The Asymmetric Effects of Financial Frictions

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Economic variables move asymmetrically over the business cycle: quickly during crises but slowly during recoveries. I show that this asymmetry is stronger in countries with less developed financial systems and greater financial frictions. Then I explain this fact using a learning model with endogenous information about economic conditions. Financial frictions, which I capture by higher bankruptcy costs, magnify the reaction of lending rates and economic activity to negative shocks and then delay their recovery by restricting information after the crisis. Empirical evidence and a quantitative exploration of the model show that this explanation is consistent with the data.

I. Introduction

Economic variables are known to move asymmetrically during the bad and good phases of a business cycle: quickly and sharply during recessions but slowly and gradually during recoveries. Interest rates on loans,

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for example, tend to rise quickly during a crisis but fall slowly and gradually during a recovery; investment and output tend to move in the opposite directions but with the same asymmetry—falling sharply during a crisis and recovering slowly. This asymmetry has been observed worldwide in most business cycles. In Mexico's 1994–95 crisis, for example, real lending rates rose 70 percentage points in just 4 months and investment and output per capita dropped 35 percent and 17 percent, respectively, in three quarters. Recovery of these variables took much longer: lending rates did not reach precrisis levels for 30 months; investment, for 2 years; and output, for almost 3 years.[1]

Understanding the sources of this asymmetry would seem critical to minimizing lengthy processes of financial distress and the inefficient resource allocation inherent to lengthy recoveries.[2] Not surprisingly, then, many studies have offered explanations for this asymmetry.[3]

No one, however, has yet systematically examined how this business cycle asymmetry differs across countries. I do that here using standard data sets and discover a new fact: the asymmetric movements of lending rates, investment, and output are stronger in less developed countries, those with weaker financial systems. I also propose an explanation for this new fact: the stronger asymmetry in less developed countries stems from their greater financial frictions, which restrict the flow of information in an economy, delaying recoveries.

I introduce a form of these frictions into a learning model with endogenous flows of information. Commonly in such models, the degree of precision of observed information depends on the level of economic activity, which varies in good and bad times, thus generating asymmetric

[1] There are many other examples. In Brazil, just in October 1997, real lending rates rose from 71 percent to 98 percent, taking 10 months to return to precrisis levels. In the first quarter of 1998, investment and GDP per capita declined 9 percent and 8 percent, respectively, taking more than 2 years to return to precrisis levels. In Indonesia, the 8 months following the Asian crisis witnessed a rise in real lending rates from 18 percent to 35 percent, taking 24 months to recover. In that case, both investment and GDP per capita declined almost 50 percent in 1998, taking more than 8 years to recover. In Russia, during April and May of 1998, real lending rates rose from 30 percent to 150 percent, taking 27 months to recover, while GDP per capita declined 12 percent in one quarter, taking more than 2 years to recover.

[2] The negative impact of lengthy recoveries in terms of misallocations has been discussed by Bergoeing, Loayza, and Repetto (2004), while the sizable macroeconomic effects of those misallocations have been estimated by Hsieh and Klenow (2009) and calibrated by Restuccia and Rogerson (2008) and Buera, Kaboski, and Shin (2011).

[3] Veldkamp (2005) studies asymmetries of lending rates, while Jovanovic (2006) and Van Nieuwerburgh and Veldkamp (2006) focus on asymmetries of real activity. The bulk of the literature, however, has focused on explanations of asymmetries in stock markets. Banerjee (1992), Welch (1992), and Banerjee and Newman (1993) explain crashes as the result of herd behavior and information cascades. Jacklin, Kleidon, and Pfleiderer (1992) explore a portfolio insurance model of stock market crashes. Allen, Morris, and Shin (2006) study information-based bubbles. Finally, Zeira (1994, 1999) proposes an informational overshooting to explain booms and crashes in stock prices.

lending rates (Veldkamp 2005) and asymmetric economic activity (Van Nieuwerburgh and Veldkamp 2006). These models, however, assume frictionless environments in which lenders and borrowers have symmetric information about both aggregate and idiosyncratic shocks. In my model, I assume asymmetric information about idiosyncratic shocks; they are observable to borrowers for free and observable to lenders only at a cost. I show that the financial frictions created by this costly state verification increase the asymmetry in the movements of lending rates, investment, and output.

The basic setting of my model is straightforward: entrepreneurs can start a venture only if they borrow funds. Whether they borrow or not, and how much they borrow, depends on prevailing lending rates, which are set by lenders on the basis of their overall expectations about ventures succeeding and entrepreneurs repaying. These expectations depend on signals from previous ventures: if many have succeeded, then the economy is more likely to be in good times, or a state in which entrepreneurs have a low probability of defaulting on their loans.

In a standard setting like this, without financial frictions, whether a venture succeeds or fails is perfectly observed. When lenders think the state is good, they charge low rates. As a consequence, entrepreneurs borrow to start a lot of ventures, and thus, as loans are repaid, many signals about the state of the economy are generated. When the state changes to bad, so that ventures have a lower probability of success, the signals of many failed ventures allow lenders to easily infer that conditions have changed, and they raise rates quickly to account for the higher probability of default. Thus, in bad times, rates are high, and there is not much borrowing. When the state changes back to good, therefore, the limited number of existing ventures offers few signals about the switch, lenders learn about it slowly, and lending rates decline only gradually. This endogenous learning process is what generates asymmetric movements of lending rates, translating into asymmetric movements of investment and output.

To study the role of financial frictions in this asymmetry, I replace the standard assumption of symmetric information with an assumption of asymmetric information. I assume that borrowers know the result of a venture, but lenders can learn about it only by incurring positive costs. This asymmetric information induces borrowers to falsely renege on their loans or to report successful ventures as failures. To motivate borrower truth-telling, lenders must spend resources to verify reports of failures and pursue defaults to bankruptcy. These monitoring and bankruptcy costs are measures of how costly it is to overcome financial frictions.

The addition of these extra costs is reflected in the greater asymmetry in environments with frictions. The monitoring and bankruptcy costs increase lending rates, especially when the economy is moving from good times to bad. As this happens, reported failures increase, so lenders raise rates to take account of the larger probability of default. The higher expected monitoring and bankruptcy costs magnify the rate rise compared to those in a frictionless setting, depressing economic activity even further. Thus, as times turn good again, fewer signals about conditions are generated, and the learning that fuels recoveries is slower. The larger rise in lending rates combined with their slower recovery means greater asymmetry in the movements of lending rates and economic activity in economies with frictions.

I reach these conclusions by exploring the role of financial frictions on asymmetry in two versions of the model. First, I construct a simple partial equilibrium framework with exogenous default rates, an exogenous price of capital, exogenous loan sizes, and no consumption smoothing. My purpose here is primarily to illustrate the learning mechanism I have described. Yet I find that a calibrated version of this model is quantitatively consistent with my documented new fact: reasonable levels of monitoring and bankruptcy costs roughly predict the empirical cross-country differences in asymmetry.

In order to better assess the quantitative implications of my explanation, I extend the simple partial equilibrium version of the model into a general equilibrium version. I impose risk shocks to the cross-sectional variance of productivity; endogenize default rates, capital prices, and loans; and allow for consumption smoothing. A calibrated version of this extended model does a better job than the simple model in predicting the empirical cross-country differences in asymmetry. It also better matches second moments of lending rates and economic activity.

A natural alternative view of the cross-country asymmetry I have documented is that exogenous shocks are simply more asymmetric in less developed countries. However, the data do not support that view. Using data on default rates for different regions and countries, I document that their movements are, in fact, symmetric across crises and recoveries.

In contrast, the data do support my learning explanation. Using data on stock volatility for many countries, I show that uncertainty, a proxy for information precision in the economy, is asymmetric: uncertainty increases suddenly during crises and declines gradually thereafter. Furthermore, I document a significant positive correlation between the asymmetry of uncertainty and the asymmetry of lending rates across countries. This implies that while shocks are symmetric, information is asymmetric. Thus the asymmetry of lending rates, investment, and output is not a reflection of asymmetric fundamentals but rather of asymmetric learning.

My paper proposes a different view of recent work that suggests that the nature of shocks differs across countries. Aguiar and Gopinath (2007), for example, exploit data on consumption and net exports to disentangle permanent from transitory productivity shocks. They argue that the primary sources of fluctuations in underdeveloped economies are shocks to the trend of productivity, while in developed economies productivity shocks tend to be transitory around a stable trend. My work complements these findings. Rather than imposing shocks that are exogenously different in underdeveloped economies, I start from the premise that shocks are symmetric and identical across countries but that underdeveloped economies have larger financial frictions. I show that, in the presence of learning, financial differences induce differences in the time irreversibility of endogenous variables—lending rates, investment, and output—that show up in their asymmetry. Though not the focus of this paper, the time irreversibility from learning also affects the serial correlation of endogenous variables, and then the higher persistency of Solow residuals in underdeveloped economies could be just a manifestation of larger financial frictions.

