data

The primary data source is a series of firm-level surveys conducted in Indonesia, Korea, Thailand and the Philippines between December 1998 and February 1999.[8] The four surveys combined cover 3143 firms in seven manufacturing sectors: electronics, textiles, garnments, food processing, chemicals, machinery and auto parts.

Surveys were conducted by the respective governments of each of the four countries, with technical support provided by the World Bank. In each country, firms were selected randomly

on publicly listed firms, and examines the effect of bank failures on the stock market value of the bank's client firms.

Both the papers just mentioned do indeed find that client firms experience negative abnormal stock market returns around the date of the announced bank failure. This evidence is quite compelling prima facie, although one could argue the abnormal returns simply reflect that failure of a firm's bank is a bad signal about the quality of the firm. It is also somewhat unsatisfying in the sense that banking relationships are generally considered to be most important for small, privately-held firms, not the large public firms analyzed by these papers.

[8] A similar survey was also conducted in Malaysia, but the underlying data has not been made available for researcher use.

from a public directory of manufacturing firms. Detailed information on the target sample was then collected partially through face-to-face interviews with company employees, and partially through a written questionaire (the questionaire was used to collect more quantitative data, like balance sheet, production, and human resources information). As well as current information, firms reported retrospective balance sheet information for the 1996 and 1997 financial years as well as explicit measures of the extent to which the firm was affected by the deteriorating financial climate and the crisis more generally. (For example, firms reported whether or not they were refused credit for three different time periods encompassing both before and during the crisis). Hallward-Driemeier (2001) contains a more detailed description of the survey methodology and features.

Participation in the survey was, of course, voluntary, and response rates for this second part of the survey were somewhat lower than for the first, reflecting the fact that it was a written questionaire rather than a face-to-face interview, and that asked questions about quantitative data (eg. balance sheet and profit and loss details) for which firms either were unwilling to divulge, or did not keep detailed records.

Basic descriptive features of the data are summarized in Table 2.1 and Table 2.2. As the first part of Table 2.1 shows approximately 60 per cent of the firms are small and medium sized enterprises with less than 150 employees. Smaller firms have more concentrated banking relationships on average, with 74 per cent of small firms (<150 employees) dealing with only a single financial institution, compared to only 10 per cent of firms with more than 500 employees. The size distribution of firms in the survey is reasonably similar across countries, with a slightly higher proportion of large firms in the Philippines than in Thailand or Korea. Firms are spread unevenly across the seven represented manufacturing industries, with the largest proportion of firms coming from the 'garnments and textiles' and 'chemicals' subindustries.

Table 2.2 summarizes in more detail the balance sheet data provided by firms in the survey. Based on the reported data, firms were quite highly leveraged, with a book liabilities/assets ratio (measured at the end of 1996) of 0.65. (To the extent that the estimated book assets understate market values, this presents an overestimate of market leverage). Average leverage varied somewhat across countries, being highest in the Philippines and Korea and lowest in Indonesia. Profits averaged 14 per cent of book assets.

The survey provides two different measures of the strength of banking relationships: (i) the length of time the firm has been dealing with its primary bank, and (ii) the concentration of banking services, measured by the number of financial institutions the firm has relationships with. Long, continuous banking relationships are presumed to provide lenders with opportunities to glean private information about the firm, and to develop better and more efficient ways of monitoring. The 'number of relationships' variable is meant to capture both the idea that when a firm deals with many financial institutions, lending is less concentrated and there is thus less 'learning by lending', as well as other problems associated with multiple lenders (eg. moral hazard in teams problems in monitoring the firm, and the possibility of risk shifting amongst intermediaries with different levels of seniority). These two variables have been used in other contexts by a substantial number of papers in the literature on banking relationships (eg. see Petersen and Rajan, 1994, 1995, two of the most widely-cited papers).[9]

As shown in the table, across the whole sample firms dealt with on average 3.8 financial institutions. Smaller firms had more concentrated relationships than larger firms, as previously discussed. Firms had been dealing with their primary financial institution for an average of 11 years.

2.4.1 What happened in East Asia?

The Asian financial crisis began in the middle of 1997 and was characterized by large currency depreciations, a reversal of foreign capital inflows and sharp declines in output and investment in the main crisis-afflicted countries: Korea, Indonesia, Malaysia, Thailand and (to a lesser extent) the Philippines. The crisis was also associated with large declines in lending by financial institutions; the growth in total real credit in each of the crisis countries was strongly positive in the first half of 1997, but negative by the middle of 1998.[10]

The identification strategy described above assumes that aggregate borrowing conditions did indeed decline during the early part of the Asian crisis. This requires that the large decline in lending observed during this period is not just a reflection of declining investment opportunities, but resulted in part from a downward shift in the *supply* of credit. Several papers have examined the question of whether the Asian crisis was associated with a a supply-side credit contraction: a 'credit crunch'.

Ding, Domaç and Ferri (1998) collect a substantial amount of information about lending, intermediation spreads and so on for East Asian countries during the crisis period. Beyond the simple fact that credit declined, they also find: (i) a shortening of the maturity on new lending to firms (ii) a 'flight to quality' in lending: that is, a substitution towards larger firms and away from small and medium enterprises (iii) an increase in intermediation spreads (the difference

[9] The empirical literature has had some success in discovering positive benefits of lending relationships using these measures. Using US data from the Survey of Small Business Finance, Petersen and Rajan (1994) find that firms with long relationships with their primary lender rely more on bank credit and less on alternative costly forms of finance such as trade credit. Using the same data source, Berger and Udell (1995) find that for lines of credit, strong relationships are associated with lower interest rates on bank loans. D'Auria et al. (1999), using panel credit registry data on a sample of Italian firms, find that more concentrated banking relationships are correlated with lower interest rates paid by firms, although longer banking relationships are not.

[10] See Domac and Ferri (1999). As one dramatic example, the growth rate in lending by private banks in Indonesia dropped from +30 per cent around the middle of 1997 to -40 per cent in the latter part of 1998.

between lending rates and market interest rates), and (iv) where observable, an increase in the rejection rate by financial institutions of new loan applications.

These factors are consistent with a supply-driven decline in credit. At least some if not all are consistent with the alternative hypothesis that credit fell passively as a response to declining firm prospects. Cognizant of this identification problem, other papers have tried various methodologies to disentangle supply and demand components of the aggregate fall in credit. Agenor, Aizenman and Hoffmaister (2000) calculate estimates of bank excess liquid assets in Thailand – the idea being that a demand-induced decline in credit will show up as an increase in excess reserves. They find no evidence that such a buildup of excess reserves occurred, consistent with the view that the decline in credit was supply-induced. In related work, Ghosh and Ghosh (1999) estimate equations for the demand and supply of credit in Indonesian and Korea. They find during the early part of the crisis (until the first quarter of 1998) that supply of credit was the short side of the market. From then onwards, aggregate credit is demand constrained, as Indonesia and Korea slipped into deep recessions.

Ito and Pereira de Silva (1999), focusing on macroeconomic data and a survey of commercial banks in Thailand, find evidence of increases in credit spreads, a decline in total intermediation, and a reduction in credit even to groups (such as exporters) who might have expected to benefit from a depreciation in the Thai baht. The latter piece of information in particular is cited as evidence of a supply-side reduction in credit.

Finally, the effects of the crisis on the lending standards of financial institutions is demonstrated in the summary statistics presented in Table 2.2. In the first six months of 1997 (before the beginning of the crisis) 9 per cent of firms were refused credit by a financial institution. This percentage rose sharply to 18 per cent in the second half of 1997, and 23 per cent for January-June 1998.

On the other hand, Dollar and Hallward-Driemeier (2000) and Dwor-Frecaut et al (1999) cite evidence from the same World Bank survey used in this chapter that the most important concern of firms during the crisis was a lack of aggregate demand, rather than explicit credit rationing. Responses to other survey questions do however seem to indicate a shortage of credit, at least for a sizeable number of firms. Firstly, firms in the World Bank survey overwelmingly reported that credit availability from banks had become more restrictive (in Thailand for example, 69 per cent of firms reported that credit had become more restrictive, while only 3 per cent reported that it had become less restrictive). Secondly, as the model from Section 2.2 shows, a shortage of bank credit may rear its head in terms of wider intermediation spreads and a higher cost of debt for firms, rather than explicit credit rationing; this is relevant since Ding, Domaç and Ferri (1998) document that intermediation spreads increased substantially during the crisis, and high interest rates *were* generally cited as one of the most important causes of output declines by firms.

Taken as a whole, this literature suggests the availability of credit from financial intermediaries did deteriorate markedly during this period, especially over the early part of the crisis (the second half of 1997 and early part of 1998). The 'credit crunch' was perhaps less important in propagating the crisis than the precipitous decline in exchange rates and the sudden reversal in foreign investment, although such statements are difficult to make definitively, given the difficulty in disentangling cause and effect. (Caballero and Krishnamurthy, 2003, for example, show how the interaction between domestic and international credit constraints can substantively influence the behavior of the exchange rate during periods of financial crisis.)

2.5 Evidence

In this section, I present results from estimating equations (2.7) and (2.8) using several different measures of the availability of credit, and the two measures of the intensity of banking relationships discussed earlier: ie. the length of the firm's relationship with its primary financial institution (log(1 + relationship length in years)), and the concentration of the firm's interaction with financial institutions (log(1+no. of banking relationships)).

In each case, a range of controls for firm characteristics are included in the specification: firm size (log assets), profitability (profits / assets at the end of 1996), leverage (debt / assets at the end of 1996), age (log(1+firm age in years)), and a set of industry*country interaction dummies. I also experimented with more parsimonious models, in which some or all of these controls were excluded from the regressions (this did not in general have much of an effect on the results, as discussed below).

2.5.1 Availability of credit from domestic banks

As a first measure of the severity of credit constraints, firms in two of the four countries, Indonesia and Korea, were asked to assess on a five point scale how the availability of bank credit to their firm had evolved since the beginning of the crisis (where 1= availability of bank credit significantly increased, 5 = availability of bank credit significantly decreased).

I estimate equation (2.8) using this measure as a proxy for $\Delta credit_{it}$. Results are presented in Table 2.3. Since the dependent variable is measured on a discrete scale, the equation is estimated as an ordered probit. The resulting estimates are then scaled to represent the marginal expected rate of change of the relevant RHS variable on the dependent variable. This is calculated as an average derivative across observations in the sample, ie. by adding a small increment to the value of the RHS variable for each observation and calculating the resulting rate of change in the dependent variable.[11]

Column 1 presents the baseline estimates, in which data from both countries is combined into a pooled sample. Examining these estimates, both relationship variables indicate that firms with weak relationships were substantially more likely to experience a deterioration in lending conditions. A doubling of relationship length (eg. from 2 to 4 years) improved the respondent's impression of credit conditions by 0.17 points, while doubling the intensity of relationships (eg from dealing with four lenders to dealing with only two) improved the respondent's view of credit conditions by 0.18 points. Both these estimates are statistically significant at the 1 per cent level.

The other coefficient estimates are generally consistent with accounts in the literature about a 'flight to quality' in lending in East Asia during the crisis. Namely, younger firms experienced a larger decline in the availability of bank credit conditions, as did firms with higher debt levels prior to the onset of the crisis. Interestingly, firm size was not significantly correlated with changes in credit availability (at least after controlling for other firm characteristics).

Column 2 presents a more parsimonious specification in which several of the balance sheet variables are omitted from the regression. This allows for a larger sample size (since a number of firms, especially smaller firms, did not report complete balance sheet information, perhaps because they did not maintain detailed accrual accounting records). The results are broadly similar to before (the coefficient on relationship length is somewhat smaller, while the coefficient on the number of lenders is somewhat larger, both are still statistically significant at the 1 per cent level).

Finally, columns 3 and 4 estimate the same model separately for Korea and Thailand, rather than using the combined pooled dataset. Quantitatively, the results from these country-specific regressions are similar to before, although the standard errors are somewhat larger reflecting the smaller individual sample sizes (especially for Thailand, the smaller of the two subsamples).

2.5.2 Availability of credit from other sources

As highlighted by the earlier section on identification issues, it is not obvious ex ante whether the measures of relationship strength used in the last regression do indeed reflect exogenous sources of variation in bank-firm informational problems; a plausible alternative is that they simply proxy for unmeasured dimensions of firm quality or firm creditworthiness.

Without a valid instrument for the strength of relationships, it is difficult to resolve this issue

[11] The 'dprobit' command in STATA uses the same procedure to scale probit estimates to reflect the effect of a change in RHS variables on the probability of observing a value of 1 for the binary dependent variable. (There is no equivalent command for ordered probits or bivariate probits, so in these cases I hand-coded the calculation instead.)

entirely. However, one way of distinguishing between these two hypotheses is to examine how firms rated the availability of sources of credit *other* than bank credit. According to the second explanation, (that measured 'bad relationships' are simply a proxy for 'bad firms') firms with weak relationships should have experienced a larger decline in credit availability proportionately from all sources. On the other hand, if the measured bank relationships variables do measure exogeous differences in relationship strength, the deterioration in credit availability should be most pronouced for bank finance in particular, and less so for other credit sources.[12]

Fortunately, the World Bank survey asks several questions that do indeed allow us to conduct such a test. Namely, for the same two countries, Korea and Thailand the survey asks firms to rate changes in the availability of credit not just from domestic banks, but also from three other sources: suppliers, family and friends and moneylenders. (These four questions are all worded in the same way, and answers are measured on the same five point scale ie. 1= availability of credit from source in question significantly increased, 5 = availability of credit from source in question significantly declined).

Thus, I re-estimate the model in equation (2.8), replacing the dependent variable with each of these three alternative measures of credit availability (suppliers, family and friends, and moneylenders) in turn. There is unfortunately a sample selection issue - some firms answered the question for some but not all of the credit sources, meaning that the sample is different in each case. To minimize these sample selection problems, each time I estimate a regression using one of the alternative sources of credit as the dependent variable, I re-estimate the 'availability of bank credit' regression using the same sample. These two regressions, which by construction are based on the same sample of firms, can then be compared side-by-side.

Results are presented in Table 2.5. The table is split in three (banks vs trade credit, banks vs moneylenders and banks vs family and friends), in each case the results for the alternative form of credit are presented in the first column, then the results for bank credit, based on the same sample, in the second column.

As in Table 2.3, the relationship variables are statistically significant predictors of the change in the availability of bank credit for each subsample (generally at the 5 per cent or 1 per cent level). But notably, this is not true for the alternative sources of credit. In each case, neither of

[12] Note that we should not necessarily expect, even if the available variables do genuinely measure exogenous variation in relationship strength, that there will be literally no correlation between relationship strength and the supply of (for example) supplier credit.

The reason why is that inferior access to bank credit for firms with weak relationships is likely to have a 'follow on' effect on the willingness of others (suppliers, moneylenders and so on) to provide finance to the firm, simply because the firm's overall debt capacity will be lower.

So we should not necessarily expect no relationship between relationship variables and supply of non-bank forms of credit. We should, however, find the correlations are substantially smaller than for the availability of bank credit.

the relationship variables is statistically significant, and, although the coefficients are generally correctly signed, the point estimates are always substantially smaller than the corresponding cofficient from the bank credit regression.

This consistent picture lends credence to the idea that the bank relationship variables are more than simply proxies for omitted measures of firm creditworthiness. Weak banking relationships particularly affected firms' ability to garner credit from domestic banks – but the effect on firm's access to other forms of credit was much weaker and in fact not statistically distinguishable from zero.

2.5.3 Was the firm refused credit by a financial institution?

Although interesting, firms' qualitative answers about changes in the availability of credit are somewhat difficult to interpret in terms of real economic outcomes. We now turn to an alternative measure of credit constrainedness, provided by firms' answers to the question: 'Were you refused credit by a financial institution during the period [...] to [...]?'

Under a pecking-order type model (Myers and Majluf, 1984) firms first attempt to rely on internal finance to fund working capital and investment; firms who are unable to do so rely on external debt and then equity finance. Firms who were unable to obtain external debt finance occupy a lower position in the pecking order than those who either did receive debt finance, or did not seek it because they were able to finance operations and investment out of retained earnings.

Firms in the survey answer the question 'Were you refused credit by a financial institution?' for three different time periods: January-June 1997 (pre-crisis), July-December 1997 (as the crisis was beginning) and January-June 1998 (during the middle of the crisis period). This time series dimension is attractive in that it allows us to separately identify the before-and-after effect of relationships on this measure of credit-constrainedness ie. to estimate the differences-in-differences equation (2.7).

I estimate two separate bivariate models.[13] In the first model, the dependent variables are

[13] The reason for estimating only two of these three periods at once is a practical one: the bivariate probit is estimated using numerical techniques, and when three equations are used instead of two, computation time becomes extremely long because of the need to evaluate triple integrals when producing the parameter estimates. For this reason, STATA does not provide an option for estimating trivariate probits, and I was unable to find an ado file for performing such a regression.