My paper is also related to recent work on the relevance of credit markets for economic fluctuations. Gilchrist, Yankov, and Zakrajsek (2009) study a data set of corporate bond trading in the secondary market and find that credit market shocks have contributed significantly to US economic fluctuations during the 1990–2008 period. Gilchrist and Zakrajsek (2012) construct an index of credit spread and show that innovations to the component that is orthogonal to the current state of the economy lead to significant declines in economic activity. These findings are consistent with my results; movements in credit spreads that do not reflect the current state of the economy because of learning frictions have the quantitative potential to drive economic activity nontrivially.

Finally, my paper complements the recent work of Christiano, Motto, and Rostagno (2012). They show the quantitative relevance of risk shocks to capture crises and recoveries and match moments of financial variables, such as the countercyclicality of lending rates. In contrast to their work, mine focuses on a standard real business cycle model, allows for learning and asymmetries, and compares the performance of the model across countries.

Overall my study is an empirical (Sec. II), theoretical, and quantitative (Secs. III and IV) investigation of the effects of financial frictions on the asymmetric movements of lending rates, investment, and output. Section V provides empirical support for my explanation, and Section VI presents concluding remarks.

II. Financially Underdeveloped Economies Are More Asymmetric

I begin by showing empirically that movements of real lending rates, investment, and output per capita are more asymmetric in countries with less developed financial systems. This finding, which I will denote the *main finding* throughout the rest of the paper, is robust to different ways to measure financial development. Even though in this section I just document a correlation between financial development and asymmetry and not a causal relation, in the next sections I propose a learning mechanism under which financial development reduces asymmetry and provide evidence to support the mechanism.

To measure unconditional asymmetry, I use the skewness of log changes over time. If a variable is more likely to experience large jumps than to experience large drops of the same magnitude, the skewness of its log change is positive. Furthermore, a larger unconditional asymmetry is captured by a larger skewness in absolute terms. In this section I use International Monetary Fund (IMF) monthly data on real lending rates and quarterly data on real investment and real GDP per capita, from 1960 to 2008, for 100 countries. An exhaustive description of the data and the complete list of countries in the sample are in Appendix A.

A. *General Measures of Financial Development*

I first analyze the relation between asymmetry and standard measures of financial development. For each country, I use the sample average of credit to the private sector as a percentage of GDP from the World Bank's World Development Indicators (WDI) database. Panel A of table 1 shows simple regressions between this variable and the skewness of lending rates, investment, and output.[4] Panel B shows simple regressions just for lending rates, considering different sample periods (1960–85 and 1985–2008) and different sample countries (all countries and non-African countries).[5] Since, on average, the skewness of lending rates is positive and the skewness of economic activity is negative, the coefficients show a statistically significant negative relationship between financial development and the magnitude of asymmetry in all cases.

To provide a better sense of the cross-country differences in asymmetry, I classify countries into groups that, according to Levine (1997), strongly correlate with financial development: level of income per capita, membership in the OECD, level of contract enforcement, and the

[4] In online App. C, I follow three alternative approaches to measure the asymmetry of lending rates. First, I obtain skewness of log deviations from trend. Second, I obtain skewness of log changes in lending spreads, computed as the difference between lending rates and the rate of domestic 3-month Treasury bills, which is a measure of risk-free interest rates. Finally, I obtain skewness of log changes in lending spreads, but computed with respect to the rate of US 3-month Treasury bills. The relations between these alternative measures of asymmetry and financial development are consistent with the ones I show here.

[5] Since African countries in general have high levels of asymmetry, I restrict the sample in this particular way to confirm that the relation is not just driven by African fixed effects. Since the data on investment and output are scarce for African countries, results are almost identical to those in the full sample in panel A and hence are not reported.

TABLE 1
ASYMMETRY AND FINANCIAL DEVELOPMENT

	A. Dependent Variable			B. Dependent Variable: Skewness Lending Rates			
				All Countries		Non-African Countries	
	Skewness Lending Rates 1960–2008	Skewness Investment 1960–2008	Skewness Output 1960–2008	1960–85	1985–2008	1960–85	1985–2008
Credit to private sector/GDP	−.020	.007	.006	−.036	−.023	−.043	−.017
	(.007)***	(.003)**	(.003)**	(.014)**	(.005)***	(.017)**	(.005)***
Constant	2.94	−.73	−.50	4.86	2.66	5.36	2.14
	(.44)***	(.19)***	(.17)***	(.72)***	(.42)***	(1.07)***	(.48)***
Observations	94	46	52	47	94	31	70

NOTE.—Robust standard errors are reported in parentheses. For each country, the sample average of yearly credit to the private sector as a percentage of GDP is computed during the corresponding period.
* Significant at 10 percent.
** Significant at 5 percent.
*** Significant at 1 percent.

presence of bureaus in the financial system that maintain information about the standing of borrowers. Table 2 shows simple averages of skewness for lending rates, investment, and output across countries in each group for the whole sample period. Since data for lending rates are monthly, I am also able to split the sample into two subperiods. The conclusion is the same in all cases. Richer countries, OECD countries, and countries with good contract enforcement and information flows show, on average, less asymmetry than their less developed counterparts (poorer countries, non-OECD countries, and countries with bad contract enforcement and information flows). This evidence reinforces the initial conclusion of a negative relation between financial development and the asymmetry of lending rates and economic activity.

How to interpret these cross-country differences in skewness? Consider a variable that changes 1 percent in one period and then recovers to previous levels in subsequent periods. Skewness reflects the speed of such a recovery when the sudden 1 percent change always happens in the same direction (lending rates always rise, or economic activity always drops).

A lending rate skewness of 0.28 (for the richest countries in the period 1985–2008) implies that a 1 percent increase in lending rates in one month is compensated, on average, with a decline of 0.85 percent during the next month. At the other extreme, a lending rate skewness of 2.91 (for the poorest countries in the period 1985–2008) implies that a 1 percent increase in lending rates in one month is compensated, on average, with a gradual decline during the next 10 months. Similarly, for economic activity, an investment skewness of −0.14 (for the richest countries) implies that a 1 percent decline in investment in one quarter

TABLE 2
AVERAGE ASYMMETRY BY COUNTRY CLASSIFICATION

Country Classification	Lending Rates 1960–85	Lending Rates 1985–2008	Lending Rates 1960–2008	Investment 1960–2008	Output 1960–2008
Income group 1 (richest)	2.71	.28	1.54	−.14	.07
Income group 2	3.17	1.55	1.72	−.48	−.40
Income group 3	4.22	1.77	2.08	−.68	−.42
Income group 4 (poorest)	4.87	2.91	3.34	−1.09	−.49
OECD	2.48	.87	1.75	−.28	−.05
Non-OECD	4.36	1.98	2.46	−.44	−.30
High contract enforcement	2.11	.45	1.36	−.19	−.01
Low contract enforcement	4.20	2.44	2.95	−.21	−.20
Private bureau	2.04	.87	1.40	−.19	−.06
No private bureau	5.16	2.25	2.66	−.71	−.56

NOTE.—Income classifications are from the World Bank (WDI). Contract enforcement indicator is from Levine et al. (2000). Existence of a private bureau is from Djankov et al. (2007). Asymmetry by group is the average skewness across member countries.

is compensated, on average, with an increase of 0.93 percent during the next quarter. At the other extreme, an investment skewness of −1.09 (for the poorest countries) implies that a 1 percent decline in investment in one quarter is compensated, on average, with a gradual increase during the next two or three quarters.

I can use this exercise to interpret the economic significance of the coefficients in table 1 as well. The credit to private sector as a percentage of GDP in the poorest income group is, on average, 13 percent. Using the coefficient from the first regression, a one standard deviation increase in financial development (32 percent) would reduce skewness by 1.15 (roughly the difference in skewness between income groups 3 and 4 during 1985–2008). This difference implies that recoveries happen, on average, 6 months faster, taking, on average, 4 instead of 10 months.

In online Appendix C, I repeat these regressions controlling for other, potentially relevant, variables such as GDP per capita, volatility of GDP, and inflation. For lending rates, conclusions are roughly the same. Not surprisingly, though, for investment and output the differences in skewness seem to be more related to the level of economic development (measured by GDP per capita) than to the level of financial development. Still, when regressing the asymmetry of economic activity on the asymmetry of lending rates, I find a statistically and economically strong positive correlation: an increase of one standard deviation of skewness in lending rates implies an increase of one standard deviation in the skewness of both investment and output. Moreover, these positive correlations remain significant even with the aforementioned controls. This is an important finding: the asymmetry in the cost of borrowing and the asymmetry of economic activity are strongly and significantly correlated, both economically and statistically.

B. Specific Measures of Financial Development: Financial Frictions

Now I study the correlation between the asymmetry of lending rates, investment, and output with more specific measures of financial development that capture a particular financial friction: the asymmetric ex post information about repayment possibilities in credit markets, where borrowers tend to know more about their own income than lenders. A measure of the severity of this friction is the cost for lenders to verify borrowers' information, which under standard debt contracts is given by the cost of taking a defaulting borrower to bankruptcy.

Data on bankruptcy costs that are comparable across countries are taken from Djankov et al. (2008), who, using a standardized case study of an insolvent firm called Mirage, compute estimates of how difficult it is for lenders to go through bankruptcy procedures in terms of bankruptcy costs, duration, and recovery rates. Table 3 shows simple regressions

TABLE 3
Asymmetry and Bankruptcy Costs

	Dependent Variable: Skewness of Lending Rates						Dependent Variable: Skewness of Investment			Dependent Variable: Skewness of Output		
	1960–2008			1985–2008								
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Cost of bankruptcy	.037			.045			−.028			−.013		
	(.012)***			(.012)***			(.014)**			(.013)		
Bankruptcy duration		.221			.210			−.122			−.128	
		(.100)**			(.116)*			(.061)**			(.055)**	
Recovery rate			−.014			−.019			.005			.007
			(.007)**			(.007)***			(.004)			(.003)**
Constant	1.265	1.252	2.356	.669	.806	2.046	−.028	−.058	−.617	−.056	.088	−.58
	(.322)***	(.347)***	(.398)***	(.294)**	(.382)**	(.407)***	(.187)	(.149)	(.238)**	(.167)	(.132)**	(.189)***
Observations	85	85	85	85	85	85	44	44	44	51	51	51

Note.—Robust standard errors are reported in parentheses. All independent variables are from Djankov et al. (2005, 2008).
* Significant at 10 percent.
** Significant at 5 percent.
*** Significant at 1 percent.

between these measures and skewness of lending rates, investment, and output. The positive relationship between bankruptcy costs and asymmetry is captured by positive coefficients for cost and duration of bankruptcy and negative for recovery rate for lending rates and the opposite sign for investment and output. All coefficients have the expected signs and are statistically significant in almost all cases.

I also use a second set of variables to proxy directly the level of asymmetric information in financial relations. Porter et al. (1999) report four variables closely related to the performance of financial and banking systems for granting access and quality of information and reducing monitoring costs: legal protection for financial assets, sophistication of financial markets, availability of Internet banking, and health of banking systems.[6] Tables 4 and 5 show simple regressions of skewness of lending rates, investment, and output on these variables. The coefficients for lending rates are negative and statistically significant, and the coefficients for investment and output are positive and statistically significant in almost all cases. Again, larger financial frictions—costly monitoring and slow information flows in financial markets—induce larger asymmetries of movements in lending rates and economic activity.

Unfortunately, there is a high cross-country correlation between the development of financial systems and the development in other sectors of the economy, and so the larger asymmetries may be simply related to less development in those other sectors. However, the evolution of skewness over time for each country provides elements that suggest the specific importance of financial development. First, technology is closely related to the efficiency of financial systems: a highly developed technology in a country, such as computers and telecommunications, translates into low monitoring and bankruptcy costs within its financial sector, as highlighted by Merton (1987). Indeed, table 2 shows that, for all classification groups, asymmetry in lending rates decreases over time, maintaining the ranking among them. Second, in Appendix C, I compare skewness in a given country before and after financial liberalization processes, which are shocks that abruptly open an economy to competition and induce the adoption of modern and more efficient practices, reducing informational frictions. While lending rates become more symmetric after financial liberalizations, they become more asymmetric after financial restrictions.

To conclude, regardless of which indicator is examined as a measure of financial development—standard such as credit to the private sector as a percentage of GDP and enforcement of contracts, or more specific measures of financial frictions, both across countries and over time, such as

[6] These are reported on the basis of an index that ranges from 1 (worst) to 7 (best).

TABLE 4
ASYMMETRY OF LENDING RATES AND MONITORING COSTS

	DEPENDENT VARIABLE: SKEWNESS OF LENDING RATES							
	1960–2008				1985–2008			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Legal protection for financial assets	−.40				−.71			
	(.24)*				(.24)***			
Sophistication of financial markets		−.40				−.62		
		(.21)*				(.19)***		
Availability of Internet banking			−.54				−.57	
			(.25)**				(.24)**	
Health of banking systems				−.33				−.56
				(.16)**				(.16)***
Constant	3.47	3.16	3.80	3.14	4.55	3.61	3.43	3.82
	(1.40)**	(1.04)***	(1.23)***	(.95)***	(1.40)***	(.98)***	(1.21)***	(.98)***
Observations	56	56	56	56	56	56	56	56

NOTE.—Robust standard errors are reported in parentheses. All independent variables are from Porter et al. (1999).
* Significant at 10 percent.
** Significant at 5 percent.
*** Significant at 1 percent.

TABLE 5

Asymmetry of Economic Activity and Monitoring Costs

	Dependent Variable							
	Skewness of Investment				Skewness of Output			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Legal protection for financial assets	.25 (.17)				.25 (.14)*			
Sophistication of financial markets		.21 (.12)*				.19 (.10)*		
Availability of Internet banking			.23 (.13)*				.22 (.10)**	
Health of banking systems				.18 (.10)*				.17 (.10)*
Constant	−1.74 (.91)*	−1.34 (.57)**	−1.46 (.64)**	−1.33 (.56)**	−1.57 (.80)*	−1.10 (.48)**	−1.20 (.47)**	−1.10 (.54)**
Observations	40	40	40	40	45	45	45	45

Note.—Robust standard errors are reported in parentheses. All independent variables are from Porter et al. (1999).

* Significant at 10 percent.

** Significant at 5 percent.

*** Significant at 1 percent.

bankruptcy costs, monitoring costs, health or sophistication of financial markets, the historical evolution of technology for all countries, or financial liberalization processes—there is a clear and significant negative relationship between financial development and asymmetries on lending rates and economic activity.

III. A Partial Equilibrium Model

I provide now a model that captures both theoretically and quantitatively the negative relation between financial development and asymmetries. In particular, I show that large financial frictions, modeled as large bankruptcy costs that make it difficult to overcome asymmetric information between borrowers and lenders, induce asymmetric movements of lending rates as a response to symmetric shocks to fundamentals. Furthermore, more asymmetric lending rates translate into more asymmetric investment and output.

In this section I develop a simple partial equilibrium model that introduces financial frictions into a setting with endogenous information flows and discuss the mechanism behind the negative relation between financial development and asymmetries. In the next section, I extend this simple partial equilibrium model into a general equilibrium model that endogenizes default rates, loan sizes, and the price of capital in a setting with infinitely lived households that smooth consumption and learn about aggregate fundamentals. The extension to a general equilibrium setting does not add any theoretical insight but improves the quantitative performance of the model in several dimensions.

A. The Model

In this model, I embed financial frictions into Veldkamp's (2005) frictionless partial equilibrium model, where entrepreneurs should borrow to invest in a risky venture and all agents learn about an aggregate economic state. The economy has a credit market with a finite number N of entrepreneurs without funds on their own and $M > N$ perfectly competitive investors, each with one unit of indivisible capital but no business ideas. Both entrepreneurs and investors are risk neutral and live for a single period. Since some entrepreneurs will borrow to start a venture, some investors effectively will become lenders. Unlike Veldkamp's model, my model has ex post asymmetric information between borrowers and lenders about the repayment possibilities of borrowers, which I refer to as a financial friction.

At the beginning of period t, each entrepreneur i observes a business opportunity that pays v_{it} at the end of the period in case of success and zero otherwise. The payoffs v_{it} are drawn from a support $(\underline{v}; \bar{v})$ with a probability given by the density function $f(v)$.[7] All ventures require the same initial investment (normalized to one). If entrepreneurs decide to undertake the venture, they must borrow the money. If they decide not to borrow, their only option is to work for an exogenously fixed wage w. Investors can either lend the indivisible unit of capital to entrepreneurs or invest it in a riskless bond that pays an exogenous and constant rate $1 + r$.