I did, however, estimate a bivariate probit based on the *first difference* of whether the firm was refused credit. That is, the dependent variables in the two equations are $[I(Jan - Jun\ 1998) - I(Jan - Jun\ 1997)]$ and $[I(Jul - Dec\ 1997) - I(Jan - Jun\ 1997)]$, where $I(x)$ is an indicator variable: $I(x) = 1$ if the firm was refused credit during period 'x', and $I(x) = 0$ otherwise.

Results from this regression (available on request) are very similar to those displayed in Tables 5 and 6 - namely that the coefficient on the concentration of bank relationships is significant in both equations, while the coefficient on relationship length is not.)

indicator variables for whether the firm was refused credit in the (pre-crisis) period January-June 1997, and then in the period January-June 1998. In the second model, the periods covering January-June 1997 and July-December 1997 are used instead. Since the probability of a given firm being refused credit is likely to be strongly correlated.across the two periods, a bivariate probit that explicitly allows for such within-firm correlations is used to estimate these two models.

Results for the first set of bivariate probit regressions are presented in Table 2.5. First we turn attention to the 'number of relationships' variable. In the pre-crisis period (Jan-Jun 1997) this variable is positive but not statistically different from zero. In the post crisis period, however, the magnitude of the coefficient increases by nearly a factor of six, and becomes statistically significant at the 1 per cent level. Doubling the concentration of the firm's lending relationships (eg. from 4 to 2) reduces the probability that the firm is refused credit in the within-crisis period by 11 percentage points. In the pre-crisis period, the corresponding probability is only 2 percentage points (not statistically different from zero). The differences-in-differences parameter γ (i.e.. the coefficient on the interaction term $relation_i{*}borrow.cond_t$) is found as the difference between these two probabilities: 0.112 - 0.02 = 0.092. As the table shows, this coefficient is statistically different from zero at the 1 per cent level (p=0.0022).

This result suggests that relationships did indeed become much more important during the crisis. On the other hand, for the relationship length variable, the results are much less pronounced. The coefficient has the expected negative sign, and is slightly larger in magnitude after the crisis than before (-0.029 compared to 0.025). But the difference between these two parameter estimates is economically small and statistically insignificant (p = 0.507).

Results for the second set of bivariate probit regressions (in which the two dependent variables cover Jan-Jun 1997 and July-Dec 1997) are similar. Again, the coefficient on the concentration of relationships (log(1+number of relationships)) becomes highly statistically and economically significant during the crisis, and the change in the parameter between the two equations is statistically different from zero at the 1 per cent level. But again, the coefficient on log(1+relationship length) is not statistically significant.

The chart below breaks down in more detail the correlation between lending concentration and the availability of bank finance before and during the crisis. The graph is based on estimates from Columns 3 and 4 of Table 2.5 and Table 2.6, in which I use a more flexible version of the log(1+number of relationships) variable by replacing it with several dummy variables corresponding to the number of relationships (ie. firm dealt with 1, 2, 3, 4, 5 or 6+ lenders).

As the chart shows, before the crisis there is no statistically or economically significant link between the concentration of relationships (one exclusive lender rather than many) and the probability of being refused a loan. But in the second half of 1997 and first half of 1998,

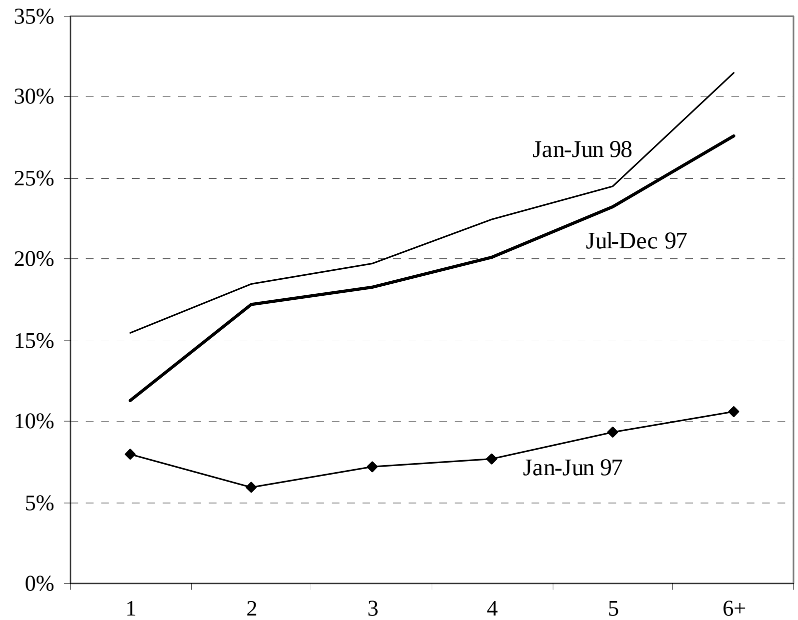


Figure 2-2: Prob. refused credit (y axis) vs concentration of banking relationships (x axis)

firms who dealt exclusively with one financial institution were much less likely to have been denied credit. During the early part of the crisis, the probability of experiencing a loan refusal increased by 3 percentage points for firms who dealt with one institution, but by between 9 and 17 percentage points for firms who dealt with multiple dispersed lenders.

2.5.4 Did insufficient bank finance result in lower output?

We now consider an additional dimension of the connection between lending relationships and the availability of credit – the extent to which insufficient credit from financial institutions contributed to the decline in output experienced by many firms during the crisis.

The World Bank survey asked firms in all countries whether output from their factory had declined since the onset of the crisis. Firms whose output had declined were then asked to rank the importance of different factors as causes of the decline in production. Among the reasons suggested by the survey were (i) insufficient bank finance for working capital (ii) insufficient finance from suppliers and (iii) insufficient revenue. As with several other questions, respondents ranked each factor on a five point scale from 1 (not at all important) to 5 (very important).

Following the same procedure as for the estimates presented in Table 2.3 and Table 2.4, I estimate equation (2.8) by ordered probit, using each of these variables in turn as a proxy for

$\Delta credit_{it}$. As before, we want to test (a) whether the relationship variables are statistically significant predictors of the extent to which insufficient bank finance contributed to the decline in output and (b).whether the relationship variables are more important in explaining the importance of bank finance for output than for other rival explanations for the decline in output (our check on the endogeneity of the bank relationship variables).

Results from these three regressions are presented in Table 2.7. Column 1 examines whether strong- and weak-relationship firms differed in the extent to which they ranked 'lack of bank finance for working capital' an important determinant of lower output. Both measures of relationships are correctly signed (ie. longer and more concentrated relationships are correlated with bank credit being a less important determinant of lower output). The 'concentration of relationships' measure is statistically significant at the 1 per cent level; the coefficient of 0.327 implies that doubling the concentration of the firm's lending patterns (eg. relationships with two institutions rather than four) reduces the extent to which the firm cited bank credit as a significant reason for lower output by around a third of a point (on a 1-5 scale). As in Tables 2.5 and 2.6, results for the 'length' dimension of relationships are less strong - the coefficient estimate of -0.053 is correctly signed but not statistically different from zero.

Results from Column 1 can then be compared to Column 2 (dependent variable: inadequate revenue as a reason for output declines) and Column 3 (dependent variable: inadequate credit from suppliers as a reason for output declines). In Column 2, the lending concentration measure of bank relationships drops by 2/3 relative to Column 1, and is only statistically significant at the 10 per cent level, while the 'relationship length' measure of bank relationships becomes incorrectly signed (although still not statistically significant). In Column 3, the lending concentration measure of bank relationships is significant at the 5 per cent level, although the point estimate is still much smaller than in Column 1.

These results are somewhat more ambiguous than those in Tables 2.3 and 2.4, especially for the 'length' dimension of relationships. However, they are still consistent with the basic prediction stated earlier: namely that relationships are better predictors of the extent to which bank credit caused lower output, than predictors of output declines. This adds some further weight to the hypothesis that the relationship variables are not simply general proxies for unmeasured dimensions of firm quality.

2.5.5 Summary and Discussion

At the onset of the Asian financial crisis, a period during which bank credit conditions appeared to have tightened considerably, I find evidence that firms with concentrated lending relationships or long-standing relationships with their primary lender experienced a substantially smaller decline in the availability of credit. Firms with strong banking relationships became substantially less likely to be refused a loan, less likely to self-report that availability of credit from banks had declined, and less likely to report that lack of bank finance had contributed to output declines.

These findings are economically significant; for example, my central estimates suggest that during the early part of the crisis, loan refusal rates increased by 3 percentage points for firms who dealt exclusively with a single FI, but by between 9 and 17 percentage points for firms who dealt with multiple dispersed lenders. Firms with more concentrated lending patterns did not enjoy a statistically significant advantage in terms of loan refusal rates before the crisis began. Also, the strength of banking relationships predicts changes in the availability specifically of *bank* credit, but not other types of credit, suggests measured relationship variables do genuinely capture some measure of specific informational problems between banks and firms, rather than simply being general proxies for unobserved dimensions of firm quality.

Finally, the results presented above were somewhat stronger for the 'concentration' measure of banking relationships (ie. the extent to which financial services and borrowing occurred with a single or small number of institutions) than the 'length' dimension of relationships, which was correctly signed but not statistically significant in every specification. The reason for this finding is not obvious from the data at hand, but it might suggest for example that free rider problems associated with 'duplicated monitoring' externalities may become particularly significant during times when bank lending is credit constrained.

2.6 Conclusions

The first contribution of this chapter is to provide empirical evidence on the proposition that banking relationships are most valuable to firms during periods when credit is tight, in the extreme during a 'credit crunch'. I present a simple model that highlights the conditions under which we might expect such a prediction to hold true, and then present empirical evidence exploiting the exogenous decline in bank credit conditions at the beginning of the Asian financial crisis – several pieces of evidence suggest that during this period, financial institutions did, on average, maintain lending to firms with whom they had long, exclusive relationships, while cuting back lending to other firms.

As well as being interesting from a purely corporate finance viewpoint, the evidence presented here provides a new perspective on the macroeconomic 'flight to quality' in lending often observed during times of financial crisis. For example, they imply the fact that younger firms have had less time to build relationships with lenders accounts for some part of the reason why young firms often suffer more during such episodes. It also perhaps suggests new arguments for procyclical capital requirements, and/or aggressive lender of last resort policies – in addition to any concerns about bank runs, the cost of allowing a financial institution to fail may be much larger during a time of crisis, because of the enhanced value of the relationship capital embodied in the threatened institution (see Diamond, 2001, for a further discussion of related prudential policy issues).

Finally, on a methodological level, the empirical work in this chapter takes some early steps to address the endogeneity problems that bedevil much of the empirical literature on relationship banking. In particular, the fact that I find banking relationships are strong predictors of changes in the availability of bank loans in particular, but not other types of credit, suggests measured relationship variables do in fact capture something about the specific informational problems between banks and their client firms. Addressing these endogeneity problems more comprehensively remains an important challenge for future research.

2.7 References

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2.8 Appendix A: Proofs and calculations

2.8.1 Sufficient conditions for $\frac{d}{dc}\left[\frac{dI}{d\beta}\right] < 0$ and $\frac{d}{dc}\left[\frac{df(I)}{d\beta}\right] < 0$

Sign of $\frac{d}{dc}\left[\frac{dI}{d\beta}\right]$. The rate of change of investment with respect to the required rate of return on bank capital is:

$$\frac{dI}{d\beta} = \frac{c}{p_H - p_L}.\frac{1}{f''(I)} < 0 \tag{2.9}$$

The second derivative $\frac{d}{dc}\left[\frac{dI}{d\beta}\right]$ is given by:

$$\frac{d^2 I}{dcd\beta} = \underbrace{\frac{1}{p_H - p_L}.\frac{1}{f''(I)}}_{<0} \underbrace{- \frac{c}{p_H - p_L}\frac{dI}{dc}\left[\frac{f'''(I)}{f''(I)^2}\right]}_{<0 \text{ if } f'''(I)<0} \tag{2.10}$$

So thus the sign of $\frac{d}{dc}\left[\frac{dI}{d\beta}\right]$ is ambiguous. A sufficient (although not necessary) condition for $\frac{d}{dc}\left[\frac{dI}{d\beta}\right] < 0$ is $f'''(I) < 0$. As an example of how this condition is not necessary is shown below, using the parametric production function $f(I) = I^\alpha$. Even though $f'''(I) > 0$, $\frac{d^2 I}{dcd\beta} < 0$ as long as α is not too close to 1.

Sign of $\frac{d}{dc}\left[\frac{df(I)}{d\beta}\right]$. In this case the second derivative is given by:

$$\frac{df(I)}{d\beta} = \frac{1}{p_H - p_L}.\frac{f'(I)}{f''(I)} + \frac{c}{p_H - p_L}\frac{dI}{dc}\left[1 - \frac{f'''(I).f'(I)}{[f''(I)]^2}\right] \tag{2.11}$$

So again the sign of $\frac{d}{dc}\left[\frac{df(I)}{d\beta}\right]$ is ambiguous, and as in the case of investment $f'''(I) < 0$ is a sufficient condition for the decline in output to be larger for firms with weak relationships. But in this case, the sufficient condition is even weaker than before - it is possible for $\frac{d^2 I}{dcd\beta} > 0$ but $\frac{d^2 f(I)}{dcd\beta} < 0$ (although not the converse) because the firm's production function is concave.

2.8.2 Parametric example: $f(I) = I^\alpha$

This appendix assumes a production function of the form $f(I) = I^\alpha$, and examines conditions under which firms with weak relationships (high c) experience larger percentage and/or absolute declines in output, investment, profitability and the cost of funds. In other words, I try to sign the second derivative $\frac{d^2 x}{dcd\beta}$ for different x's (i.e. $x = I$, $ln(Y)$ etc.).

Percentage change in investment.

$$\frac{dI}{d\beta} = \frac{c}{p_H - p_L} . \frac{1}{f''(I)}$$

Recall that the first order condition for investment is:

$$f'(I^*) = \frac{1}{p_H} + \frac{c}{p_H - p_L}\left(\beta - \frac{p_L}{p_H}\right)$$

Substituting in $f'(I^*) = \alpha I^{\alpha-1}$ and taking logs gives us:

$$\ln I = \frac{1}{\alpha - 1} \ln \left[\frac{\frac{1}{p_H} + \frac{c}{p_H - p_L}\left(\beta - \frac{p_L}{p_H}\right)}{\alpha} \right]$$

Taking the derivative w.r.t. c gives us

$$\frac{d \ln I}{dc} = \frac{1}{\alpha - 1} \frac{\frac{1}{p_H - p_L}\left(\beta - \frac{p_L}{p_H}\right)}{\frac{1}{p_H} + \frac{c}{p_H - p_L}\left(\beta - \frac{p_L}{p_H}\right)}$$

Now taking the second derivative yields:

$$\begin{aligned}
\frac{d^2 \ln I}{dcd\beta} &\propto -\left[\left[\frac{1}{p_H} + \frac{c}{p_H - p_L}\left(\beta - \frac{p_L}{p_H}\right)\right]\frac{1}{p_H - p_L} - c\left[\frac{1}{p_H - p_L}\right]^2\left(\beta - \frac{p_L}{p_H}\right)\right] \\
&\propto -\frac{1}{p_H}\frac{1}{p_H - p_L} < 0
\end{aligned}$$

Thus the percentage decline in investment is unambiguously higher for firms with weak relationships (c_M relative to c_L).

Percentage change in output.

$$\begin{aligned}
\frac{dlnY}{dc} &= \frac{d \ln Y}{d \ln I} . \frac{d \ln I}{dc} \\
&= \alpha \frac{d \ln I}{dc}
\end{aligned}$$

Thus $\frac{d^2 \ln Y}{dcd\beta} = \alpha \frac{d^2 \ln I}{dcd\beta} < 0$. So the percentage decline in output is also unambiguously higher for firms with weak relationships (c_M relative to c_L).

Absolute change in investment. From the first order condition in the main text, optimal investment is given by:

$$I = \left[\frac{\frac{1}{p_H} + \frac{c}{p_H - p_L}\left(\beta - \frac{p_L}{p_H}\right)}{\alpha} \right]^{\frac{1}{\alpha-1}}$$

So taking the derivative w.r.t. β :

$$\begin{aligned}
\frac{dI}{d\beta} &= \frac{c}{p_H - p_L}\frac{1}{\alpha(\alpha-1)}\left[\frac{\frac{1}{p_H} + \frac{c}{p_H - p_L}\left(\beta - \frac{p_L}{p_H}\right)}{\alpha} \right]^{\frac{2-\alpha}{\alpha-1}} \\
&= \frac{c}{p_H - p_L}\frac{1}{f''(I^*)} < 0
\end{aligned}$$

Taking the second derivative, we find that:

$$\frac{d}{dc}\left[\frac{dI}{d\beta}\right] \propto -\{ \left[\frac{\frac{1}{p_H} + \frac{c}{p_H - p_L}\left(\beta - \frac{p_L}{p_H}\right)}{\alpha} \right]^{\frac{2-\alpha}{\alpha-1}} + \frac{2-\alpha}{\alpha(\alpha-1)}\frac{\beta - \frac{p_L}{p_H}}{p_H - p_L}\left[\frac{\frac{1}{p_H} + \frac{c}{p_H - p_L}\left(\beta - \frac{p_L}{p_H}\right)}{\alpha} \right]^{\frac{2-\alpha}{\alpha-1}-1} \}$$

Can show from this expression that $\frac{d}{dc}\left[\frac{dI}{d\beta}\right] < 0$ iff

$$\frac{p_H - p_L}{\beta p_H - p_L} + c > \frac{2-\alpha}{1-\alpha}$$

This condition is satisfied for a small enough α, but is not satisfied as $\alpha \longrightarrow 1$.