In every period t, the probability of success is the same for all ventures, θ_g in good times (G) and θ_b in bad times (B), where $\theta_g > \theta_b$ and G and B are the only two possible states of an aggregate variable that follows a Markov process with persistence $1 - \lambda$. I assume that neither borrowers nor lenders can observe the state of the economy when negotiating a loan but that both try to infer it from observations of venture realizations in previous periods. More explicitly, the expected probability of success of a venture in period $t + 1$ is determined as follows. From the n_t funded ventures in period t, agents observe that s_t succeeded and form posterior beliefs μ'_t, using Bayes's rule and a prior $\mu_t = \Pr(G)_t$:

$$\mu'_t = \Pr(G|n_t, s_t)_t = \frac{\theta_g^{s_t}(1-\theta_g)^{n_t-s_t}\mu_t}{\theta_g^{s_t}(1-\theta_g)^{n_t-s_t}\mu_t + \theta_b^{s_t}(1-\theta_b)^{n_t-s_t}(1-\mu_t)}. \quad (1)$$

Adjusting these posteriors by the probability of a state change, the probability of being in a good state in $t + 1$ is

$$\mu_{t+1} = \Pr(G)_{t+1} = (1-\lambda)\mu'_t + \lambda(1-\mu'_t). \quad (2)$$

Finally, the expected probability of success of a given venture in $t + 1$ is

$$\theta_{t+1} = \Pr(s)_{t+1} = \mu_{t+1}\theta_g + (1-\mu_{t+1})\theta_b. \quad (3)$$

When a loan is negotiated between an entrepreneur i and an investor j at the beginning of period t, both observe the venture's potential payoff v_{it} and agree on the expected probability of success θ_t, updated as above using information from $t - 1$. Ex post, however only the entrepreneur can observe for free whether its own project was successful or not.

At the end of the period, borrowers may pay the stipulated lending rate to lender j, which I refer to as $1 + \rho_{jt}$, or default. In case of default, the lender can take the borrower to bankruptcy at a cost γ. Bankruptcy is the procedure under which the lender verifies the failure of the proj-

[7] These bounds are chosen such that an entrepreneur with a business opportunity with payoffs under $\underline{v}$ would never start the venture and an entrepreneur with a business opportunity with payoffs above $\bar{v}$ would always start the venture for all plausible lending rates given the parameters in the economy.

ect and seizes the payoff v_{it} if it finds out that the project was indeed successful.[8] Following the costly state verification literature initiated by Townsend (1979), I assume that γ is the cost of all activities involved in verification and bankruptcy, including judiciary costs and delays, accountant and attorney fees, asset storage, preservation and liquidation costs, restructuring and seniority restrictions, and so forth. Since initial investment for each venture was normalized to one, a bankruptcy cost of $\gamma = 0.3$, for example, represents a cost of 30 percent of the initial investment. This cost γ is intimately related to the degree of financial development in a country, and it is the main parameter in the model to drive cross-country differences in asymmetry. Finally, I assume that there is full commitment to the loan contract (lenders cannot renege from taking a borrower to bankruptcy in case of default) and pure bankruptcy strategies.[9]

The timing of the model in each period t is as follows:

1. Entrepreneurs and investors agree on their beliefs of being in a good state (μ_t).
2. Investors offer loan contracts, taking into account the potential bankruptcy costs γ. Entrepreneurs decide whether or not to borrow and start a venture given those contracts. A borrower who is indifferent between loan contracts is randomly assigned to the investors offering those contracts. Entrepreneurs who do not borrow work at an exogenous wage w. Investors who do not lend invest in a riskless bond that pays $1 + r$.
3. Production occurs. A borrower receives cash flows when the venture is successful.
4. Borrowers report the result of their ventures to lenders and contracts are fulfilled. Entrepreneurs and investors consume and die. All reports and verification results are publicly available to the next cohort of agents.
5. The new cohort of entrepreneurs and investors use the public information above to update beliefs (μ_{t+1}). The state changes with a probability λ.

B. Equilibrium Outcomes

Here I define and characterize the equilibrium. Even though there is an analytical solution in each period, it is not possible to write the dynamics of the model explicitly. The nature of the equilibrium, however, sheds

[8] Since borrowers are short-lived and not fully liable, the maximum penalty that can be imposed in case of default is seizure of all current assets, v_{it}.

[9] I focus on nonstochastic bankruptcy for expositional purposes. In App. C, I show that allowing for stochastic bankruptcy does not modify the results.

light on the effect of financial frictions on the asymmetry of lending rates, investment, and output.

Definition 1. A subgame perfect Nash equilibrium (SPNE) for an initial belief μ_0 is given by time sequences of borrowing (b_{it}) and payment decisions in case of success (z_{it}) for each entrepreneur i, lending rates (ρ_{ijt}) and monitoring decisions (π_{jt}) for each investor j, and Bayesian beliefs about the probability of being in a good state μ_t, such that the following problems are solved in each period t:

- Each entrepreneur i maximizes expected utility,

$$\max_{b_{it}\in\{0,1\};z_{it}\in[0,1];j\in\{1,\ldots,M\}} b_{it}\theta_t\{z_{it}[v_{it}-(1+\rho_{ijt})]+(1-z_{it})(1-\pi_{jt})v_{it}\} + (1-b_{it})w,$$

  where $\theta_t = \mu_t\theta_g + (1-\mu_t)\theta_b$ is the expected probability of a successful venture.
- Each investor j maximizes expected profits,

$$\max_{\rho_{ijt}\in\mathbb{R},\pi_{jt}\in\{0,1\}} \mathbb{I}_{jt}\theta_t[z_{it}(1+\rho_{ijt})+(1-z_{it})\pi_{jt}(v_{it}-\gamma)] - \mathbb{I}_{jt}\pi_{jt}(1-\theta_t)\gamma + (1-\mathbb{I}_{jt})(1+r),$$

  where $\mathbb{I}_{jt}=1$ if some borrower decides to take a loan from this investor j in period t.
- Beliefs are updated using Bayes's rule, following equations (1), (2), and (3), where the total number of ventures funded is $n_t = \sum_{i=1}^{N} b_{it}$.

The following proposition characterizes the unique SPNE with nonstochastic monitoring, which takes the form of an optimal standard debt contract. The proof is in Appendix B.

Proposition 1. In each period t, all investors j set the same lending rate

$$1+\rho_t = \frac{1+r}{\theta_t} + \frac{1-\theta_t}{\theta_t}\gamma \tag{4}$$

to all borrowers i and monitor every default $(\pi_{jt}=1)$. All borrowers report the truth $(z_{it}=1)$, and all entrepreneurs borrow $(b_{it}=1)$ randomly from an investor j whenever

$$v_{it} \geq \tilde{v}_t = \frac{1}{\theta_t}[1+r+w+(1-\theta_t)\gamma]. \tag{5}$$

A key dynamic variable is the total number of ventures n_t funded in the economy (the sum of entrepreneurs who borrow in period t), which is also the total investment per period:

$$n_t = \sum_{i \in \{1,\ldots,N\}} \mathbb{I}_{\{v_{it} \geq \tilde{\nu}_t = (1/\theta_t)[1+r+w+(1-\theta_t)\gamma]\}}, \tag{6}$$

where $\mathbb{I}$ is an indicator functions that equals one if equation (5) holds for an entrepreneur i, and zero otherwise.

Total investment is nondecreasing in the expected probability of success θ_t (since $\partial\tilde{\nu}_t/\partial\theta_t \leq 0$), hence on the probability of being in a good state μ_t (from eq. [3]). This is important for the determination of signals in the economy. When μ_t is high, θ_t is also high, the borrowing cutoff value $\tilde{\nu}_t$ is low, and the number of funded ventures is large. In contrast, from equation (4), lending rates are decreasing in the probability of success θ_t (because repayment is more likely, and hence bankruptcy is less likely) and also decreasing in bankruptcy costs, γ. Furthermore, since

$$\frac{\partial(1+\rho_t)}{\partial\gamma} = \frac{1-\theta_t}{\theta_t} > 0,$$

lending rates are more sensitive to bankruptcy costs when success probabilities are low.[10] Finally, output is

$$y_t = \sum_{i \in \{1,\ldots,N\}} \mathbb{I}_{\{v_{it} \geq \tilde{\nu}_t\}} \theta_{\text{state}} v_{it} \tag{7}$$

and depends both on the expected probability of success, θ_t (which determines the number of ventures through its impact on $\tilde{\nu}_t$), and on the realized probability of success, $\theta_{\text{state}} \in \{\theta_b, \theta_g\}$ (which determines the number of those ventures that do succeed).