Absolute change in output.

$$\frac{dY}{d\beta} = \frac{dY}{dI}.\frac{dI}{d\beta} = \frac{c}{p_H - p_L}\frac{1}{\alpha(\alpha-1)}\left[\frac{\frac{1}{p_H} + \frac{c}{p_H - p_L}\left(\beta - \frac{p_L}{p_H}\right)}{\alpha} \right]^{\frac{1}{\alpha-1}}$$

So

$$\frac{d^2Y}{d\beta dc} \propto -\{ \left[\frac{\frac{1}{p_H} + \frac{c}{p_H - p_L}\left(\beta - \frac{p_L}{p_H}\right)}{\alpha} \right]^{\frac{1}{\alpha-1}} + \frac{1}{\alpha(\alpha-1)}\frac{\beta - \frac{p_L}{p_H}}{p_H - p_L}\left[\frac{\frac{1}{p_H} + \frac{c}{p_H - p_L}\left(\beta - \frac{p_L}{p_H}\right)}{\alpha} \right]^{\frac{1}{\alpha-1}-1} \}$$

Simplifying this expression as before, $\frac{d}{dc}\left[\frac{dI}{d\beta}\right] < 0$ iff:

$$\frac{p_H - p_L}{\beta p_H - p_L} + c > \frac{1}{1-\alpha}$$

Again, this condition is satisfied for a small enough α, but is not satisfied as $\alpha \longrightarrow 1$. It is however a less stringent condition than for investment, the reason being that since the production function is concave, it is possible for firms with higher output to experience a proportionately larger fall in investment but proportionately smaller fall in output (the converse is not possible).

2.8.3 Log-linearization

$I(c,\beta)$ denotes that variable I is a function of c and β. I could variously be log-output, investment, borrowing capacity etc., and is a negative function of both arguments c and β. We can always rewrite the expression for $I(c,\beta)$ as:

$$\begin{aligned} I(c,\beta) &= I(c_0,\beta_0) + [I(c,\beta_0) - I(c_0,\beta_0)] + [I(c,\beta) - I(c,\beta_0)] \\ &= I(c_0,\beta_0) + \underbrace{[I(c,\beta_0) - I(c_0,\beta_0)]}_{\#1} + \\ &\quad \underbrace{[I(c_0,\beta) - I(c_0,\beta_0)]}_{\#2} + \underbrace{[I(c,\beta) - I(c,\beta_0)] - [I(c_0,\beta) - I(c_0,\beta_0)]}_{\#3} \end{aligned} \tag{2.12}$$

where the 0 subscripts denote baseline levels of β and c, where $\beta_0 < \beta$ and $c_0 < c$. Taking a Taylor series approximation, I can rewrite the parts of this expression: $\#1 \approx [c - c_0] \left.\frac{dI(c,\beta_0)}{dc}\right|_{c=c_0}$, $\#2 \approx [\beta - \beta_0] \left.\frac{dI(c_0,\beta)}{d\beta}\right|_{\beta=\beta_0}$, $\#3 \approx [\beta - \beta_0] \left(\left.\frac{dI(c,\beta)}{d\beta}\right|_{\beta=\beta_0} - \left.\frac{dI(c_0,\beta)}{d\beta}\right|_{\beta=\beta_0} \right) = [\beta - \beta_0][c - c_0] \left.\frac{d^2 I(c,\beta)}{dc d\beta}\right|_{\beta=\beta_0, c=c_0}$.

I can thus write a linear equation for output as:

$$credit_{it} = \tau_t + \alpha.relation_i + \delta.borrow.cond_t + \gamma[relation_i.borrow.cond_t] + \Gamma X_{it} + \varepsilon_{it} \tag{2.13}$$

where:

$relation_i = -[c - c_0]$,

$borrow.cond_t = -[\beta - \beta_0]$,

$\tau_t = I(c_0, \beta_0)$,

$\alpha = \left.\frac{dI(c,\beta_0)}{dc}\right|_{c=c_0}$,

$\delta = \left.\frac{dI(c_0,\beta)}{d\beta}\right|_{\beta=\beta_0}$,

$\gamma = \left.\frac{d^2 I(c,\beta)}{dcd\beta}\right|_{\beta=\beta_0, c=c_0}, < 0$ in general, as shown the two preceeding parts of Appendix A.

X_{it} is a vector of other controls, and ε_{it} is a stochastic error term. As discussed in the text, under fairly general conditions theory predicts $\alpha > 0$, $\delta > 0$ and $\gamma < 0$.

Table 2.1
Descriptive Statistics

	All	***All countries: by # banking rships***					Indonesia	Korea	Philipines	Thailand
	countries	*1*	*2*	*3-5*	*>5*	*?*	*1*	*2*	*3*	*4*
Number of firms:	3143	749	713	848	419	414	940	857	694	652
Proportion of firms with:										
<150 employees	0.58	0.74	0.61	0.56	0.20	0.66	0.54	0.65	0.46	0.63
150-500 employees	0.24	0.16	0.27	0.26	0.36	0.17	0.22	0.24	0.31	0.22
> 500 employees	0.18	0.10	0.12	0.17	0.43	0.17	0.24	0.11	0.22	0.16
didn't answer question	*0.14*									
Proportion of firms in:										
1 lending relationship	0.27	1.00	0.00	0.00	0.00	na	0.48	0.08	0.21	0.35
2 lending relationships	0.26	0.00	1.00	0.00	0.00	na	0.28	0.19	0.29	0.30
3-5 lending relationships	0.31	0.00	0.00	1.00	0.00	na	0.20	0.42	0.35	0.26
>5 lending relationships	0.15	0.00	0.00	0.00	1.00	na	0.04	0.31	0.13	0.09
didn't answer question	*0.13*									
Proportion of firms by industry:										
electronics	0.16	0.15	0.16	0.17	0.20	0.14	0.20	0.17	0.16	0.13
food	0.17	0.19	0.16	0.13	0.10	0.29	0.32	0.00	0.24	0.10
autoparts	0.08	0.07	0.08	0.09	0.14	0.01	0.00	0.14	0.00	0.19
chemicals	0.20	0.18	0.16	0.22	0.25	0.22	0.29	0.28	0.17	0.00
machinery	0.05	0.02	0.05	0.08	0.09	0.00	0.00	0.18	0.00	0.00
garnments & textiles	0.34	0.39	0.40	0.31	0.22	0.34	0.34	0.23	0.38	0.54
didn't answer question	*0.00*									

Table 2.2
Additional Descriptive Statistics

		All countries	Indonesia	Korea	Philipines	Thailand
Number of firms:		*3143*	940	857	694	652
Assets (end 96, US$m):	mean	*80.58*	41.71	139.62	115.03	22.34
	st. dev.	*1308.64*	358.79	715.34	977.63	152.49
Profits/assets:	mean	*0.13875*	0.42	0.03	0.07	0.05
	st. dev.	*0.43*	0.63	0.13	0.80	0.39
Employment	mean	*383.7*	448.8	359.7	456.5	247.99
	median	*105*	128	97	173	72
	st. dev.	*1218.20*	1081.10	1496.70	1471.20	580.50
Liabilities/assets:	mean	*0.65*	0.51	0.71	0.74	0.63
	st. dev.	*0.48*	0.34	0.38	0.70	0.43
Rel. length with	mean	*11.10*	9.83	12.24	11.45	10.97
primary bank (years):	st. dev.	*8.06*	8.00	8.04	8.90	7.13
No. banking relationships	mean	*3.79*	2.08	6.20	3.47	2.75
	st. dev.	*5.42*	1.72	8.25	3.77	2.93
Refused credit: Jan-Jun 97		*0.094*	0.057	0.144	0.063	0.111
Refused credit: Jul-Dec 97		*0.178*	0.107	0.271	0.122	0.209
Refused credit: Jan-Jun 98		*0.228*	0.133	0.384	0.131	0.246

Table 2.3
Change in availability of bank credit during the crisis

Dependent variable is answer to the question: 'How has the availability of credit from doestic banks changed since the onset of the crisis?' Integer between 1 (much less restrictive) and 5 (much more restrictive). Estimation is by ordered probit. Robust standard errors. Coefficients represent the rate of change change in the expected value of the dependent variable following a small change in the RHS variable for each observation in the dataset.

	(1) baseline specification	(2) parsimonious	(3) Korea only	(4) Thailand only
Relationship variables				
log(1+relationship length)	-0.168	-0.148	-0.192	-0.170
	(0.055)***	(0.054)***	(0.079)**	(0.111)
log(1+no. of relationships)	0.182	0.214	0.147	0.268
	(0.069)***	(0.065)***	(0.089)*	(0.120)**
Controls				
log(1+firm age)	-0.181	-0.150	-0.252	-0.151
	(0.098)*	(0.091)*	(0.323)	(0.120)
log(total assets)	0.031		0.040	0.007
	(0.024)		(0.036)	(0.030)
log(total employment)		0.005		
		(0.031)		
profit / assets	11.396		-29.057	20.927
	(14.245)		(31.584)	(14.140)
liabilities / assets	19.199		19.882	16.467
	(8.311)**		(11.695)	(11.052)
industry*country dummies: F-test	0.0132**	0.0014***	0.0034***	0.701
Pseudo R2	0.0327	0.028	0.0193	0.0226
Number of observations	1057	1140	685	372

***, ** and * represents two-sided statistical significance at 1%, 5% and 10% levels respectively.

Table 2.4
Change in availability of credit: banks vs other sources

Dependent variable is answer to the question: 'How has the availability of credit from *'x'* changed since the onset of the crisis?' (where *'x'* is domestic banks, family and friends, suppliers or moneylenders). Integer between 1 (much less restrictive) and 5 (much more restrictive). Estimation is by ordered probit. Robust standard errors. Coefficients represent the change in the expected probability of the dependent variable following a small change in the RHS variable for each observation in the dataset (see text for more details). Each regression includes the same set of controls as Table 3, Column 1 (firm size, firm age, industry*country dummies, profits/assets, liabilities/assets), results for these variables available on request.

	Banks vs trade credit	
	Trade credit	Banks
Relationship variables		
log(1+relationship length)	-0.062	-0.160
	(0.061)	(0.072)**
log(1+no. of relationships)	0.012	0.243
	(0.075)	(0.091)***
Pseudo R2	0.030	0.030
Number of observations	673	647

	Banks vs moneylenders	
	Moneylenders	Banks
Relationship variables		
log(1+relationship length)	-0.070	-0.255
	(0.080)	(0.091)***
log(1+no. of relationships)	0.003	0.238
	(0.134)	(0.119)**
Pseudo R2	0.030	0.056
Number of observations	380	367

	Banks vs family/friends	
	Family and friends	Banks
Relationship variables		
log(1+relationship length)	-0.023	-0.209
	(0.080)	(0.089)**
log(1+no. of relationships)	0.012	0.215
	(0.107)	(0.117)*
Pseudo R2	0.030	0.030
Number of observations	444	417

***, ** and * represents two-sided statistical significance at 1%, 5% and 10% levels respectively.

Table 2.5
Was the firm refused credit by a financial institution?

Dependent variable is answer to the question: 'Was the firm refused credit by a financial institution between [...] and [...]?' Estimation is by bivariate probit. Robust standard errors. Coefficients represent the change in the expected probability of the dependent variable following a small change in the RHS variable for each observation in the dataset (see text for more details).

	(1)		(2)	
	Jan-Jun '97	Jan-Jun '98	Jan-Jun '97	Jan-Jun '98
Relationship variables				
log(1+relationship length)	-0.025	-0.029	-0.025	-0.026
	(0.012)**	(0.016)*	(0.011)**	(0.016)
P value: 97 coeff = 98 coeff	0.507		0.389	
log(1+no. of relationships)	0.020	0.112		
	(0.014)	(0.020)***		
P value: 97 coeff = 98 coeff	0.0022***			
No. of lenders: dummies				
no.lenders =2			-0.021	0.030
			(0.022)	(0.031)
no.lenders =3			-0.008	0.043
			(0.024)	(0.035)
no.lenders =4			-0.003	0.070
			(0.028)	(0.041)*
no.lenders =5			0.013	0.091
			(0.031)	(0.043)**
no.lenders =6 or more			0.026	0.161
			(0.026)	(0.038)***
P.value: 97 coeffs = 98 coeffs			0.040**	
Controls				
log(1+firm age)	-0.023	-0.017	-0.023	-0.023
	(0.022)	(0.031)	(0.022)	(0.032)
log(total assets)	0.011	0.011	0.011	0.017
	(0.004)**	(0.006)*	(0.004)***	(0.006)***
profit / assets * 1/100	-2.711	-1.244	-2.689	-1.089
	(2.399)	(3.034)	(2.379)	(3.024)
liabilities / assets * 1/100	1.500	7.025	1.523	7.309
	(1.685)	(2.161)***	(1.674)	(2.182)***
industry*country dums.: F-test	0.0023***	0.0000***	0.0011***	0.0000***
rho	0.67		0.67	
Number of observations	1879	1879	1879	1879

***, ** and * represents two-sided statistical significance at 1%, 5% and 10% levels respectively.

Table 2.6
Was the firm refused credit by a financial institution?

Dependent variable is answer to the question: 'Was the firm refused credit by a financial institution between [...] and [...]?' Estimation is by bivariate probit. Robust standard errors. Coefficients represent the change in the expected probability of the dependent variable following a small change in the RHS variable for each observation in the dataset (see text for more details).

	(1)		(2)	
	Jan-Jun '97	Jul-Dec '97	Jan-Jun '97	Jul-Dec '97
Relationship variables				
log(1+relationship length)	-0.025	-0.014	-0.026	-0.010
	(0.012)**	(0.015)	(0.012)**	(0.015)
P value: 97:1 coeff = 97:2 coeff	0.123		0.123	
log(1+no. of relationships)	0.021	0.110		
	(0.014)	(0.019)***		
P value: 97:1 coeff = 97:2 coeff	0.0002***			
No. of lenders: dummies				
no.lenders =2			-0.019	0.060
			(0.022)	(0.030)**
no.lenders =3			0.003	0.070
			(0.025)	(0.033)**
no.lenders =4			0.003	0.089
			(0.028)	(0.039)**
no.lenders =5			0.023	0.120
			(0.030)	(0.041)***
no.lenders =6			0.030	0.164
			(0.027)	(0.037)***
P.value: 97:1 coeffs = 97:2 coeffs				
Controls				
log(1+firm age)	-0.022	-0.024	-0.022	-0.031
	(0.022)	(0.029)	(0.022)	(0.029)
log(total assets)	0.009	0.006	0.010	0.012
	(0.004)**	(0.006)	(0.004)**	(0.006)**
profit / assets * 1/100	-2.200	-2.806	-2.324	-2.571
	(2.292)	(2.778)	(2.279)	(2.825)
liabilities / assets * 1/100	1.112	3.899	1.021	4.149
	(1.566)	(1.959)**	(1.571)	(1.976)**
industry*country dummies: F-test	0.0026***	0.0067***	0.0014***	0.0009***
rho	0.842		0.843	
Number of observations	1879	1879	1879	1879

***, ** and * represents two-sided statistical significance at 1%, 5% and 10% levels respectively.

Table 2.7
Causes of output decline?

Dependent variable is answer to the question: 'How important would you rank *x* as a reason for the decline in output'. Question was asked of all firms that experienced a decline in output during the crisis. Integer between 1 (not at all important) and 5 (very important). Estimation is by ordered probit. Robust standard errors. Coefficients represent the change in the expected probability of the dependent variable following a small change in the RHS variable for each observation in the dataset (see text for more details).