C. *Implications for Asymmetry*

Since the number of signals is changing continuously, writing an explicit analytical solution of the dynamic evolution of lending rates, investment, and output is intractable. Despite this shortcoming, I can still show analytically that financial frictions tend to hinder the flow of information more after crises than before crises, inducing stronger asymmetries. The following proposition shows the conditions for bankruptcy costs to make lending rates, investment, and output more asymmetric, as in the data, and later I show that these conditions hold quantitatively.[11]

PROPOSITION 2. In an endogenous information economy, the asymmetry of lending rates and economic activity increases with bankruptcy

[10] A useful benchmark is the frictionless $\gamma = 0$, in which case the solution coincides with that in Veldkamp (2005).

[11] The proposition relies on the time irreversibility of beliefs. The link between time irreversibility and skewness depends on distributional assumptions, so I leave for the quantitative exercise the discussion of whether the model is able to match cross-country differences in skewness.

costs if the sensitivity of economic activity to lending rates increases with bankruptcy costs. More specifically, a sufficient condition for this result is

$$R > \left(\frac{\theta_b}{\theta_g}\right)^{\underline{n}}, \qquad (8)$$

where $R = \min_{\nu \leq \nu'} f(\nu')/f(\nu)$ is the minimum ratio of densities for all projects' payoffs $\nu \in [\underline{\nu}, \bar{\nu}]$ and $\nu' \in [\nu, \bar{\nu}]$, while $\underline{n}$ is the lowest number of ventures feasible in equilibrium (n_t when beliefs are θ_b).

This proposition is proved in Appendix B. The asymmetry of lending rates and economic activity tends to increase with bankruptcy costs, but there are limits to this result, which are characterized by condition (8): larger bankruptcy costs do not make economic activity less sensitive to lending rates. Since the right-hand side of equation (8) is less than one, the condition is trivially fulfilled when the distribution of payoffs is uniform (since the densities are a constant evaluated at any ν and $R = 1$) or when the cumulative distribution is a convex function of ν (since the densities are increasing in ν over the relevant support $\nu \in [\underline{\nu}, \bar{\nu}]$ and $R > 1$). More importantly, this condition is more easily fulfilled when θ_g is large with respect to θ_b or when the number of firms financed under the most pessimistic beliefs, $\underline{n}$, is large.

What is the intuition for this sufficient condition? Take, for example, the extreme case in which bankruptcy costs are so large that they prevent economic activity almost completely. Since in such a country economic activity is always very low, the effect of a large increase in lending rates is not very noticeable, and the number of signals does not drop much further. In this case, more pessimistic beliefs do not have any effect on restricting activity further, thus having a negligible effect on fluctuations and asymmetries. The condition avoids this possibility. In the quantitative section, I show that for the empirically relevant range of bankruptcy costs, the condition is fulfilled and financial frictions do increase asymmetries.

Provided that the condition is satisfied, the intuition of why bankruptcy costs increase asymmetries is captured in figure 1. Panel *A* shows the crisis magnification force of bankruptcy costs. A given decrease in the expected probability of success generates a greater jump in lending rates in countries with higher bankruptcy costs (the increase in lending rates for a country with high bankruptcy cost ρ_t^H is larger than the increase in lending rates for a country with low bankruptcy cost ρ_t^L, when both start from the same beliefs about the aggregate state). The sufficient condition (8) guarantees that this larger increase in lending rates translates into a larger reduction in economic activity and the number of signals.

Panel *B* of figure 1 shows the recovery-delaying force of bankruptcy costs. The gap between lending rates in countries with different monitoring costs widens as the expected probability of success decreases (the

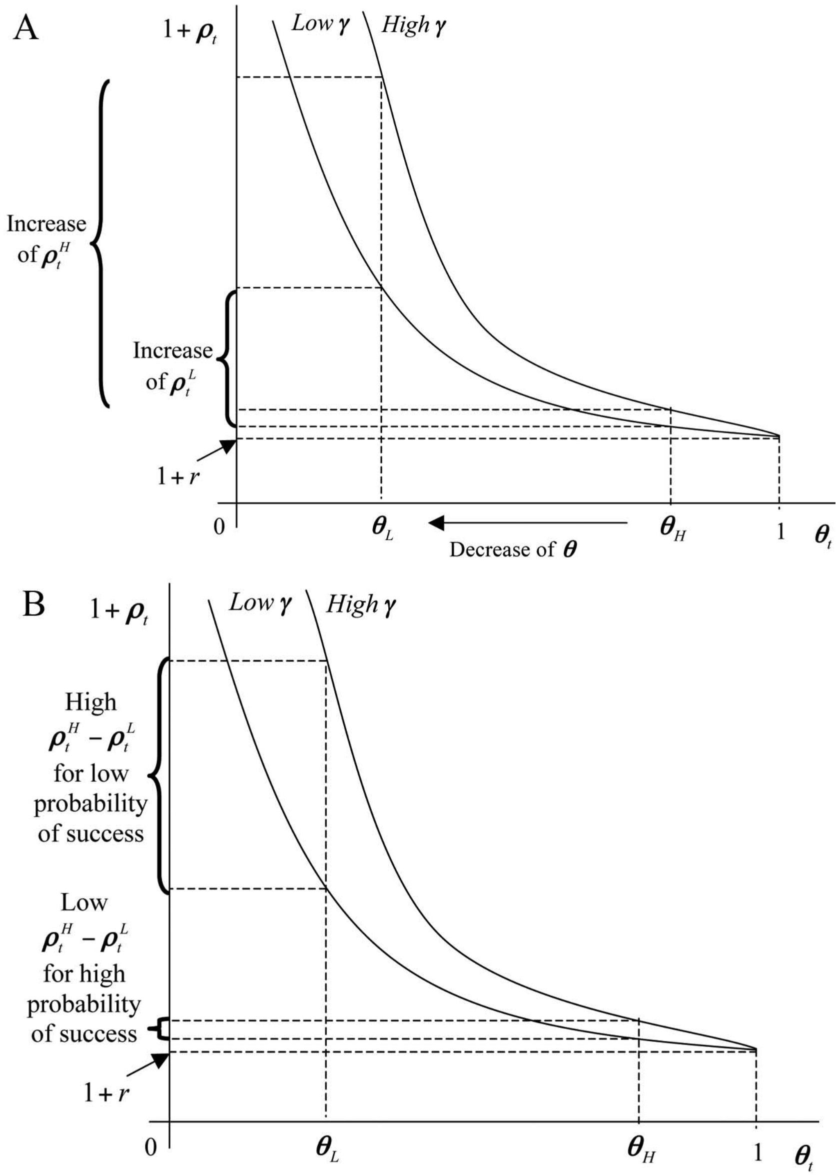

FIG. 1.—Monitoring costs magnify crises and delay recoveries

difference $\rho_t^H - \rho_t^L$ when the probability of success is low is larger than when the probability of success is high). This implies that the speed of recoveries after bad times differs between the two countries more than the speed of crises after good times. Both forces are key for having more asymmetry.

D. A Quantitative Assessment

Now I perform a quantitative assessment of the simple partial equilibrium model. I calibrate and simulate the model to show that, with some limitations, it roughly matches the observed cross-country differences in skewness for reasonable levels of bankruptcy costs.

1. Parameters

I calibrate the model monthly for a country with average levels of financial development (such as Argentina, Mexico, or Indonesia). Probabilities of success (θ_g and θ_b) are calibrated using corporate bond default rates listed by Moody's for 1970–2008. Since long time series of default rates for emerging market bonds are unavailable, I use information on US speculative grade bonds, which are riskier than typical US corporate bonds and investment grade bonds. Good and bad times are defined using NBER business cycle dates. Monthly default in good times is 0.35 percent ($\theta_g = 0.9965$) and in bad times is 0.85 percent ($\theta_b = 0.9915$), which is consistent with yearly default rates of 3 percent and 5 percent in good and bad times, as in Veldkamp (2005).[12]

The probability of a state transition, $\lambda = 0.027$, is obtained using world GDP from the Penn World Tables. As in Veldkamp (2005), booms and busts are defined for each country as years with positive and negative growth of real GDP per capita. Since there is an average of 36.5 months between state changes, there is a 2.7 percent probability of transition per month.