	Insufficient bank loans for working capital	Insufficient revenue	Insufficient credit from suppliers
Relationship variables			
log(1+relationship length)	-0.053	0.059	-0.054
	(0.072)	(0.056)	(0.061)
log(1+no. of relationships)	0.327	0.132	0.193
	(0.092)***	(0.074)*	(0.078)**
Controls			
log(1+firm age)	-0.065	-0.072	-0.262
	(0.133)	(0.113)	(0.111)**
log(total assets)	0.001	-0.043	-0.006
	(0.033)	(0.020)**	(0.023)
profit / assets	6.165	-0.861	-11.620
	(11.856)	(9.571)	(10.468)
liabilities / assets	25.705	-12.966	16.016
	(9.450)***	(7.284)*	(7.929)**
industry*country dummies: F-test			
Pseudo R2	0.016	0.086	0.018
Number of observations	1238	1319	1228

***, ** and * represents two-sided statistical significance at 1%, 5% and 10% levels respectively.

Chapter 3

Commodity price shocks, consumption and risk sharing in rural Thailand

(Joint with Professor Robert Townsend, University of Chicago)

Financial institutions, in co-operation with international development organizations such as the World Bank, and the International Taskforce on Commodity Risk Management, have begun to develop and implement strategies providing commodity price and weather insurance to primary producers in developing countries. But at present we have only a limited understanding of how effective these nascent initiatives might be, and how they are likely to interact with existing risk-bearing mechanisms. In this chapter we examine how shocks to the price of rubber, an important but volatile Thai export commodity, affect the income, consumption and intra-household remittances of rural Thai households. In contrast to related work on rainfall shocks, we find preliminary evidence that rubber price shocks are not well insured or smoothed – remittances, borrowing and saving play only small roles in ameliorating the effect of these shocks on the consumption of affected households. We argue that differences in the relative persistence of the two types of shocks provide a plausible reason why our results diverge so sharply from previous research, drawing on the literature on buffer stock models of consumption behavior and risk sharing with limited commitment.

3.1 Introduction

The agricultural incomes of farmers in developing countries are sensitive to fluctuations in weather and commodity prices. Whether or not these exogenous shocks have important consequences for consumption and welfare depends vitally on the availability or otherwise of adequate risk-sharing opportunities: which may include some combination of self-insurance through borrowing, saving or storage, explicit insurance contracts or financial instruments, remittances from neighbours, friends or family members, government transfers and so on.

Even though commodity-based derivative financial markets have been active for several decades, in developing countries such markets are rarely used for insurance purposes by individual farmers. Consequently, increasing attention has been paid recently to improving small farmers' access to commodity market instruments. As a prominent example, the International Task Force (ITF) on Commodity Risk Management in Developing Countries was convened by the World Bank in 1999 with a mission to 'bridge the market gap that has arisen between providers of risk management instruments and small farmers .... [by] exploring new market based instruments that would assist developing countries in managing their vulnerability to commodity price fluctuations'.[1]

Although such efforts are gaining momentum, they also beg a number of important questions. Most fundamentally, to what extent are such proposed instruments unnecessary, in the sense that existing risk-sharing mechanisms already adequately shield consumption from the effects of price or weather shocks? With respect to rainfall fluctuations, there is in fact substantial evidence consistent with this proposition that households are already well insured. Paulson and Miller (2000) show the effect of rainfall shocks on the incomes of Thai rice farmers is partially ameliorated by offsetting changes in remittances. Paxson (1992) shows that Thai households self-insure much of the remaining rainfall-induced variability in income through borrowing and saving; in fact Paxson is unable to reject the hypothesis that such shocks have exactly offsetting effects on income and saving, leaving consumption unchanged. Jacoby and Skoufias (1998) reach similar conclusions (i.e. that rainfall shocks result in have no discernable effect on consumption) using panel data on Indian villagers from the ICRISAT dataset.[2]

On the face of it, these findings suggest market-based insurance products being developed by ITF and others should be expected to generate only relatively modest welfare benefits. However, even aside from any methodological criticisms of these papers themselves[3], it is not

[1] The basic model proposed by the ITF is for farming households to purchase insurance from an intermediary (such as an agricultural bank) who then takes an offsetting position in financial markets to lay off their risk against movements in the underlying commodity price. A number of preliminary studies and pilot programs have been implemented, covering (amongst others) coffee price risk in Vietnam, India, Mexico, and Nicaragua, cocoa in the Dominican Republic and Ghana, cotton in Uganda and Tanzania, copper in Mongolia, and rubber in Thailand. A rainfall insurance program was designed and pre-tested in Nicaragua and Morocco. Rabobank is the financial intermediary for some of these examples.

A rainfall insurance program for castor and groundnuts in Andra Preadesh, India is currently being implemented by the World Bank in collaboration with ICIC Lombard and the KBS branch of BASIX, a microfinance lender. Anecdotal reports suggest concerns the uptake on this insurance scheme is lower than anticipated.

See http://www.itf-commrisk.org for more details and a list of programs.

[2] See Rosenzweig (2001) for a review of this literature.

[3] Rosenzweig (2001) highlights the fact that the studies cited above do not generally model the possibility that labor supply may respond to changes in income; this may lead to a bias in the estimated response of consumption to rainfall shocks (the sign of the bias is ambiguous, it depends on parameter values and the structure of the model).

N.B. Households are also likely to be engaged in various *ex ante* strategies to smooth income itself: plot at all obvious how well their findings generalize to other types of exogenous income risk such as commodity prices.

One important reason why is that commodity price shocks are generally quite persistent (ie. positively autocorrelated); while rainfall shocks are not. Cashin, Liang and McDermott (1999) produce median-unbiased estimates of the persistence of price shocks for a large number of important commodities. A small subset of their results is reproduced below:

	% shock dissipated after 1 year	half-life of shock (months)
Rubber	18	43
Copper	10	80
Timber	43	15
Coffee	10	80
Rainfall	≈ *100*	≈ <*3*

In two cases (copper and coffee), the half-life of price shocks is more than six years, while for rubber it is around $3\frac{1}{2}$ years. (This is fairly representative; the half-life of shocks is more than five years for the majority of commodities examined by Cashin et al.) In contrast, Paxson is unable to reject that regional Thai rainfall is uncorrelated even at a quarterly frequency.[4]

In this chapter we study rubber prices, and hence focus explicitly on persistent (although not permanent) shocks to agricultural incomes. A priori, we might expect to find quite different consumption and savings responses, relative to the work on transitory rainfall shocks discussed above. Firstly, insurance and credit markets are sometimes thought to work less well if long-term arrangements are needed. Empirically, Asdrubali, Sorensen and Yosha (1996) suggest via a variance decomposition that even in a developed economy such as the United States, credit markets play a substantially smaller role in smoothing long-term (5-10 year) shocks to income. Likewise the theoretical literature on risk sharing with limited commitment (e.g, Alvarez and Jermann, 1999) and borrowing with credit limits (e.g. Deaton, 1991) suggests in some cases that persistence is an obstacle to smoothing consumption and diversifying risk (see Section 3.5 for a further discussion). Secondly, even under a permanent income model, we would expect changes in current income to feed through more to consumption when shocks are persistent, simply because such shocks have larger effects on permanent income relative to current income. Indeed, persistent shocks allow a much sharper statistical test of the permanent income model

fragmentation, crop diversification, and a mix of occupations among household members. The point would be that income (and consumption) may appear not to move much with shocks only because somewhat inefficient countermeasures may have been taken.

[4] Although see www.iboro.ac.uk for evidence that rainfall is persistent in the Sahel, as well as Simonds (1997) who provides evidence of rainfall persistence in Australia.

It should also worth noting that even if rainfall itself is not autocorrelated, temporary droughts or floods may still have some persistent effects on income (for example, through altering the level of the water table, which in part reflects a weighted *sum* of past rainfall shocks).

relative to the complete markets benchmark, since under the latter, the effect of price shocks on consumption should be zero regardless of the stochastic properties of income, after including fixed effects for the presumed risk-sharing group. (In contrast, when shocks are transitory, both models predict the shocks will have little effect on consumption.)

A further motivation for examining rubber prices in particular is more practical in nature: as well as being an important Thai export commodity, rubber was also the target of one of four original commodity price insurance pilot studies commissioned by the World Bank and ITF. Yet the program was not approved in the end by the Thai agricultural development bank (BAAC), which noted, among other potential problems, that there had been no study of the potential demand for price insurance by its clients. Here we provide such as study. We use a similar methodology to Paxson and Paulson and Miller, allowing us to compare our results fairly directly to theirs.

To preview our main empirical findings, in contrast to other papers in the literature, we find that movements in rubber prices result in large changes in consumption and income, and only small changes in household savings. We also find that remittances play a much smaller role in insuring consumption against these shocks than is the case for transitory rainfall shocks. We then review the literature on obstacles to trade and present two simple models to help interpret why our results for persistent shocks are different to those of other papers for transitory shocks cited above.

The remainder of this chapter proceeds as follows. Section 3.2 explains the empirical methodology and links the empirical equations to the permanent income and complete risk-sharing benchmark models of consumption. Section 3.3 describes the various datasets we use for the empirical work, these include separate cross-sectional micro-datasets on Thailand households and villages, and time-series data on rubber commodity prices. Section 3.4 presents our empirical findings, and contrasts them to other findings in the literature. Section 3.5 interprets our results relative to the two benchmark models (permanent income and complete markets) and also relative to two other popular models of consumption behavior – the buffer stock model (ie. a permanent income/life cycle model with borrowing constraints) and models of risk-sharing with limited commitment. Section 3.6 concludes, and discusses opportunities and plans for future research.

3.2 Methodology

3.2.1 Baseline empirical model

Here we describe Paxson's (1992) basic methodology and how we use it to estimate the effect of rubber price shocks on household income, savings and consumption.

Household i's income at time t consists of a permanent component and transitory component: $y_{it} = y_{it}^P + y_{it}^T$. The permanent component is assumed to be a linear function of a vector of fixed household characteristics X_{it}, such as the age-structure composition of the household, education of household members, household landholdings, the time dates over which the household is observed, and the physical location of the household: $y_{it}^P = \alpha_0 + X_{it}\alpha_1$.

Unlike the components of permanent income, shocks to transitory income affect income in the current period, but their effect on income in future periods become arbitrarily small over time (that is y_{it}^T is a stationary process).[5] Here we use rubber price shocks as an exogenous source of variation in income, consumption and savings, so transitory income is decomposed as $y_{it}^T = \alpha_2 E_{it} R_t + \varepsilon_{it}$. R_t is the price of rubber at time t, and E_{it} indexes the household's sensitivity to rubber price shocks, while ε_{it} captures other sources of transitory fluctuations in income.

Substituting these in, household income is given by:

$$y_{it} = \alpha_0 + X_{it}\alpha_1 + \alpha_2 E_{it} R_t + \varepsilon_{it} \tag{3.1}$$

We also start by assuming household consumption is a linear function of the same vector of explanatory variables.[6] This is generally no more than a convenient linear approximation (see Blundell, Pistaferri and Preston, 2002 for the derivation of the approximation), although will be exactly true in a model with CARA utility and normally distributed shocks:[7]

$$c_{it} = \delta_0 + X_{it}\delta_1 + \delta_2 E_{it} R_t + u_{it} \tag{3.2}$$

Since savings is given identically by $s_{it} \equiv y_{it} - c_{it}$ the determinants of savings are found as the difference between the corresponding coefficients in equation (3.1) and equation (3.2). The coefficients of interest are α_2 and δ_2, which measure dy_{it}/dR_t and dc_{it}/dR_t- respectively the

[5] This distinction between the permanent and transitory components of income, although convenient from an expository point of view, is somewhat blurred in practice. For example, if R_t is very highly autocorrelated, then shocks to rubber prices have almost permanent effects on income. Or, on the other hand, shocks to the skill premium could cause transitory changes in the effect of education or age on income. One could instead just think of y_{it}^P and y_{it}^T as representing different sources of shocks to income.

[6] X_{it} includes controls for life-cycle characteristics of the household, which may affect current consumption differently to current income.

[7] Consider an infinitely lived household with an exponential felicity function maximizing $U_t = -\frac{1}{\gamma} E_t \left[\sum_{i=t}^{\infty} \beta^t \exp(-\gamma c_i)\right]$; and income stream following an $AR(1)$ process: $y_t = \bar{y} + \rho y_{t-1} + \varepsilon_t$ where $\varepsilon_t \sim niid(0, \sigma^2)$. Denote the household's wealth at time t by W_t, and assume the household can borrow and lend at interest rate $r = 1/\beta - 1$. Under these special conditions, the current-period consumption of the household is given by the simple linear form:

$$c_t = \underbrace{\mu + (1-\beta)W_t}_{\substack{\text{permanent income} \\ \text{component}}} + \underbrace{\frac{1-\beta}{1-\rho\beta}[y_t - \mu]}_{\substack{\text{current income: deviation} \\ \text{from long run average}}} - \underbrace{\frac{\beta}{1-\beta}\frac{1}{2}\sigma^2\gamma}_{\substack{\text{precautionary savings} \\ \text{component}}}$$

where $\mu = \frac{\bar{y}}{1-\rho}$ is the unconditional mean of y_t. The current period saving of the household is correspondingly given by:

$$s_t = -(1-\beta)W_t + \frac{\beta(1-\rho)}{1-\rho\beta}[y_t - \mu] + \frac{\beta}{1-\beta}\frac{1}{2}\sigma^2\gamma$$

As $\rho \to 1$ (ie. as the shock becomes close to permanent), a unit shock to income results in a unit change in c_t, leaving saving unchanged. Conversely, as $\rho \to 0$, only the fraction $1 - \beta \approx 0$ is consumed).

effect of rubber price shocks on income and consumption (and therefore savings via $\alpha_2 - \delta_2$).

3.2.2 Relationship to the perfect risk-sharing benchmark

How can the above equations be interpreted in terms of a perfect risk-sharing (ie. complete markets, hereafter CM) model of consumption behavior? In such a setting, changes in aggregate consumption provide a sufficient statistic for changes in the consumption of individual agents or households (Wilson, 1968). That is: $c_{it} = c_{it}(\lambda_i, e_t)$ where e_t is the aggregate endowment (equal to aggregate consumption in a closed economy).

In some special cases, such as when agents have CARA or CRRA utility functions, the perfect risk-sharing benchmark implies a linear sharing rule for the total current period endowment (e_t) of the relevant risk-sharing unit :

$$c_{it} = a_i + b_i e_t \tag{3.3}$$

Under CARA or CRRA preferences, a_i is a function of household Pareto weights and b_i is a function of the coefficients of household risk aversion.[8]

Is there any kind of mapping between the reduced form predictions from the sharing rule (3.3) and the PIH consumption equation (3.2)? The perfect risk-sharing benchmark is generally tested by taking the first difference of equation (3.3) and controlling for changes in aggregate consumption using a year-group fixed effect at the level of the risk sharing group. One test of the model is an exclusion restriction: additional household variables (such as current household income) should not be statistically significant if added to Equation (3.3) (eg. Townsend, 1994). More recently, Duflo and Udry (2003) develop an alternative test based on overidentifying restrictions on the elasticities of consumption of different goods.

If, however, X_{it} includes time-group fixed effects, and we (somewhat bravely) interpret the other variables of X_{it} as proxies for the household's Pareto weight, then we can interpret the PIH consumption equation in levels (3.2) in terms of the complete market benchmark. Namely the prediction of the perfect risk-sharing benchmark in terms of the estimates of equation (3.2) is that $\delta_2 = 0$, ie. household consumption is unaffected by rubber-price-induced income shocks, once aggregate consumption has been controlled for through the relevant fixed effects.

Under CM, the $\delta_2 = 0$ prediction is independent of the stochastic properties of the income shock. Under PIH $\delta_2 > 0$, and the magnitude of δ_2 depends positively on the persistence of the rubber price shock (as shown algebraically in footnote 7). Consequently, empirical tests of CM and/or the PIH that use serially uncorrelated income shocks (eg. rainfall variation as used by Paxson (1992) and Jacoby and Skoufias (1998)) have relatively low power in distinguishing between the PIH and CM benchmarks compared to estimates based on more persistent shocks.

[8] See Chapter 2 of Townsend (1993) for the derivation and formulas, and a general discussion of the perfect risk-sharing model.

3.2.3 Summary

Based on the above discussion, the predictions of three different canonical models (autarky, Permanent Income Hypothesis (PIH) and perfect risk-sharing) is summarized in the table below (Δx denotes the change in x following a commodity-price induced increase in income):

	R_t iid	R_t autocorrelated	R_t shocks permanent
Autarky	$\Delta c_{it} = \Delta y_{it}$	$\Delta c_{it} = \Delta y_{it}$	$\Delta c_{it} = \Delta y_{it}$
PIH	$\Delta c_{it} \approx 0$	$0 < \Delta c_{it} < \Delta y_{it}$	$\Delta c_{it} \approx \Delta y_{it}$[9]
Complete risk-sharing (controlling for aggregate consumption)	$\Delta c_{it} = 0$	$\Delta c_{it} = 0$	$\Delta c_{it} = 0$

Under hand-to-mouth autarky, changes in income lead directly to changes in consumption (thus $\delta_2 = \alpha_2$). Under complete risk-sharing the opposite is true; aggregate consumption is a sufficient statistic for household consumption; so after controlling for aggregate consumption (which empirically we do using a year-quarter dummy), price shocks have an exactly offsetting effect on income and savings, leaving consumption unchanged (ie. $\delta_2 = 0$).

Under a permanent income type model, the relationship between δ_2 and α_2 depends on the persistence of the income shock. For a short-lived transitory shock to income, nearly all the change in income will be saved (dissaved) so $\Delta s_{it} \approx \Delta y_{it}$ (i.e. empirically $\delta_2 \approx 0$). On the other hand, if R_t is highly serially correlated, most of the shock will be reflected in consumption.

The basic empirical strategy involves estimating (3.1) and (3.2) using repeated cross-sections of household data. Multiple cross-sections (or a panel) are required to distinguish the effect of aggregate transitory shocks (which vary only through time) from regional or other fixed effects. Paxson estimates these equations using rainfall shocks as a determinant of changes in transitory income, and is unable to reject the hypothesis $\Delta s_{it} = \Delta y_{it}$ (ie $\Delta c_{it} = 0$).

3.3 Data

As described above, we use variation in rubber prices as a source of fluctuations in household income and consumption. Data on real rubber prices is presented in Figure 3.1. Prices exhibit large year-to-year fluctuations: for example, the price fell by approximately half between 1980 and 1982, and fell again by more than half between 1988 and 1993 before recovering in the mid-1990s during a period of extremely low rubber stockpiles.

[9] In the CARA-normal model mentioned earlier, $\Delta c_{it} = \Delta y_{it}$ exactly when shocks are entirely persistent. But as Carroll (2001) shows, this short run unitary response of consumption will not necessarily hold true in general (although it must hold in the long run simply because of the consumer's budget constraint).

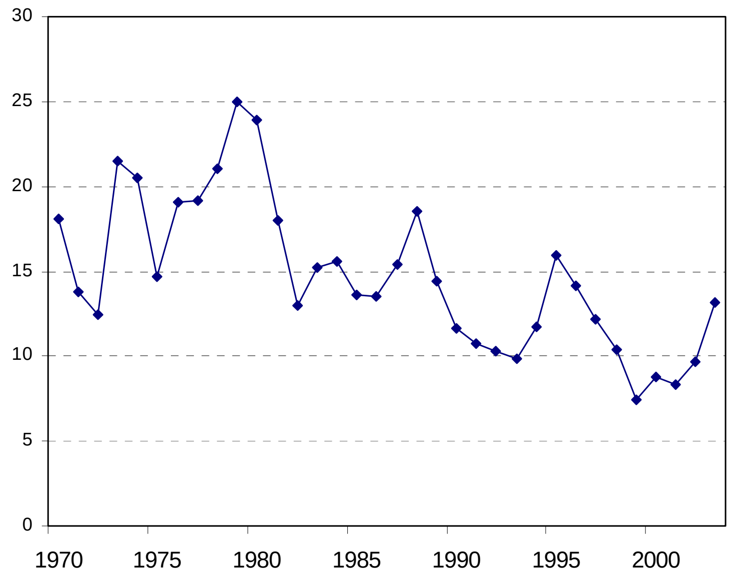

Figure 3-1: Real rubber price (1996 Thai baht / kg * $\frac{1}{100}$. Source IFS)

Evident from the graph and as shown in Table 3.1, rubber price shocks are quite persistent with a half-life of around $3\frac{1}{2}$ years. Real prices have drifted downward on average over the sample period (driven in substantial part by increasing competition from synthetic rubber substitutes).

Data on Thai households is drawn from two main sources.

The Thailand Socio-Economic Survey (SES) is a cross-sectional dataset that contains detailed socioeconomic data on a representative sample of Thai households, and has been conducted at least biannually since 1986.[10] The survey includes comparable information to several other country socioeconomic surveys, including information on sources of household income over the past twelve months, data on household consumption in the survey month (or the most recent week for food consumption), and demographic information including the geographic location of the household and number, age, sex and education level of family members. This study makes use of data from the 1988, 1990, 1992, 1994, 1996, 1998 and 1999 surveys.

The Community Development Database (CDD) is a village level dataset, also collected on a biannual basis during even-numbered years. The dataset is intended to be a census of all Thai villages, and does in practice present data on a very high proportion of them. We use the CDD to provide information about the reliance of the village on the rubber industry: the proportion of households in the village involved in rubber tapping, and the presence or otherwise of a

[10] Prior to 1986, surveys were conducted every 5 years. In addition to the standard biannual surveys, an additional survey was also conducted in 1999 to provide information about the impact of the Asian financial crisis on the Thai economy.

rubber processing plant in the village. This information is not reported in the SES (the SES does not include an occupation code to signify that the individual works in the rubber industry).

The village identification numbers used in the SES are generally changed from survey to survey, and are different again to the village identification numbers used in the CDD. Observations from the SES were matched to their corresponding CDD village number by hand, using copies of the original handwritten SES survey record sheets (these sheets contain the village name, allowing a match to the CDD codes to be made).

The first part of Table 3.1 presents information on the sample size from each wave of the SES, as well as the number matched to CDD villages. Note that around 60 per cent of the observations in the SES are from non-rural areas (either urban areas or sanitary districts). For example, in 1998 only 10622 of the total 23549 households surveyed were located in a rural area.

Most, although not all, rural households were matched to a CDD village code. In 1988, 3400 of 4769 (70%) of rural observations from the SES were matched; this percentage rises to 9471 from 10622 (89%) for the 1998 SES. A total of 44350 observations were matched across all surveys (from 1988 to 1999).

The remainder of Table 3.1 presents some other basic summary statistics about the sample. All nominal variables (income, consumption, rubber prices etc.) were converted to 1996 prices by deflating using the Thai consumer price index.[11] Average real income for households in the sample was 6869 baht, and average consumption was 5745 baht.

The CDD reports every two years the number of households in a given village who earned income from rubber tapping, and also the total number of households in the village. We use these two pieces of information to calculate E_{it}, the proportion of households in the respondents village who reported earning income from rubber tapping; we use E_{it} to proxy the household's exposure to rubber price shocks.

[11] As highlighted by Paxson (1992), care must be taken during this conversion, since consumption expenditures relate to spending over the most recent month (for non-food expenditure) or week (for food expenditure), when prices are on average higher, whereas income data reflects income earned over a 12 month period. So consumption is deflated using the CPI in the survey month, while income is deflated by the average value of the deflator over the last year. NB: This timing difference means that measured nominal household saving, if simply calculated from the SES as the difference between nominal income and nominal consumption, would understate the true level of household savings.

The table below summarizes the distribution of E_{it}.

Prop. households earning income from rubber tapping	Freq.	Percent
0-20%	38635	87.8
20-40%	1041	2.4
40-60%	985	2.2
60-80%	1251	2.8
80-100%	2097	4.8
Total	**44009**	**100.0**

Around 88 per cent of the sample is drawn from villages for whom less than 20 per cent of households earned income from rubber tapping (as Table 3.1 shows, around 82 per cent came from villages where *no* households earned rubber-tapping income). Villages involved in rubber tapping are heavily concentrated in the southern part of Thailand, although a smaller number of villages from central Thailand and the northeast also report earning income from rubber (this proportion is increasing over the sample).

3.4 Empirical Evidence

Our basic empirical strategy begins by estimating the income equation (3.1) and consumption equation (3.2) discussed in Section 3.2. Of primary interest is the relationship between $E_{it}R_t$ – the interaction between real rubber prices (R_t) and the household's exposure to price shocks (E_{it}) – and income, consumption and saving; that is α_2, δ_2 and $\alpha_2 - \delta_2$.

As previously discussed, the SES does not provide direct information about whether the income of particular households are sensitive to movements in rubber prices. However, the Community Development Database (CDD) does report, for nearly every village in Thailand, the proportion of villagers who derive at least part of their income from rubber tapping. We use this variable as a proxy for E_{it} (the household's sensitivity to rubber price shocks).[12]

We standardize R_t to a mean of 0 and standard deviation of 1. So α_2 and δ_2 measure the change of income and consumption following a one standard deviation shock to rubber prices for a village in which every household is involved in rubber tapping, relative to a village where no rubber tapping occurs.

As well as the interaction term, we also include separate individual controls for E_{it} and R_t amongst the other covariates. Controlling for E_{it} ensures the estimates of α_2 and δ_2 do

[12] This proxy also reflects the fact that, even if the respondent household is not directly involved in the tapping or processing of rubber, it may still be indirectly be very sensitive to rubber price shocks; for example because it provides services to others in a village whose primary source of income is linked to rubber.

not simply pick up *permanent* differences in the income and savings of rubber and non-rubber villages, rather than transitory differences induced by changes in the price of rubber. (We also include a separate control for $E_{it} * time$, in case there are permanent differences that are changing deterministically over time). The rationale for controlling separately for R_t is similar; since R_t varies only through time we account for it by including a time dummy for each year-quarter in which a household is observed in the sample.

Additional controls (columns of X_{it}) included (i) 8 dummies for the sex and education level of adult household members (ii) 5 controls for number of children in different sex-age categories (ii) dummy variables for which of 73 changwats (provinces) the household is located in (iii) dummies for the year-quarter the household was surveyed (iv) 5 dummies for the amount of land held by the household and/or whether the household was a renter (v) 8 dummies for the socio-economic class of the household head (vi) 13 dummies for the type of enterprise (if any) the household head was primarily engaged with. To focus on the key estimates, coefficient estimates for the controls are generally excluded from most of the tables of results. However, Table 3.8 presents more detailed results for our main specifications for the interested reader.

3.4.1 Basic results: linear model

Estimates of the parameters in equations (3.1) and (3.2) are presented in Table 3.2. Estimation is by weighted least squares (using SES sampling weights[13]), and Huber-White robust standard errors are employed to adjust for any remaining heteroskedasticity.

Turning to column 1, α_2, the coefficient on $E_{it}R_t$ as a determinant of household income has the expected positive sign: when rubber prices are high (low), households in villages with a high proportion of rubber tappers ('rubber villages' for short) experience an increase (decrease) in income relative to other households.[14] A one standard deviation fall in rubber prices reduces income in rubber villages by 521 baht; this corresponds to 7.7 per cent of average household income. This estimate is statistically significant at the 1 per cent level (z-stat = 3.9). Rubber villages have a somewhat (938 baht) lower income on average compared to non-rubber villages.

Columns 2 and 3 presents estimates of the effect of rubber price shocks on household saving and consumption respectively (NB: only one of these is independently estimated; since we define consumption identically as $c_{it} = y_{it} - s_{it}$, any one of columns 1,2 or 3 is a linear combination of the other two). The results suggest that little of the rubber-price-induced change in income is absorbed by borrowing and saving. The point estimate of $\delta_2 - \alpha_2$ from Column 2 (ie. the

[13]This weighting is necessary because the SES on average oversampled urban households relative to rural households, and was also unrepresentative along several other dimensions. We do not use the sampling weights provided by the Thailand National Statistics Office, because of some methological concerns about the way they were calculated. Instead, sampling weights are generated using the same method as Jeong (2004). Namely, each household is assigned a sampling weight inversely proportional to (sample households in region-community type)/(population of households in region-community type). Information about the number of households in each region-community type cell was drawn from the Thailand Statistical Yearbook.

[14]NB: For ease of expression, we will sometimes use the shorthand term 'rubber village' to refer to a village in which all households derive at least some income from rubber tapping, and 'non-rubber village' for a household in which no households derive income from rubber tapping.

coefficient on $E_{it}R_t$) implies that a one standard deviation fall in rubber prices reduces saving for households in rubber villages by only 38 baht relative to non-rubber households (6 per cent of the estimated change in income, and in fact not statistically distinguishable from zero). The remainder (483 baht) is reflected in a change in consumption. That is, our point estimate of the marginal propensity to consume out of rubber-price-induced changes in income is 0.94.

As well as being inconsistent with a complete markets model, the results are strikingly different to related work (Paxson, Jacoby and Skoufias etc.) on the effects of rainfall shocks on agricultural households in developing countries. These papers (reviewed in more detail in the Introduction) in general find that such shocks have large effects on income but no discernable effect on consumption.

A simple permanent income model can account for part of the divergence of our results from the previous literature, simply because rubber price shocks are quite persistent, and thus have large effects on permanent income. As a rough guide, we take Cashin, Liang and McDermott's estimate of an autocorrelation parameter of 0.82, assume a discount factor and interest rate of 0.1, and apply these to the CARA-normal permanent income model from Footnote 7: this yields a marginal propensity to consume of $\frac{1-\beta}{1-\rho\beta} = 0.38$. But our estimated marginal propensity to consume of around 0.9 is still economically and statistically different to this number We defer further discussion of possible explanations to the end of this section and to Section 3.5.

The second part of Table 3.2 estimates the same three equations, but presents estimates based on median regressions, rather than least squares. This provides a useful robustness test of the importance of outliers for our results, and is also an indirect check on the functional form of the equations. The median regression results do in fact seem to reinforce these concerns about functional form. The basic result, that changes in income induced by rubber price shocks mainly show up in consumption, remains (the estimated marginal propensity to consume, 231.589/243.363 = 0.95, is almost identical to before). But the estimated magnitude of the effect of rubber price shocks on income is much smaller, only 243 baht, compared to 521 baht in the first part of the table. (We wouldn't expect any difference on average if the linear model used here and by Paxson is correctly specified).

3.4.2 Log-linear model

Given these concerns about functional form and model specification, we experimented with some alternative formulations; among these, we estimated a simple Box-Cox model (ie. y_{it} is transformed to $\frac{y_{it}^{\lambda}-1}{\lambda}$, and λ is estimated empirically along with the right-hand-side variables – this nests both both the linear ($\lambda = 1$) and log-linear ($\lambda = 0$) specifications as special cases).

The estimated coefficient for λ is 0.09; although we statistically reject both $\lambda = 1$ and $\lambda = 0$ at the 1 per cent level, the point estimate is much closer to the log linear model. The log-linear specification also beats a linear model in a simple horse race based on restricted log-likelihoods from the Box-Cox specification. We thus estimate the following equations by weighted least squares (again employing the SES sampling weights and Huber-White robust standard errors):

$$ln(y_{it}) = \alpha_0 + X_{it}\alpha_1 + \alpha_2 E_{it}R_t + \varepsilon_{it} \tag{3.4}$$

$$ln(c_{it}) = \gamma_0 + X_{it}\gamma_1 + \gamma_2 E_{it} R_t + u_{it} \tag{3.5}$$

Results are presented in the first two colums of Table 3.3.

Looking at the first row of the table, there is now no statistically significant difference between the average income and consumption of households from rubber villages and non-rubber villages (unlike the linear model, where observations from villages with high rubber concentration had statistically lower average incomes). As in the linear model, incomes of households in rubber villages are sensitive to price changes: a one standard deviation fall in rubber prices reduces income of farmers in rubber villages by 6.4 per cent, statistically significant at the 1 per cent level. Consumption increases by 6.9 per cent (also significant at the 1 per cent level). We calculate the marginal propensity to consume at the point of means of the data as $MPC = d\ln c/d\ln y * E(y)/E(c)$; as shown in the Table this estimated MPC is 0.897. So the main conclusion of the linear model remains: changes in rubber prices result in large changes in income and consumption with household savings playing only a small role in ameliorating the effect of income shocks.

Columns 3 and 4 of Table 3.3 present median regression estimates of the log-linear model. Unlike the linear model, in terms of overall magnitudes the coefficient estimates of α_1 and γ_1 are relatively insensitive to switching to the median regression estimator. The ratio does change somewhat – the point estimate of the MPC is somewhat lower at 0.683 rather than 0.897, but still much larger than the permanent income hypothesis would predict.

3.4.3 Remittances

A number of papers – among them Paulson and Miller (2001), Lucas and Stark (1985) and Rosenzweig (1988) – have found evidence that remittance income acts as a source of insurance against various types of income shocks (as might be predicted by models in which there is some degree of group risk-sharing). We next examine the extent to which this is true for shocks to rubber prices. We regress either remittances or the log of remittances on the same vector of explanatory variables used for equations (3.1) and (3.2). As before, we are primarily interested in the coefficient on the interaction term $E_i R_t$.

Estimates are presented in Table 3.4. Column 1 follows the linear specification from Table 3.1; the results suggest that a one standard deviation shock to rubber prices (causing a change in income of 521 baht) results in an estimated change in remittances of 62 baht in the opposite direction (statistically significant at the 1 per cent level). This is consistent with an insurance view of remittances – when rubber prices fall, income falls but remittances increase to make up part of the gap.

This result is however quite sensitive to the model specification. Since 67 per cent of households in the sample receive no remittances, we estimate a censored (Tobit) model, which in this context is statistically more appropriate than least squares. The estimated coefficient on $E_{it}R_t$ from this model, displayed in column 3 of Table 3.5, is 72 baht, but no longer statistically significant. Moreover, in Column 4 we also tried a log-linear specification – replacing the dependent variable *remit* by log(1+*remit*) – and find a coefficient that is wrong-signed (although statistically insignificant).

Taken together, these estimates provide weak evidence at best that changes in remittances reduce the effect of the rubber price shock on household income. At most, remittances reduce the size of the income shock by 10-11 per cent.[15] Even this upper bound is substantially lower than those estimated using Thai data in response to non-persistent (eg. rainfall, gambling losses) shocks; most comparably, Paulson and Miller's results suggest that remittances reduce the effect of rainfall shocks on income by 22 per cent, double our upper bound.[16]

As discussed in more detail in Section 3.5.1, these differences in the role of remittances with respect to different types of shocks are not consistent with a pure intra-household risk-sharing model (which would predict that all types of income shocks should be shared according to the same rule) or with a risk-sharing model augmented by moral hazard. It may, however, be suggestive of the role of limited commitment (ie. the idea that risk-sharing agreements are implicit, and that participants cannot pre-commit *ex ante* not to abandon or renegotiate the terms of the agreement in the future) – one implication of this class of models is that risk-sharing arrangements are more difficult to maintain when shocks to income are positively autocorrelated.