The parameter N is critical for the speed at which the economy learns about the aggregate state, but it does not have a clear empirical counterpart because it is the maximum possible number of independent signals, not the maximum possible number of projects.[13] I calibrate N to match skewness of lending rates for countries of income group 3 (1.77) using their average level of bankruptcy costs from Djankov et al. (2008) (16.6 percent), which delivers $N = 41$. This number is consistent with the number of independent signals, $N = 25$, that Veldkamp (2005) computed by measuring the speed of price adjustments in the United States. With $N = 25$, the skewness of lending rates when $c = 16.6$ percent is 1.97, and results are quantitatively very similar.

[12] For developed countries, I perform the exercise using information on "all corporate" bonds, when yearly probabilities of default are 2 percent and 3 percent in good and bad times, respectively. Results are similar.

[13] In the model these are the same because I assume uncorrelated projects, but if they were highly correlated, a large number of projects would still generate a small number of independent signals. Indeed, if every firm in a country were generating an independent signal, forecast errors for macroeconomic aggregates would be negligible, which suggests that projects are highly correlated and their information content for total activity is restricted.

I assume that venture payoffs are distributed uniformly in $[\underline{v}, \bar{v}]$, where $\underline{v} = (1 + w + r)/\theta_g$ and $\bar{v} = (1 + w + r)/\theta_b$, which implies that there is activity for the range of possible beliefs.[14] Finally, parameters r and w affect only the scale of lending rates, and skewness is invariant in scale.[15]

Using these parameters, I simulate lending rates for 600 periods (recall that I compute skewness using monthly data over 50 years) and compute the unconditional skewness of their log changes. I repeat this simulation 10,000 times, obtaining Monte Carlo standard deviations. For expositional purposes I use the same parameters for all countries and compare their asymmetries purely from modifying a single parameter, γ, the bankruptcy costs.

2. Implications for Asymmetry

Table 6 compares the empirical skewness of lending rates, investment, and output with their model counterparts. Even though the only difference across countries that I impose in the model comes from the different levels of bankruptcy costs reported by Djankov et al. (2008), it reproduces well the positive relation between bankruptcy costs and asymmetries, but not its sensitivity. The skewness of lending rates for income group 3 (1.77) was targeted to calibrate N, but the data exhibit less asymmetry than the model for countries with low bankruptcy costs and more asymmetry than the model for countries with high bankruptcy costs. The model generates excessive levels of skewness for economic activity, but it is still surprisingly successful considering that no moment of investment and output has been targeted and there is no serious model of economic activity. The fit of the model can improve considerably by introducing additional differences in default probabilities and exogenous signals, but this would contaminate the exercise of identifying the contribution of bankruptcy costs to asymmetry.[16]

To illustrate the nature of the mechanism, figure 2 displays an example of the model's lending rate dynamics under the same shock realizations but different levels of bankruptcy costs. I show the paths of lending rates over 100 simulated periods (out of 600 periods) of one simulation (out of 10,000 simulations) for three economies with different levels of bankruptcy costs: $\gamma = 0$, $\gamma = 0.25$, and $\gamma = 0.5$. Three clear patterns emerge: (i) lending rates are higher in economies with higher bankruptcy

[14] Results assuming a normal distribution with 95 percent in $[\underline{v}, \bar{v}]$ are similar, with slightly higher skewness.

[15] Skewness is independent of r and w because the support for the distribution of v_i is $[\underline{v}, \bar{v}]$ in terms of r and w, as defined in the text.

[16] In App. C I show that the model's predictions in terms of levels and volatilities are also consistent with the data, but with limitations that are relaxed in the general equilibrium version of the model.

TABLE 6

Skewness from the Partial Equilibrium Model

Country Classification	Bankruptcy Costs	Skewness from Data			Skewness from Partial Equilibrium Model		
		Lending Rates	Investment	Output	Lending Rates	Investment	Output
Income group 1 (richest)	7.2	.28	−.14	.07	1.54	−.77	−.62
Income group 2	15.8	1.55	−.48	−.40	1.74	−.95	−.77
Income group 3	16.6	1.77	−.68	−.42	1.77	−.97	−.78
Income group 4 (poorest)	24.4	2.91	−1.09	−.49	2.02	−1.03	−.85
OECD	8.8	.87	−.28	−.05	1.56	−.82	−.65
Non-OECD	19.2	1.98	−.44	−.30	1.85	−.99	−.81
High contract enforcement	10.9	.45	−.19	−.01	.61	−.87	−.70
Low contract enforcement	23.3	2.44	−.21	−.20	1.98	−1.02	−.84
Private bureau	11.5	.87	−.19	−.06	1.62	−.88	−.70
No private bureau	21.1	2.25	−.71	−.56	1.90	−1.01	−.82

Note.—Income classifications are from the World Bank (WDI). Contract enforcement indicator is from Levine et al. (2000). Existence of a private bureau is from Djankov et al. (2007). Bankruptcy costs are from Djankov et al. (2008).

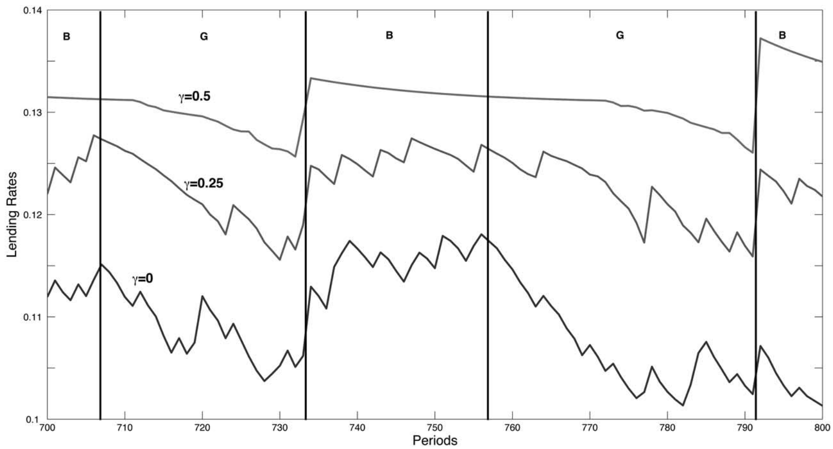

FIG. 2.—Model's evolution of lending rates with different levels of monitoring costs

costs; (ii) when the economy moves from good times (G) to bad times (B), lending rates jump everywhere, but more in countries with higher costs; and (iii) when the economy moves from bad times (B) to good times (G), lending rates decline everywhere, but faster in countries with lower costs.

Caveats.—What are the limits of the model? The model fails to explain the very low levels of lending rates' skewness among the richest countries. Even when imposing $\gamma = 0$, the model delivers a skewness of 1.4 while the data exhibit skewness of 0.28 during the period 1985–2008. One interpretation is that the conditions calibrated for countries in income group 3 in recent years are roughly the average conditions that characterized developed countries in previous years: average skewness for the richest countries in the period 1960–2008 was 1.54. An alternative way to accommodate the low skewness of the richest countries is to impose their empirical levels of default ($\theta_g = 0.98$ in good times and $\theta_b = 0.97$ in bad times) and to assume that there is a large fraction of economic activity that does not require external financing.

The model also fails to explain the high levels of lending rates' skewness among the poorest countries. To match those levels, however, requires plausible levels of bankruptcy costs. For example, a skewness of 2.91 (for income group 4) is consistent with bankruptcy costs of around 38 percent rather than the 24.4 percent reported by Djankov et al. (2008).[17] In contrast, the change of other parameters needed to match

[17] There is still debate in the literature about the right measurement of monitoring and bankruptcy costs. Warner (1977) estimated a cost of around 4 percent of the firm's total assets considering only direct costs of bankruptcy for the railroad industry. Altman (1984) raised the estimation to 20 percent by including indirect costs, such as lost sales and lost

a skewness of 2.91 in a frictionless environment ($\gamma = 0$) seems implausible.[18] We would need very stable states (with $\lambda = 0.002$ and then states changing every 42 years on average), very persistent bad times (lasting 20 years on average), or very clear signals (either 30 percent of firms defaulting in bad times or barely no firm defaulting in normal times). This caveat also poses the question of which other channels may restrict information flows during recessions in less developed countries.

The most important caveat, however, arises from the partial equilibrium nature of the results for economic activity. In this model, investment and output are roughly the same object and so are difficult to compare with the data. In the next section I relax this assumption and develop a general equilibrium model with more realistic counterparts in terms of economic activity.