3.4.4 Robustness checks

Tables 3.5 and 3.6 subject the log-linear model specification to various robustness checks.

Table 3.5. Columns 1 and 2 reproduce (for comparison purposes) the first two columns of Table 3.3. The next two columns present estimates based on observations just from the southern part of Thailand (where most rubber production is located, especially in the early part of the sample). Results are similar, although the estimated coefficients are slightly smaller than those based on Thailand as a whole (one explanation for this: perhaps even non-rubber-producing villages in the South are somewhat sensitive to rubber prices for example because they trade heavily with nearby rubber-dependent areas nearby). The estimated MPC is smaller also, at 0.51, although it is difficult to draw firm conclusions – the standard errors are quite large because of the smaller sample size in the South. [We conducted a statistical test of the null hypothesis that the ratio of the consumption to income coefficients is the same in the South as in the rest of Thailand, and were unable to reject the null (p = 0.703)][17]

Columns 5 and 6 include three additional variables that allow for a more flexible estimated relationship between rubber-income-intensity, income and consumption. Namely, a dummy

[15] 62/(521+62) = 0.106.

[16] Paxson estimates that a one standard deviation negative shock to rainfall reduces income by 13%. Paulson and Miller find that for households who receive remittances, a one standard deviation negative rainfall shock increases remittances by 291 (this corresponds to an average of 291 x 0.2166 = 63.0 baht across all households, since households who receive remittances make up only 21.66% of all households). Average income is 1769, so this is 63/1769 = 3.6 per cent. 3.6/[13+3.6] = 22 per cent of the shock.

[17] More precisely: we interacted the $E_i R_t$ variable with a dummy variable D_{sth} equal to 1 if the household is located in the South, and added this variable to both income and consumption equations. We then estimated the consumption and income equations jointly, and tested for the joint significance of $E_i R_t D_{sth}$ in the two equations.

variable equal to 1 if $E_i > 0$ and 0 otherwise is included in the specification, both on its own, and interacted with $E_i * time$ and with E_iR_t. None of these three additional variables are statistically significant in either the consumption or income equation.

Next, columns 7 and 8 of Table 3.5 use a more parsimonious specification, in which the trend terms $E_i * time$ are excluded from the model. This makes almost no difference to the results.

Finally, Column 7 estimates the effect of rubber price shocks on income relative to consumption using an alternative approach based on instrumental variables. Rather than estimating separate consumption and income equations, we regress log consumption on log income itself (and the set of controls X_{it}) and then instrument income by the interaction term E_iR_t. It can be verified algebraically that the two different estimation procedures in fact yield numerically equivalent estimates of the marginal propensity to consume: (in this case 0.897, as shown in the table).

Table 3.6. The first part of Table 3.6 again uses the basic log-linear specification from Table 3.3, but with clustered standard errors (clustered at the village level), to account for the plausible possibility that the unexplained portion of income and consumption may be correlated across households within a village (eg. because of unobserved village level shocks, differences in land quality or rainfall averages across villages and so on). Clustering sometimes has large effects on standard errors, although here, the effects are relatively modest; the standard errors increase slightly (indicating positive within-cluster correlations), but the interaction term E_iR_t is still statistically significant at the 1 per cent level by a substantial margin.

The last four columns include a larger set of location dummies. Recall that the basic set of controls includes dummies for which of 73 changwats (provinces) the household resides in; Columns 3 and 4 replace these with *changwat*surv.year* dummies. As well as being a useful test of the sensitivity of the results to a more exhaustive set of controls, this model specification is also interesting from the perspective of the risk-sharing discussion in Section 3.2.2. Namely, when interpreting results in terms of a risk-sharing benchmark, it is important to control for aggregate consumption at the level of the risk-sharing unit for each different time period over which consumption is observed. In any case, the results are fairly similar to before, although the coefficient on E_iR_t in the consumption regression is somewhat smaller than before (causing the point estimate of the marginal propensity to consume to drop from 0.89 to 0.62).

Finally, in Columns 5 and 6 we estimate a specification in which fixed effects are included at the level of the village. Now the E_iR_t interaction terms are smaller and statistically insignificant in both the income and consumption equations. This result is, however, fairly unsurprising – because recall that the interaction term E_iR_t does not vary across households within a given village. So after controlling for village fixed effects, the only variation remaining in E_iR_t comes from the small number of villages who are surveyed in multiple years.(for whom E_iR_t will be different across the different years they are surveyed). So the effective sample size is substantially smaller than in previous model specifications.

3.4.5 Results disaggregated by household wealth

Table 3.7 takes the basic log specification, but breaks up the sample into several subsamples according to household wealth (proxied by the size of the household's landholdings). We might expect the relative effect of rubber price shocks on consumption to be larger for less wealthy landholders (because they have less access to banks, for example, or have less collateral against which to secure loans).

Examining the estimates in the Table, however, there is no apparent evidence of this; ie. there is no obvious pattern between the size of landholdings and estimated marginal propensity to consume out of income generated as a result of rubber price shocks. These results are somewhat surprising, and perhaps at odds with a credit constraints based story of our empirical results.[18] It is worth noting, however, the potentially pitfalls involved in interpreting reduced form results of this sort as evidence of structural impediments to borrowing and lending. For example, poorer or otherwise more financially constrained households may be taking alternative measures (such as maintaining higher rice storage or other forms of precautionary savings, changes in occupational choice or labor supply) to protect consumption against commodity-price induced shocks to income.

3.4.6 Econometric issues

Although our results seem interesting, and are strikingly different to those found in the previous literature, there are some potential data and econometric limitations to our approach, to which we now turn. A first potential problem involves our approach to measuring households' exposure to shocks – namely that E_i is an imperfect proxy, since it reflects village-average intensity, rather than the rubber price intensity for the specific household in question. What effect does this have on the interpretation of our estimated coefficients – is there the usual attentuation bias associated with RHS measurement error?

The problem is not in fact as serious as it might seem. Firstly, the degree of any attenuation will (at least under classical measurement error) be the same order for both the consumption equation (3.2) and income equation (3.1), and thus have no effect on the ratio of the two coefficients. Secondly, since we understand the source of the measurement error (ie. the village-averaging of rubber price exposure) we can estimate its magnitude. In fact in many circumstances replacing E_{it} with its village average still produces consistent estimates of δ_2

[18] One particularly anomalous result relates to the estimates based on the subsample of households whose heads were *non-farmers* (ie. a group that includes entrepreneurs, clerical workers, laborers and other occupational groups listed in the summary statistics in Table 1). As expected, the rubber price interaction term $R_t E_{it}$ was not a statistically significant explanator of the incomes of households in this group (expected because it is unlikely these households derive a substantial proportion of their income from rubber tapping). However, the $R_t E_{it}$ coefficient was statistically significant (and positively signed) in predicting the consumption of this group. One explanation that could rationalize this result is that rubber price shocks have a lagged effect on the income of non-farmers in rubber-dependent villages (since they provide services to agricultural households who are directly dependent on rubber income). In which case, as the permanent income hypothesis would predict, consumption drops immediately in expectation of lower future income. However, this explanation seems speculative at best.

and α_2 just as if we had rubber price intensity data for individual households (although the standard errors are larger).[19]

More difficult to dismiss are concerns that we do not model in a structural way other dimensions of households' responses to rubber price shocks. For example, Rosenzweig (2001) highlights the fact that unmodelled endogenous labor supply responses to income shocks can bias estimated coefficients either upward or downward, depending on the structure of the underlying model. Similar comments no doubt apply with respect to other unobserved margins along which households can respond to shocks (such as migration, occupational choice and so on).[20] These comments suggest that further progress could be made by taking a more structural approach than the one presented here. Even so, one argument in our defence is worth making: although it is difficult to meet some of these criticisms head on (the SES does not, for example, include information on households' labor supply) we do use a similar methodology to Paxson and a number of other papers who nevertheless find very different results to us. In order to dismiss these differences, one would have to argue that the structural criticism presented in Rosenzweig somehow applies very differently with respect to the two types of shocks.

3.4.7 Discussion

To summarize, our main empirical findings are three:

[1] Our central estimates suggest a one standard deviation shock to rubber prices causes a 6-7 per cent change in current-year income for 'rubber' households relative to 'non-rubber' households. (The total effect on the net present value of future income is substantially larger though, because shocks are autocorrelated).[21]

[2] Point estimates suggest a one unit change in income induced by rubber price shock results in little change in saving (0-0.4 units, depending on the model specification and estimation procedure), and large changes in consumption (0.6-1.0 units). Although there is considerable uncertainty around these parameter estimates, the null hypothesis that rubber price shocks cause offsetting effects on income and savings (with no net effect on consumption) is easily rejected at the 1 per cent level of significance in all of our specifications.

---

[19] Assume the true model for predicting outcome variable y for household i in village v is $y_{i,v} = \beta x_v D_{i,v} + u$. x_v is some kind of aggregate shock, like rubber prices, which we allow to vary across villages for example because village observations are observed at different points in time. $D_{i,v} \epsilon (0,1)$ measures whether the i'th household in village v is exposed to the shock.

But assume that instead we only observe only the village average exposure to x, $\bar{D}_v$. So we estimate by least squares the equation $y = \beta x_v \bar{D}_v + u$. The OLS estimator of β is $\hat{\beta} = (\sum_v \left[\sum_i x_v \bar{D}_v x_v \bar{D}_v\right])^{-1}(\sum_v \left[\sum_i x_v \beta x_v D_{i,v} + u\right])$. Taking the plim of both parts of this expression it can be verified that as v becomes large, $plim_v(\hat{\beta}) = \beta$ (since by the law of large numbers, $\frac{\Sigma_v \Sigma_i \bar{D}_v \bar{D}_v}{\Sigma_v \Sigma_i 1} = \frac{\Sigma_v \Sigma_i D_{i,v} \bar{D}_v}{\Sigma_v \Sigma_i 1}$).

[20] With respect to migration: we did try restricting the sample just to households who have not moved in the previous 10 years – this did not affect the substance of our results. It is more difficult to test hypotheses about the effect of shocks on labor supply, since no such labor supply information is provided in the survey.

[21] A 'back-of-the-envelope' calculation suggests the total impact of the shock on NPV of income is approximately four times the effect on current-year income (ie. 20-24 per cent of current-year income) – assuming an AR(1) process with serial correlation coefficient of 0.82, and real interest rate of 10 per cent.

[3] We find no robust relationship between rubber price shocks and remittances income for households affected by those shocks.

These results are not consistent with perfect risk-sharing; after controlling for aggregate consumption (through a series of time dummies and/or time-region dummies) rubber price shocks have substantial effect on consumption of households sensitive to rubber prices. Part of the response of consumption could be explained by a permanent income type model. But this seems only a partial explanation (as we explain earlier, the PIH predicts a marginal propensity to consume of around 0.4, still substantially less than what we find. There are other possibilities, for example there may be uncertainty from the perspective of Thai farmers about the stochastic properties of the rubber price process. In this section, we review two well-studied deviations from the CM and PIH benchmarks, and discuss the extent to which these alternative models can help explain our empirical findings.

3.5 Variations on CM and PIH

Our most striking empirical finding is that consumption responds substantially (in fact often quite close to 1 for 1) to changes in income associated with fluctuations in rubber prices. A second deviation from the previous literature: remittances seem to be less useful for smoothing the effect of rubber price shocks in Thailand than is true for rainfall shocks.

In this section, we review two well-studied deviations from the CM and PIH benchmarks (respectively the buffer stock model, and models of risk-sharing with limited commitment), and discuss the extent to which these alternative models can help explain these two empirical findings. At this stage, our analysis in this regard is qualitative rather than quantitative, nevertheless the discussion below does provide a useful perspective on our empirical findings.

The first part of this section briefly reviews the literature on risk sharing with limited commitment. It highlights the fact that limited commitment more severely constrains risk-sharing arrangements when shocks are persistent. We relate this to our empirical results on remittances.

In the second section, we show in a simple two-period example that a buffer stock model with exogenous borrowing constraints (such as Deaton 1991, who simply assumes households can save but not borrow) does not help explain our results. In fact, the opposite is true, we would expect larger deviations from the permanent income benchmark when income shocks are iid (eg. rainfall shocks) than when shocks are persistent (eg. rubber price shocks). (The reason why is that when shocks are iid, there is a larger difference between current income and expected future income, implying that the household needs to borrow more today to smooth consumption over time.)

This result is weakened and in some cases overturned when the 'farmer' agent's borrowing constraint is endogenized. In a model where loans are collateralized against the farmer's income producing asset ('farm'), the cost of default is lower when income shocks are persistent, because times when the farmer wants to borrow (ie. current income is low) are also times when the value of the farm is low (because when shocks are persistent, expected future income is also low).

3.5.1 Risk sharing with limited commitment

As discussed above, several papers have found evidence that remittances are sensitive to the economic conditions of the receiving household; most directly related to our chapter Paulson and Miller (2001) use part of the same Thailand SES dataset that we use, and find evidence that remittances are sensitive to transitory rainfall and gambling shocks. We however find remittances respond much less to persistent changes in income induced by rubber price shocks. These differences are not consistent with a pure intra-household risk-sharing model (which would predict that all types of income shocks should be shared between household members according to the same sharing rule based on Pareto weights and differences in risk aversion). The results are also not easily reconciled with a risk-sharing model augmented by moral hazard (since shocks to rainfall or rubber prices are exogenous to the household, unlike gambling expenses or healthcare spending).

These results do however seem consistent with the predictions of models of risk-sharing with limited commitment (eg. Ligon, Thomas and Worrall 2002, Alvarez and Jermann 1999, Coate and Ravallion 1993). In these models, risk-averse agents reach implicit arrangements to share idiosyncratic variation in joint incomes. However, such arrangements are not contractible, and agents can choose to default (sometimes at some cost) on the arrangement and revert to autarky.

Alvarez and Jermann in particular explicitly examine how the self-enforcement of risk-sharing arrangements varies with the persistence of income shocks. Their basic result is that it is more difficult to enforce such arrangements when shocks are positively autocorrelated. The intuition behind this result: when shocks are very persistent, a household who experiences a high realization of income in the current period is also likely to have high income in the future also, and correspondingly a low probability of being a net receiver in the risk-sharing arrangement. This in turn makes such a household more likely to renege on risk-sharing arrangements, and reduces the overall level of sustainable risk-sharing.

Although it is difficult to draw too much from our single example, this story seems consistent with differences in the role of remittances in smoothing the effect of persistent rubber price shocks relative to transitory rainfall and gambling shocks. It would be interesting to test this hypothesis more systematically using a broader range of commodity price shocks.

3.5.2 Buffer stock model

The distingushing feature of a buffer stock model (relative to the permanent income benchmark) is a lower bound on agents' wealth, generated either through an exogenous restriction on borrowing (Deaton, 1991) or because there is a positive probability that future income is equal to zero (Carroll, 1992). Under either assumption, there will exist a range of of low income realizations where it is difficult for the household to borrow more, and thus the marginal propensity to consume is high or even unity. The consumer attempts to avoid hitting this bound through precautionary saving (in addition to any precautionary savings motive induced by the shape of the agent's utility function). Gourinchas and Parker (2001), Carroll and Kimball (2001), Carroll (2001) and Feigenbaum (2004) are recent contributions to the buffer stock literature.

Directly related to the question at hand, Deaton (1991) considers an infinite period model in which consumers are simply prohibited from borrowing. He conducts simulation exercises and shows that the ratio of consumption volatility to income volatility is increasing in the persistence of income shocks. Of course, this result would also hold true in a simple PIH model without borrowing constraints. So Deaton's result is not decisive in answering the question of whether persistence induces a high consumption response in a buffer stock framework *relative* to the PIH benchmark.

Below we consider two simple expository examples that help illustrate the tradeoffs involved. Both examples involve a risk-averse farmer who lives for two periods. The farmer's income is uncertain, and positively autocorrelated across periods. Her ability to smooth consumption is limited by a borrowing constraint. In the first example, the borrowing constraint is exogenous – as in Deaton (1991) we simply assume the consumer is unable to borrow any positive amount. As we show below, the sensitivity of the marginal propensity to consume to the persistence of the income process is *lower* under this assumption than under the permanent income model.

In the second example, the setup is the same but the borrowing constraint is endogenously determined. Borrowing is not ruled out by assumption (unlike the first example), but the beginning of the second period the farmer may choose to default on any outstanding loans. Since the loan is collateralized against the farmer's income producing asset ('land'), the costs of default depends endogenously on the first period income shock. When the income shock in the first period is low and shocks are persistent across periods, the expected value of the land at the beginning of the second period is also low; this in turn encourages default. Consequently, when shocks to income are persistent, the *ex ante* borrowing limit of the farmer is smaller.