IV. A General Equilibrium Model

In this section I show that the positive relationship between bankruptcy costs and the asymmetries of lending rates, investment, and output emerge quantitatively in a full general equilibrium model as well. There are several important extensions to the previous simple partial equilibrium model. First, the size of investment is not assumed to be exogenous and normalized to one but endogenously chosen by entrepreneurs when obtaining a loan. Second, the price of capital is endogenous, which plays a critical role in determining the level of investment and the effects of financial frictions. Third, there are still two types of agents (borrowers and lenders), but lenders are infinitely lived and smooth consumption, which has implications for the link between investment and output. Finally, I do not impose an exogenous shock to the probability of default, but to the cross-sectional variance of entrepreneurial returns, which endogenously determines the probability of default in the economy.

Methodologically, I extend the model of Carlstrom and Fuerst (1997) by adding a sophisticated information structure that resembles the learning mechanism discussed in the previous section. In this extension, a boom is interpreted as a period of low "risk" (low cross-sectional variance of entrepreneurial productivity), which endogenously generates low default and high output, while a recession is a period of high "risk," hence high default and low output. First, this is consistent with Bloom's (2009) findings of a negative relation between uncertainty and output, but my

profits. Finally, Alderson and Betker (1995) introduced the value of the firm as a going concern, raising the estimation even further to approximately 36 percent. We use Djankov et al. (2008) because it is the only paper with a clean comparison of these costs across countries.

[18] These are conditions similar to those Veldkamp (2005) identified to match a skewness of 2.9 for the 13 emerging countries in her frictionless environment.

explanation hinges on financial markets and not on investment irreversibilities. Second, I introduce a “risk shock” instead of a “productivity shock” mainly to tackle one of the main drawbacks of Carlstrom and Fuerst’s model, which is the procyclicality of risk premia. In contrast, my extension generates, as in the data, countercyclical risk premia. Furthermore, the quantitative relevance of risk shocks in driving large crises is consistent with the recent work of Gilchrist et al. (2009), Christiano et al. (2012), and Gilchrist and Zakrajsek (2012).

To study the quantitative implications of this extension for the asymmetry of lending rates, investment, and output, I calibrate the model along the lines of the previous section. Since learning is a critical addition, the simulation of the model requires a global solution and hence the use of projection methods. A local solution, as in Carlstrom and Fuerst (1997), is not suitable for our purposes because perturbing the model around a steady state impedes matching the sudden and large jumps in default rates and lending rates observed in the data.

In what follows I show that in a full general equilibrium model with endogenous default, endogenous investment, endogenous price of capital, consumption smoothing, and an optimal financial contract with learning, bankruptcy costs have the potential to explain quantitatively the differences in skewness across countries.

A. *The Model*

Economy structure.—The economy is inhabited by a mass $1-\eta$ of infinitely lived risk-averse households, with discount rate β and utility function $U(c)$, where $U'(c) > 0$ and $U''(c) < 0$, and a mass η of short-lived risk-neutral entrepreneurs.

At the beginning of each period, both households and entrepreneurs supply labor inelastically at wages w_t^h and w_t^e, respectively, and households rent their capital at a rate r_t to a representative firm that produces aggregate output in units of a consumption good according to an aggregate production function

$$Y_t = F(K_t, H_t, H_t^e), \tag{9}$$

where K_t is the aggregate capital in the economy, which is produced by entrepreneurs, H_t is the labor supply of households, and H_t^e is the labor supply of entrepreneurs.

In the middle of the period, after the production of the consumption good and the compensation to inputs, households make consumption and investment choices. For each unit of investment that a household wishes to purchase, it should give q_t units of consumption goods to a risk-neutral intermediary, which I call the capital mutual fund (CMF), in exchange for capital goods at the end of the period.

Entrepreneurs have access to a technology that transforms consumption goods into capital goods stochastically. The CMF uses the resources obtained from households to provide loans to entrepreneurs, who may require funds to increase their scale of production. As in the simple model, I assume symmetric information between entrepreneurs and the CMF at the time of the loan and asymmetric information ex post with costly state verification. I will formally show that a version of standard debt contracts is optimal in this setting.

At the end of the period, stochastic production is realized. Entrepreneurs with high enough production repay and consume the residual. Entrepreneurs with low production default and are monitored by the CMF. Since the CMF lends to a continuum of entrepreneurs, it diversifies their idiosyncratic risk, providing a risk-free investment opportunity to households.

The assumption of one-period-lived entrepreneurs makes their problem static and constrains them from accumulating net worth. Net worth accumulation is an interesting possibility that has been explored by Carlstrom and Fuerst (1997). However, as I discuss later, this choice critically complicates the computation of the model without adding much to the learning mechanism as a source of asymmetries.

Information structure.—An entrepreneur who invests i_t gets a stochastic return equal to ωi_t in terms of capital goods, where ω is idiosyncratic to each entrepreneur. I assume that ω is distributed lognormally with fixed mean m_ω and stochastic variance $\sigma^2_{\omega,t}$:

$$\omega \sim \Upsilon(m_\omega, \sigma^2_{\omega,t}) \equiv \Upsilon_{\sigma^2_{\omega,t}}, \tag{10}$$

where $\Upsilon_{\sigma^2_{\omega,t}}$ is the cumulative distribution function of the lognormal density $\upsilon_{\sigma^2_{\omega,t}}$.

The variance of ω is drawn each period from two possible symmetric distributions with a bounded positive support, $\sigma^2_{\omega,t} \sim \Psi(M_H, \sigma^2_{\sigma,t}) \equiv \Psi_{H,\sigma^2_{\sigma,t}}$ or $\sigma^2_{\omega,t} \sim \Psi(M_L, \sigma^2_{\sigma,t}) \equiv \Psi_{L,\sigma^2_{\sigma,t}}$, which differ only by their means, such that $M_H > M_L$.[19] These two distributions characterize two possible aggregate states of the economy, which I call a recession or bad times if Ψ_H and an expansion or good times if Ψ_L, for reasons that will become apparent later. As in the simple model, the aggregate state of the economy follows a Markov process with persistence $1 - \lambda$.

At the beginning of each period, households and newborn entrepreneurs cannot observe the aggregate state, but they try to infer it using the total output and the fraction of defaulting entrepreneurs in the past: if

[19] It is important to assume two distributions rather than two variances. Otherwise, since agents observe total production and there is a continuum of entrepreneurs, they would learn immediately the true state of the economy.

the number of defaults was high, then agents assign a high probability that the aggregate state was a recession, Ψ_H, during the previous period.

The speed of updating is given by a time-varying $\sigma^2_{\sigma,t}$. To capture the mechanism developed in the partial equilibrium model in which the precision of signals depends on the volume of economic activity, I assume that $\sigma^2_{\sigma,t}$ varies over time as a function of investment at time t. I assume the following specification:

$$\sigma^2_{\sigma,t} \equiv \frac{\sigma^2_\sigma}{i_t^\phi}, \tag{11}$$

which depends on two exogenous parameters, ϕ and σ^2_σ. Later, I will calibrate these two parameters in the same way I calibrated the maximum possible number of independent signals, N, in the simple model. The intuition is again that a higher volume of investment generates a larger number of signals, which makes the fraction of observed defaults more informative about the aggregate state of the economy.

To be more specific, agents at the beginning of period $t+1$ observe the fraction of entrepreneurs defaulting in the economy in the previous period, which is a perfect signal of $\sigma^2_{\omega,t}$, and the total volume of economic activity (which is a perfect signal of i_t and then $\sigma^2_{\sigma,t}$). On the basis of these two pieces of information, agents form beliefs about the economy having been in a good state in period t, $\mu'_t \equiv \Pr\{\Psi_t = \Psi_L\}$, using Bayesian updating:

$$\begin{aligned}\mu'_t &\equiv \Pr\{\Psi_t = \Psi_L | \sigma^2_{\omega,t}, \sigma^2_{\sigma,t}, \mu_t\} \\ &= \frac{\psi_{L,\sigma^2_{\sigma,t}}(\sigma^2_{\omega,t} - M_L)\mu_t}{\psi_{L,\sigma^2_{\sigma,t}}(\sigma^2_{\omega,t} - M_L)\mu_t + \psi_{H,\sigma^2_{\sigma,t}}(\sigma^2_{\omega,t} - M_H)(1-\mu_t)},\end{aligned} \tag{12}$$

where $\psi_{L,\sigma^2_{\sigma,t}}(\sigma^2_{\omega,t} - M_L)$ is the density function of $\Psi_{L,\sigma^2_{\sigma,t}}$ normalized with mean zero when observing default rates that imply $\sigma^2_{\omega,t}$ when the state is L. The same holds for state H. On the basis of the updated belief about the previous variance-generating distribution, Ψ_t, the belief about the current variance-generating distribution Ψ_{t+1} needs to take into account the known transition probability

$$\mu_{t+1} = \Pr\{\Psi_{t+1} = \Psi_L\} = \Pr(1-\lambda)\mu'_t + \lambda(1-\mu'_t). \tag{13}$$

These two equations are just a different version of equations (1) and (2).