Exogenous borrowing constraint (Model 1)

Basic setup. As described, the farmer lives two periods, and maximizes the sum of her within-period utilities. The farmer's felicity function has a CARA form $[u(c_i) = \frac{1}{\gamma}\exp(-\gamma c_i)]$. For simplicity we assume there is no discounting and the riskless interest rate is equal to zero. The farmer's income each period is uncertain: income realizations are normally distributed, but autocorrelated across periods with autocorrelation parameter ϕ: $y_t = \mu + \phi(y_{t-1} - \mu) + \varepsilon_t$, where $\varepsilon_t \sim N(0, \sigma^2)$.

Program. The farmer's problem at the beginning of the first period is:

$$\max u(c_0) + E_0 u(c_1) \tag{3.6}$$

subject to:

$$c_1 = y_0 + \underbrace{\mu + \phi[y_0 - \mu] + \varepsilon_1}_{y_1} - c_0 \quad \text{Budget constraint}$$

$$c_0 \leq y_0 \quad \text{No borrowing constraint}$$

In words, the farmer maximizes the sum of date 1 and date 2 consumption, subject to two constraints. The intertemporal budget constraint simply states that the sums of consumption and income across the two periods must be equal: ie. $c_1 = y_0 + y_1 - c_0 = y_0 + \mu + \phi[y_0 - \mu] + \varepsilon_1 - c_0$. The no-borrowing constraint assumes the farmer can only save in the first period, she cannot borrow.

Solution. The solution to the program falls into two regions. If first period income is high, the farmer does not optimally want to borrow, and date 0 consumption is given by the standard Euler equation $\exp(-\gamma c_0) = E\exp(-\gamma c_1)$, which reduces to:

$$E[c_1] = c_0 + \frac{1}{2}\gamma\sigma^2 \tag{3.7}$$

Substituting into the budget constraint yields $c_0^* = \frac{y_0+\mu+\phi(y_0-\mu)}{2} - \frac{1}{4}\gamma\sigma^2$ for date 0 consumption. In this region, $\frac{dc_0}{dy_0} = \frac{1+\phi}{2}$. The marginal propensity to consume is increasing in the degree of persistence (ϕ) because when ϕ is high a one unit shock to income has a larger effect on permanent income.

In the second region, the farmer would like to borrow but is unable to. In this region the marginal propensity to consume $\left(\frac{dc_0}{dy_0}\right)$ is 1. The cutoff realization of y_0 below which the farmer is credit constrained is found as:

$$y_0 < \mu - \frac{1}{2}\frac{1}{1-\phi}\gamma\sigma^2 \equiv \bar{y} \tag{3.8}$$

From this expression we can immediately see that $d\bar{y}/d\phi < 0$. That is, as the persistence of income shocks increases, the income threshold below which the farmer would like to borrow falls (ie. when ϕ is high, the farmer is *less* likely to be credit constrained). This is because persistence in income implies a smaller difference between first period income and expected second period income.[22]

The overall expected marginal propensity to consume is given by the weighted average of these two regions:

$$E_0\left[\frac{dc_0}{dy_0}\right] = P(y_0 \geq \bar{y}).\frac{1+\phi}{2} + P(y_0 < \bar{y}).1 \tag{3.9}$$

Proposition 3.1 below summarizes the relationship between the expected propensity to consume and the persistence of shocks under both the PIH and the buffer stock model developed

[22] This is easiest to see in the limiting case $\phi = 1$ (ie. income shocks are permanent). In this case, first best consumption is given by $c_0^* = y_0 - \frac{1}{4}\gamma\sigma^2$, and any innovation to y_0 causes a one-to-one shift in consumption, and *no* change in borrowing needs (the farmer always saves $\frac{1}{4}\gamma\sigma^2$).

above:

Proposition 3.1:

(a) Under the permanent income hypothesis (ie. the special case where $P(y_0 < \bar{y}) = 0$), the expected marginal propensity to consume $E_0\left[\frac{dc_0}{dy_0}\right]$ is uniformly increasing in ϕ.

(b) The derivative of the expected marginal propensity to consume w.r.t ϕ is uniformly lower under the buffer stock model ($P(y_0 < \bar{y}) > 0$) than the PIH.

Proof: (a) follows directly from the fact that under PIH $\frac{dc_0}{dy_0} = \frac{1+\phi}{2}$. (b) follows directly from the weighted average formula (3.9) combined with the fact that $d\bar{y}/d\phi < 0$. ■

Our original motivation is to ask whether the effect of borrowing constraints on the marginal propensity to consume and the volatility of consumption are magnified when income shocks are persistent. In the context of this simple two-period buffer stock model, the answer is in fact just the opposite. When income shocks are persistent, the farmer has less need to borrow to smooth consumption, so the impact of borrowing constraints on consumption patterns is lessened.

Endogenous borrowing constraint (Model 2)

We now look at the same example but with an endogenous borrowing constraint; we show this can overturn the main conclusion (ie. that borrowing constraints have less of an effect on the marginal propensity to consume when income shocks are persistent) of the previous section.

Setup/Timing. The basic setup of the model is exactly the same. But the timing of events is now as follows:

1. Farmer chooses whether to default (second period only, see below).
2. The farmer's income shock is revealed. This realization is public information.
3. Consumption/savings decision.

Default. At the beginning of the second period, the farmer can choose to default on any previous debt accrued in the first period. Since the loan is collateralized by the 'farm' (ie. the farmer's income-producing asset), the farmer loses control of this income stream upon default; the farmer's reservation level of utility in case of default is denoted by $\frac{1}{\gamma}\exp(-\gamma A)$. So unlike Model 1, borrowing is possible, but the potential for default limits the amount the farmer is able to borrow in the first period (the farmer never defaults on the loan in equilibrium).

Program. The farmer's problem at the beginning of the first period is now:

$$\max u(c_0) + E_0 u(c_1) \tag{3.10}$$

subject to:

$$c_1 = y_0 + \mu + \phi[y_0 - \mu] + \varepsilon_1 - c_0 \qquad \text{Budget constraint}$$

$$A \leq \underbrace{\mu + \phi[y_0 - \mu] - \frac{1}{2}\gamma\sigma^2}_{\text{certainty equiv. income at date 1}} - \underbrace{c_0 - y_0}_{\text{loan repayment}} \qquad \text{IC constraint}$$

The budget constraint is the same as before. The incentive compatibility condition that ensures the farmer chooses not to default on the date 0 loan at the beginning of date 1. Reading left to right, this condition states that the farmer's certainty equivalent net income (after repaying any loans) in the second period is at least as large as the certainty equivalent level of income in case of default.

Solution. As before, when first period income is high, consumption is given by the standard Euler equation $E[c_1^*] = c_0^* + \frac{1}{2}\gamma\sigma^2$. The incentive compatabilty constraint bind whenever:

$$c_0^* - y_0 \geq \mu + \phi[y_0 - \mu] - \frac{1}{2}\gamma\sigma^2 - A \equiv \text{borrowing limit} \tag{3.11}$$

Since $y_0 - \mu < 0$ in any state of nature where the farmer wants to borrow, it can be immediately seen from this expression that $d(borrowing\ limit)/d\phi < 0$. In other words, the more persistent the income shock, the less the household is able to borrow. The basic intuition is that when income shocks are persistent, ($\phi >> 0$), times when the farmer wants to borrow (current income is low), are also times when the future expected value of the farmer's income producing asset, 'land', is low. Since the penalty for default is to seize the farmer's land, this decline in value encourages default. This in turn means the farmer is able to borrow less ex ante. By substitution, the household is credit constrained whenever:

$$y_0 < \mu + \frac{2}{1+\phi}\left[A - \mu + \frac{1}{4}\gamma\sigma^2\right] \equiv \bar{y} \tag{3.12}$$

So $d\bar{y}/d\phi = -2(1+\phi)^{-2}\left[A - \mu + \frac{1}{4}\gamma\sigma^2\right] > 0$[23]. The household becomes credit constrained in more states of nature when shocks are persistent, the opposite conclusion to Model 1. Proposition 3.2 below summarizes the relationship between the expected propensity to consume and the persistence of shocks under the endogenous borrowing constraint (Model 2) and compares it to the PIH and Model 1.

Proposition 3.2:
(a) The marginal propensity to consume increases more quickly with ϕ under endogenous borrowing constraint (Model 2) than exogenous borrowing constraints (Model 1).

[23] See Appendix A.1 for confirmation that this expression is indeed greater than zero.

(b) For some $\bar{y}$, $\frac{d}{d\phi}\left[E_0 \frac{dc_0}{dy_0}\right]$ is larger under Model 2 (endogenous borrowing constraints) than under the permanent income hypothesis.

Proof: See Appendix A.2. ■.

The proof of Part (a), which says the propensity to consume is more sensitive to ϕ under the endogenous borrowing constraint than the exogenous borrowing constraint, just follows directly from the discussion above. In fact, for some values of $\bar{y}$, the propensity to consume is also more sensitive than under the permanent income (ie. no borrowing constraints) model – this is Part (b) of the Proposition.

Discussion

To summarize Propositions 1 and 2, the relationship between borrowing constraints, the persistence of income shocks and the sensitivity of consumption to those shocks is somewhat complex, and it is possible although not obvious that the existence of such constraints help explain the high marginal propensity to consume found in our empirical results. (In Model 1, borrowing constraints have a larger effect on the propensity to consume when shocks are close to iid. This is sometimes but not always true in Model 2, it depends on parameter values.)

As the second model also shows, persistent income shocks are more likely to strongly interact with borrowing constraints when changes in expected future income affect the value of collateral used to ease borrowing constraints (Kiyotaki and Moore 1997 show in general equilibrium how such effects can dramatically amplify the impact of shocks). One avenue for future empirical research to explicitly distinguish between Model 1 and Model 2 could involve analyzing interactions between commodity price shocks, borrowing constraints and local land prices and volumes.

3.6 Conclusions

In contrast to related work on rainfall fluctuations, we find preliminary evidence that rubber price shocks are not well insured or smoothed by rural households – remittances, borrowing and saving play only relatively small roles in ameliorating the effect of shocks on consumption. We argue that differences in the relative persistence of rubber commodity price shocks relative to rainfall shocks provides a plausible explanation for why our results diverge so sharply from previous findings, drawing on the literature on the buffer stock models of consumption behavior and risk sharing with limited commitment.

These results are still relatively preliminary, and we view them as the first step in a larger research program, investigating a broader range of shocks (including more sophisticated agroclimatic modelling of the effects of rainfall shocks on soil moisture and so on) and more structural modelling of the risk management mechanisms used by farmers in developing countries.

Also, as nascent weather and commodity price 'micro-insurance' schemes become more widspread, program-evaluation style research on how the introduction of these previously 'missing markets' affects consumption smoothing, ex ante diversification and so on should become both an interesting topic for academic research, and a useful policy tool in the evaluation and design of such schemes. The tentative conclusion from this chapter is that persistent rubber commodity price shocks are not well smoothed, and that the introduction of new micro-markets to insure Thai farmers against rubber price shocks, as proposed by the International Taskforce on Commodity Risk Management, may be expected to yield substantial welfare benefits.

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3.8 Appendix A: Proofs and calculations

A.1: Confirmation that $d\bar{y}/d\phi > 0$ under Model 2

From the text, recall that $d\bar{y}/d\phi = -2(1+\phi)^{-2}\left[A - \mu + \frac{1}{4}\gamma\sigma^2\right]$. So $d\bar{y}/d\phi > 0 \Leftrightarrow A + \frac{1}{4}\gamma\sigma^2 < \mu$. Note that for the farmer's borrowing limit to be positive, $\mu + \phi[y_0 - \mu] - \frac{1}{2}\gamma\sigma^2 - A > 0$ when $y_0 = c_0^*$. Now $c_0^* = \frac{y_0+\mu+\phi(y_0-\mu)}{2} - \frac{1}{4}\gamma\sigma^2$, so $y_0 = c_0^*$ implies $y_0 = \mu - \frac{1}{2}\frac{1}{1-\phi}\gamma\sigma^2$. The borrowing limit corresponding to this level of y_0 is $\mu - \frac{1}{2}\frac{1}{1-\phi}\gamma\sigma^2 - A > 0$. So thus $\mu > A + \frac{1}{2}\frac{1}{1-\phi}\gamma\sigma^2$ is a necessary condition for the household to be able to borrow. Since this is a stronger condition than $\mu > A + \frac{1}{4}\gamma\sigma^2$, $d\bar{y}/d\phi > 0$. ■

A.2: Proof of Proposition 3.2

(a) The marginal propensity to consume increases more quickly with ϕ under endogenous borrowing constraint (Model 2) than exogenous borrowing constraints (Model 1).

Proof: Recall that the formula for the expected propensity to consume is:

$$
\begin{aligned}
E_0\left[\frac{dc_0}{dy_0}\right] &= P(y_0 \geq \bar{y}).\frac{1+\phi}{2} + P(y_0 < \bar{y}).1 \\
&= 1 - P(y_0 \geq \bar{y})\left[\frac{1-\phi}{2}\right] \qquad (3.13)
\end{aligned}
$$

So:

$$\frac{d}{d\phi}\left(E_0\left[\frac{dc_0}{dy_0}\right]\right) = -\frac{d\bar{y}}{d\phi}\frac{dP(y_0 \geq \bar{y})}{d\bar{y}}\left[\frac{1-\phi}{2}\right] + \frac{1}{2}P(y_0 \geq \bar{y}) \qquad (3.14)$$

As shown in the text and Appendix A.1, $\frac{d\bar{y}}{d\phi} < 0$ under Model 1 and $\frac{d\bar{y}}{d\phi} > 0$ under Model 2. Since $\frac{dP(y_0 \geq \bar{y})}{d\bar{y}} < 0$, the first term in this expression is negative under Model 1 and positive under Model 2. So, assuming the probability of being credit constrained ($P(y_0 \geq \bar{y})$) is the same in both cases, $\frac{d}{d\phi}\left(E_0\left[\frac{dc_0}{dy_0}\right]\right)$ is uniformly higher under the endogenous credit constraints model (Model 2). ■

*(b) Over some range of $\bar{y}$, $\frac{d}{d\phi}\left[E_0\frac{dc_0}{dy_0}\right]$ is larger under Model 2 (endogenous borrowing constraints) than under the permanent income hypothesis*0.595cm

Proof: We can rewrite (3.14) as:

$$\frac{d}{d\phi}\left(E_0\left[\frac{dc_0}{dy_0}\right]\right) = \{\frac{d\bar{y}}{d\phi}\frac{dP(y_0 < \bar{y})/d\bar{y}}{P(y < \bar{y})}\left[\frac{1-\phi}{2}\right]\}P(y < \bar{y}) + \frac{1}{2}P(y_0 \geq \bar{y}) \qquad (3.15)$$

From this expression we can see that proving the proposition is equivalent to showing that the expression inside {.} is larger than 1/2. But recall that for a normal distribution with density $f(x)$ and cumulative density $F(x)$, $f(x)/F(x) \to \infty$ as $x \to -\infty$. So thus for a low enough $\bar{y}$, $\frac{d}{d\phi}\left(E_0\left[\frac{dc_0}{dy_0}\right]\right) > \frac{1}{2}$ under Model 2, and thus the marginal propensity to consume is more sensitive to changes in ϕ than under the PIH.■

3.9 Appendix B: Data sources

1. Household-level demographic and economic variables: Source Thailand Socioeconomic Survey (SES) 1988, 1990, 1992, 1994, 1996, 1998, 1999. Thailand National Statistics Office.

2. Thailand Consumer Price Index: International Financial Statistics database, IMF.

3. Nominal rubber prices: (a) International Financial Statistics database, IMF (b) Datastream, (c) Hat Yai rubber exchange, Thailand.

4. Village level intensity of rubber tapping: Thailand Community Development Database (CDD) 1988, 1990, 1992, 1994, 1996, 1998.

5. Concordance between Thailand SES and CDD: Calculations by Nid Ketanew and Anant Chiarawongse, based on original written records of SES survey employees.

6. Information on regional populations disaggregated by community type: Thailand Statistical Yearbook, various issues. Thailand National Statistics Office.

Table 3.1
Summary statistics: SES households

	88	90	92	94	96	98	99	All years
Number of observations:								
Total households	11048	13189	13461	25226	25110	23549	7789	119372
Rural households	4769	5449	5609	11145	11153	10622	3543	52290
Rural hh. matched to CDD (final sample)	3400	4060	4526	9486	9946	9741	3191	44350
Household income	4270.6	5423.1	5482.4	6491.4	7653.1	7949.4	7625.5	6782.5
Household saving	-9.9	382.4	421.0	748.0	1569.8	1908.9	1842.9	1140.9
Household consumption	4280.5	5040.8	5061.3	5743.4	6083.4	6040.5	5782.5	5641.6
Household size	3.82	3.80	3.74	3.71	3.70	3.75	3.77	3.74
Distribution of income								
10th percentile	1382.4	1528.1	1635.8	1833.2	2121.7	2251.7	2010.7	1852.2
25th percentile	2017.9	2290.2	2440.1	2726.8	3274.6	3345.0	3004.8	2805.3
50th percentile	3149.2	3650.0	3878.8	4288.7	5239.5	5318.5	5010.7	4525.6
75th percentile	5110.7	6024.8	6375.5	7203.3	8941.2	8918.3	8623.1	7650.9
90th percentile	8091.1	10009.7	10537.8	12077.7	15085.8	15060.5	14602.9	13119.7
90/10	5.85	6.55	6.44	6.59	7.11	6.69	7.26	7.08
Proportion h.holds in 'rubber villages'	0.159	0.180	0.184	0.196	0.192	0.204	0.189	0.191
Primary occupation of household head								
Farm operator, owning land primarily	0.462	0.441	0.419	0.334	0.304	0.304	0.282	0.345
Farm operator, renting land primarily	0.086	0.080	0.068	0.055	0.055	0.064	0.061	0.063
Entrepreneur, trade and industry	0.086	0.093	0.095	0.104	0.119	0.129	0.130	0.111
Professional, Technical & Managerial	0.031	0.023	0.029	0.038	0.035	0.039	0.047	0.035
Laborer	0.141	0.140	0.132	0.133	0.112	0.102	0.102	0.120
Clerical, sales and service	0.038	0.055	0.058	0.070	0.076	0.084	0.092	0.071
Production and construction	0.066	0.074	0.100	0.133	0.157	0.140	0.134	0.126
Inactive	0.089	0.095	0.099	0.133	0.141	0.139	0.152	0.127

Table 3.2
Basic results

Estimation by least squares (first part of table) and median regression (second part of table). Robust standard errors. Regresion also includes a constant and: (i) 8 dummies for the sex and education level of household head (ii) controls for number of children in 5 different sex-age categories (ii) dummies for changwat (province) location of household (iii) dummies for the year-quarter the household was surveyed (iv) 5 dummies for the amount of land held by the household and/or whether the household was a renter (v) 8 dummies for the socio-economic class of the household head (vi) 13 dummies for the type of enterprise the household head was primarily occupied with.

(A) Least squares

Dep. Variable:	**h.h.income**	**h.h.saving**	**h.h.consumption**
rubber_prop	-938.642	-371.956	-566.686
	(465.414)**	(440.771)	(265.694)**
rubber_prop * time	73.314	16.958	56.356
	(52.758)	(50.310)	(31.439)*
rubber_prop * rubber_price	521.445	37.741	483.703
	(131.282)***	(149.130)	(124.259)***
Number of observations	44009	44009	44009
R^2	0.15	0.04	0.18

(B) Median regression

Dep. Variable:	**h.h.income**	**h.h.saving**	**h.h.consumption**
rubber_prop	-139.344	-254.458	-219.973
	(163.798)	(112.071)**	(128.721)*
rubber_prop * time	28.714	40.280	4.586
	(19.532)	(13.361)***	(15.353)
rubber_prop * rubber_price	243.363	15.499	231.589
	(62.091)***	(42.473)	(48.823)***
Number of observations	44009	44009	44009

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3.3
Basic results: logs

Estimation by least squares (Columns I and II), and median regression (Columns III and IV). Robust standard errors. Regresion also includes a constant and: (i) 8 dummies for the sex and education level of household head (ii) controls for number of children in 5 different sex-age categories (ii) dummies for changwat (province) location of household (iii) dummies for the year-quarter the household was surveyed (iv) 5 dummies for the amount of land held by the household and/or whether the household was a renter (v) 8 dummies for the socio-economic class of the household head (vi) 13 dummies for the type of enterprise the household head was primarily occupied with.

	Least squares		Median regression	
Dep. Variable:	**log(h.h.income)**	**log(h.h.consumption)**	**log(h.h.income)**	**log(h.h.consumption)**
rubber_prop	-0.015	0.004	-0.025	-0.006
	(0.037)	(0.029)	(0.036)	(0.030)
rubber_prop * time	0.004	-0.001	0.005	-0.004
	(0.004)	(0.003)	(0.004)	(0.004)
rubber_prop * rubber_price	0.064	0.069	0.067	0.055
	(0.013)***	(0.011)***	(0.014)***	(0.011)***
MPC at point of means		0.897		0.683
Number of observations	44009	44009	44009	44009
R^2	0.40	0.36		

Robust standard errors. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3.4
Remittances

Estimation by least squares (Columns I and II), and censored (Tobit) regression (Columns III and IV). Robust standard errors. Regresion also includes a constant and: (i) 8 dummies for the sex and education level of household head (ii) controls for number of children in 5 different sex-age categories (ii) dummies for changwat (province) location of household (iii) dummies for the year-quarter the household was surveyed (iv) 5 dummies for the amount of land held by the household and/or whether the household was a renter (v) 8 dummies for the socio-economic class of the household head (vi) 13 dummies for the type of enterprise the household head was primarily occupied with.

Dep. Variable:	remittances OLS	remittances OLS (clustered s.e.'s)	remittances Tobit	log(1+remittances) Tobit
rubber_prop	237.965	237.965	-765.184	-2.537
	(39.763)***	(44.996)***	(270.557)***	(0.531)***
rubber_prop * time	-37.809	-37.809	25.230	0.104
	(5.846)***	(6.520)***	(31.850)	(0.063)*
rubber_prop * rubber_price	-61.952	-61.952	-72.921	0.026
	(16.898)***	(18.324)***	(99.573)	(0.196)
Number of observations	44009	44009	44009	44009
R^2	0.22	0.22		

Robust standard errors. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3.5
Sensitivity analysis: log specification

Estimation by least squares, except for Column 9 (two stage least squares). Robust standard errors. Regresion also includes a constant and: (i) 8 dummies for the sex and education level of household head (ii) controls for number of children in 5 different sex-age categories (ii) dummies for changwat (province) location of household (iii) dummies for the year-quarter the household was surveyed (iv) 5 dummies for the amount of land held by the household and/or whether the household was a renter (v) 8 dummies for the socio-economic class of the household head (vi) 13 dummies for the type of enterprise the household head was primarily occupied with.

	Least squares		Just the South		Additional terms		No trend		IVE
Dep. Variable:	ln(income)	log(cons.)	ln(income)	log(cons.)	ln(income)	log(cons.)	ln(income)	log(cons.)	log(cons.)
rubber_prop	-0.015	0.004	-0.009	0.028	-0.006	-0.030	0.009	-0.005	0.019
	(0.037)	(0.029)	(0.054)	(0.043)	(0.054)	(0.045)	(0.022)	(0.017)	(0.033)
rubber_prop * time	0.004	-0.001	-0.003	-0.011	0.006	0.004			-0.006
	(0.004)	(0.003)	(0.007)	(0.005)**	(0.007)	(0.006)			(0.004)
I(rubber_prop > 0)					-0.016	0.029			
					(0.034)	(0.029)			
I(rubber_prop > 0) * time					-0.002	-0.004			
					(0.004)	(0.004)			
I(rubber_prop > 0) * rub_price					-0.001	0.002			
					(0.014)	(0.012)			
rubber_prop * rubber_price	0.064	0.069	0.051	0.031	0.064	0.066	0.059	0.071	1.088
	(0.013)***	(0.011)***	(0.022)**	(0.018)*	(0.022)***	(0.019)***	(0.013)***	(0.011)***	(0.200)***
MPC at point of means		0.897		0.507		0.858		1.001	0.897
Number of observations	44009	44009	7353	7353	44009	44009	44009	44009	44009
R^2	0.40	0.36	0.39	0.34	0.40	0.36	0.40	0.36	0.24

Robust standard errors. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3.6
Robustness: Clustering and more location controls

Estimation by least squares, robust standard errors. Regresion also includes a constant and: (i) 8 dummies for the sex and education level of household head (ii) controls for number of children in 5 different sex-age categories (ii) dummies for changwat (province) location of household (iii) dummies for the year-quarter the household was surveyed (iv) 5 dummies for the amount of land held by the household and/or whether the household was a renter (v) 8 dummies for the socio-economic class of the household head (vi) 13 dummies for the type of enterprise the household head was primarily occupied with.

	Cluster at village level		Changwat*year dummies		Village dummies	
Dep. Variable:	ln(income)	log(cons.)	ln(income)	log(cons.)	ln(income)	log(cons.)
rubber_prop	-0.015	0.004	-0.045	-0.002	-0.071	0.005
	(0.055)	(0.041)	(0.056)	(0.047)	(0.103)	(0.092)
rubber_prop * time	0.004	-0.001	0.007	-0.003	0.001	-0.002
	(0.006)	(0.005)	(0.007)	(0.006)	(0.009)	(0.008)
rub_prop*rub_price	0.064	0.069	0.065	0.050	0.036	0.027
	(0.019)***	(0.015)***	(0.022)***	(0.019)***	(0.026)	(0.022)
MPC: point of means		0.897		0.640		0.624
No. of observations	44009	44009	44009	44009	44009	44009
R^2	0.40	0.36	0.43	0.39	0.55	0.52

Robust standard errors. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3.7
Results disaggregated by landholdings: log specification

Estimation by least squares, robust standard errors. Regresion also includes a constant and: (i) 8 dummies for the sex and education level of household head (ii) controls for number of children in 5 different sex-age categories (ii) dummies for changwat (province) location of household (iii) dummies for the year-quarter the household was surveyed (iv) 5 dummies for the amount of land held by the household and/or whether the household was a renter (v) 8 dummies for the socio-economic class of the household head (vi) 13 dummies for the type of enterprise the household head was primarily occupied with.

	land < 4 rai		4rai < land < 9 rai		9rai < land < 19 rai		19rai < land < 39 rai		land > 39 rai		Farmer, renter		Non-farmer	
Dep. Variable:	ln(income)	log(cons.)	ln(income)	log(cons.)	ln(income)	log(cons.)	ln(income)	log(cons.)	ln(income)	log(cons.)	ln(income)	log(cons.)	ln(income)	log(cons.)
rubber_prop	-0.040	0.084	-0.119	0.133	0.114	0.143	0.211	0.057	0.064	0.217	-0.198	-0.131	-0.098	-0.083
	(0.204)	(0.155)	(0.106)	(0.091)	(0.080)	(0.064)**	(0.118)*	(0.090)	(0.224)	(0.224)	(0.238)	(0.217)	(0.052)*	(0.043)*
rubber_prop * time	0.009	-0.010	0.024	-0.011	-0.000	-0.014	-0.011	-0.010	0.013	-0.015	0.022	0.009	0.006	0.006
	(0.025)	(0.019)	(0.011)**	(0.010)	(0.009)	(0.007)**	(0.014)	(0.010)	(0.029)	(0.025)	(0.043)	(0.033)	(0.006)	(0.005)
rub_prop*rub_price	0.145	0.068	0.132	0.044	0.069	0.094	0.078	0.060	0.118	0.168	0.023	-0.060	0.027	0.067
	(0.064)**	(0.057)	(0.035)***	(0.028)	(0.028)**	(0.023)***	(0.042)*	(0.036)*	(0.089)	(0.078)**	(0.134)	(0.118)	(0.020)	(0.017)***
MPC: point of means		0.48		0.32		1.20		0.68		0.96		-2.35		2.57
No. of observations	1161	1161	2905	2905	5043	5043	4178	4178	1678	1678	2376	2376	26416	26416
R^2	0.43	0.41	0.33	0.31	0.28	0.28	0.24	0.23	0.22	0.24	0.32	0.35	0.42	0.38

Robust standard errors. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3.8: Additional estimates, Tables 3.2 and 3.3

Regression estimates not presented: (i) dummy variables for each year-quarter (ii) dummies for changwat (province) the household is located in (iii) dummies for the type of enterprise the household is engaged in and (iv) constant. Each of these sets of variables is statistically significant at the 1 per cent level (coefficient estimates available on request).

	Table 3.2			Table 3.3	
Dep. Variable:	h.h.income	h.h.saving	h.h.consumption	log(income)	log(consumption)
Household composition					
No children < 5 y.o.	-103.862	-149.384	45.522	-0.020	0.006
	(70.364)	(70.218)**	(52.717)	(0.006)***	(0.005)
Males 6-11 y.o.	15.855	-130.136	145.990	0.007	0.043
	(90.195)	(91.941)	(57.924)**	(0.008)	(0.006)***
Females 6-11 y.o.	149.995	-46.343	196.338	0.013	0.047
	(115.492)	(112.549)	(59.958)***	(0.008)	(0.007)***
Males 12-17 y.o.	293.027	-69.739	362.766	0.068	0.097
	(88.371)***	(85.531)	(55.050)***	(0.008)***	(0.007)***
Females 12-17 y.o.	160.556	-284.479	445.035	0.059	0.102
	(75.992)**	(78.369)***	(59.723)***	(0.008)***	(0.006)***
Males, primary ed.	674.024	-12.894	686.918	0.146	0.143
	(91.526)***	(90.068)	(45.399)***	(0.006)***	(0.005)***
Males, secondary ed.	2,629.381	906.956	1,722.425	0.289	0.272
	(300.990)***	(279.835)***	(115.057)***	(0.012)***	(0.009)***
Males, tertiary ed.	6,816.915	2,849.882	3,967.033	0.563	0.450
	(394.253)***	(376.587)***	(301.931)***	(0.018)***	(0.015)***
Females, primary ed.	155.262	64.490	90.772	0.039	0.024
	(71.005)**	(73.663)	(44.065)**	(0.005)***	(0.004)***
Females, secondary ed.	1,310.992	286.406	1,024.586	0.172	0.170
	(265.702)***	(231.373)	(136.407)***	(0.014)***	(0.011)***
Females, tertiary ed.	5,024.702	1,786.132	3,238.571	0.408	0.337
	(424.384)***	(415.112)***	(328.142)***	(0.019)***	(0.017)***
Males, seniors	-475.263	-91.722	-383.541	-0.069	-0.074
	(100.348)***	(95.297)	(74.016)***	(0.010)***	(0.009)***
Females, seniors	-641.785	-333.468	-308.317	-0.102	-0.079
	(101.067)***	(95.828)***	(71.432)***	(0.011)***	(0.009)***
Region (omitted category = north)					
Region = central	-215.389	-712.846	497.456	0.085	0.127
	(287.176)	(271.415)***	(210.483)**	(0.042)**	(0.034)***
Region = northeast	-464.102	-504.949	40.848	-0.003	-0.007
	(287.558)	(266.769)*	(242.542)	(0.042)	(0.034)
Region = south	-297.302	-1,079.108	781.806	0.015	0.145
	(429.824)	(350.929)***	(290.578)***	(0.050)	(0.039)***
Class of household head					
Not farmer	-518.014	-467.397	-50.617	0.022	0.033
	(1,521.850)	(1,400.095)	(291.156)	(0.046)	(0.033)
Farm operator, own land	-6,777.065	-2,972.174	-3,804.891	-0.953	-0.636
	(1,786.577)***	(1,661.227)*	(498.036)***	(0.075)***	(0.056)***
Farm operator, renter	-5,731.486	-2,432.526	-3,298.961	-0.755	-0.466
	(1,531.020)***	(1,415.157)*	(403.992)***	(0.048)***	(0.037)***
Entrepreneur, trade and industry	-3,431.223	-1,377.606	-2,053.617	-0.527	-0.319
	(462.445)***	(443.308)***	(352.556)***	(0.027)***	(0.024)***
Laborer	-6,517.858	-2,681.189	-3,836.669	-0.937	-0.609
	(385.635)***	(381.761)***	(314.385)***	(0.023)***	(0.020)***
Clerical, sales and service	-3,813.425	-1,980.150	-1,833.275	-0.323	-0.197
	(380.761)***	(365.819)***	(305.641)***	(0.023)***	(0.021)***
Production and construction	-4,923.489	-2,139.262	-2,784.227	-0.546	-0.369
	(390.982)***	(381.369)***	(311.971)***	(0.023)***	(0.020)***
Inactive	-4,680.190	-1,774.049	-2,906.141	-0.696	-0.487
	(394.486)***	(381.912)***	(316.128)***	(0.024)***	(0.021)***
Landholdings					
<4 rai	-201.432	21.785	-223.217	-0.144	-0.022
	(590.778)	(546.317)	(279.423)	(0.056)**	(0.042)
4-9 rai	-25.099	58.772	-83.872	-0.027	0.040
	(577.134)	(534.306)	(259.966)	(0.054)	(0.040)
9-19 rai	695.169	376.599	318.569	0.171	0.152
	(571.041)	(525.266)	(255.911)	(0.054)***	(0.040)***
19-39 rai	1,927.124	738.457	1,188.667	0.418	0.293
	(582.913)***	(557.252)	(297.440)***	(0.054)***	(0.040)***
>39 rai	5,305.899	2,986.109	2,319.791	0.763	0.468
	(983.166)***	(946.167)***	(298.911)***	(0.056)***	(0.042)***

* significant at 10%; ** significant at 5%; *** significant at 1%