Timing.—Timing can be described as follows:

1. Entrepreneurs and households agree on their beliefs of being in a good state (μ_t).

2. A representative firm that produces the consumption good Y_t hires labor from households and entrepreneurs and rents capital from households.
3. Households decide how much of their income to consume and how much to use to purchase investment goods from the CMF (claims on capital goods at the end of the period), at a price q_t per unit of capital goods in terms of consumption goods.
4. The CMF uses the resources from households to lend to entrepreneurs using an optimal financial contract and diversifying all idiosyncratic risk.
5. Entrepreneurs borrow consumption goods from the CMF to transform i_t units of the consumption good into stochastic ωi_t units of capital goods.
6. The aggregate state and the variance of $\sigma^2_{\omega,t}$ are realized. Production happens, financial contracts are fulfilled, and entrepreneurs consume.
7. Households and the new cohort of entrepreneurs use public information about i_t and $\sigma^2_{\omega,t}$ to update beliefs (μ_{t+1}). The state changes with a probability λ.

Optimal financial contract.—As in the simple model, the financial friction comes from ex post asymmetric information between the entrepreneur and the CMF. Even when the contract still takes the form of a standard debt contract, entrepreneurs also choose the size of the loan i. Since production is linear in i and entrepreneurs would like to borrow infinitely, their net worth is critical to restricting the size of the loan. Since entrepreneurs are short-lived, their net worth is simply the labor wage received at the beginning of the period:

$$n_{et} = w^e_t. \tag{14}$$

Costly state verification implies that, even when entrepreneurs observe their production ωi_t for free, it costs γi_t to the CMF to observe and seize the entrepreneur's production. Under the optimal contract, each entrepreneur borrows $i_t - n_{et}$ from the CMF and agrees to repay $(1 + r^k_t)(i_t - n_{et})$ capital goods at the end of the period. The entrepreneur defaults if production is not enough to cover the debt, which occurs when $\omega < \bar{\omega}_t$, where

$$\bar{\omega}_t \equiv \frac{(1 + r^k_t)(i_t - n_{et})}{i_t}. \tag{15}$$

Since the price of capital in period t is q_t, the lending rate in units of consumption is

$$1 + \rho_t = q_t(1 + r^k_t). \tag{16}$$

This is just an expanded version of equation (4). In the simple model, we assumed $q_t = 1$, $i_t = 1$, and $n_{et} = 0$; then $1 + \rho_t = \bar{\omega}_t$, and the entrepreneur defaults if payoffs are lower than $1 + \rho_t$.

Finally, assuming commitment, the CMF monitors the project and seizes all production only if the entrepreneur defaults, paying the bankruptcy cost γ per unit of investment. This optimal contract is summarized in the next proposition and proved in Appendix B.

PROPOSITION 3. The optimal financial contract is characterized by i_t and $\bar{\omega}_t$ that solve the problem

$$\max_{i_t, \bar{\omega}_t} q_t i_t f(\bar{\omega}_t, \mu_t)$$
$$\text{subject to } q_t i_t g(\bar{\omega}_t, \mu_t) \geq i_t - n_{et}, \tag{17}$$

where $n_{et} = w_t^e$, $f(\bar{\omega}_t, \mu_t)$ is the fraction of the expected net capital output received by the entrepreneur, and $g(\bar{\omega}_t, \mu_t)$ is the fraction of the expected net capital output received by the lender. The solution is characterized by the first-order conditions

$$\{i_t\}: \quad q_t f(\bar{\omega}_t, \mu_t) + \zeta_t [q_t g(\bar{\omega}_t, \mu_t) - 1] = 0, \tag{18}$$

$$\{\bar{\omega}_t\}: \quad \zeta_t = -\frac{f_\omega(\bar{\omega}_t, \mu_t)}{g_\omega(\bar{\omega}_t, \mu_t)}, \tag{19}$$

where f_ω and g_ω are the respective derivatives $f(\bar{\omega}_t, \mu_t)$ and $g(\bar{\omega}_t, \mu_t)$ with respect to $\bar{\omega}$, and ζ_t is the Lagrange multiplier.

As in the simple model, the optimal level of investment, i_t, changes the speed of updating, but entrepreneurs do not internalize this positive effect when choosing the size of the loan, and each single entrepreneur takes it as given when solving his contracting problem. The speed of updating will then be determined in equilibrium by consistency with each entrepreneur's choice. This is the critical externality that introduces inefficiencies in the model. There is a noninternalized gain from having more investment in bad times and speeding up recoveries.

Agents' optimization problem.—In order to solve the agents' problems, we first need to consider the law of motion of aggregate capital in the hand of households, which agents take as given when solving their maximization problem. On the one hand, given the linearity of the problem, the distribution of wealth does not enter as a state variable when aggregating. On the other hand (exactly as in eq. [7] of the simple model), capital depends both on the true variance, $\sigma^2_{\omega,t}$, and on the expected variance through the financial contract, summarized by $\bar{\omega}_t$. The true law of motion of aggregate capital, as a function of $\sigma^2_{\omega,t}$ and $\bar{\omega}_t$, is

$$K_{t+1}^{\sigma^2_{\omega,t}} = (1 - \delta) K_t + \eta i_t [m_\omega - \Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)\gamma]. \tag{20}$$

The households' problem is dynamic, with budget constraint

$$c_t + q_t(k_{t+1} - (1-\delta)k_t) \leq w_t^l + k_t r_t, \tag{21}$$

and recursively, households' problem is

$$V(K_t, \mu_t) = \max_{c_t} U(c_t) + \beta E_{t,\mu_t}[V(K_{t+1}, \mu_{t+1})] \tag{22}$$

subject to (12), (13), (20), and (21). The Euler equation, which summarizes the dynamic demand for capital, is then

$$q_t U_{c,t} = \beta E_{t,\mu_t}\{U_{c,t+1}[q_{t+1}(1-\delta) + r_{t+1}]\}. \tag{23}$$

Developing expectations explicitly, we get

$$\begin{aligned} q_t U_{c,t} = \beta\bigg(\mu_t \int & \{U_{c,t+1}(X_{t+1}^{\sigma^2_{\omega,t}})[q_{t+1}(X_{t+1}^{\sigma^2_{\omega,t}})(1-\delta) \\ & + r_{t+1}(K_{t+1}^{\sigma^2_{\omega,t}})]\} d\Psi_{H,\sigma^2_{\sigma,t}} + (1-\mu_t)\int \{U_c(X_{t+1}^{\sigma^2_{\omega,t}})[q_{t+1}(X_{t+1}^{\sigma^2_{\omega,t}})(1-\delta) \\ & + r_{t+1}(K_{t+1}^{\sigma^2_{\omega,t}})]\} d\Psi_{L,\sigma^2_{\sigma,t}}\bigg), \end{aligned}$$

where $X_{t+1}^{\sigma^2_{\omega,t}} = \{K_{t+1}^{\sigma^2_{\omega,t}}, \mu_{t+1}^{\sigma^2_{\omega,t}}\}$ is the set of next-period states given by equations (12), (13), and (20), conditional on the realized variance $\sigma^2_{\omega,t}$. Next period's consumption and price of capital depend on both states next period, $X_{t+1}^{\sigma^2_{\omega,i}}$, while next period's interest rate depends only on capital next period, $K_{t+1}^{\sigma^2_{\omega,i}}$.

The entrepreneurs' problem is static. They solve the contracting problem, invest in their stochastic projects, repay their debt or default, and consume whatever residual is left. Their aggregate consumption is then

$$c_t^e = q_t\left(\frac{w_t^e f(\bar{\omega}_t, \mu_t)}{1 - q_t g(\bar{\omega}_t, \mu_t)}\right), \tag{24}$$

where $f(\bar{\omega}_t, \mu_t)$ is the expected share of total capital output that goes to entrepreneurs and $g(\bar{\omega}_t, \mu_t)$ is the expected share of total capital output that goes to lenders, given the ex ante price of capital q_t, which is fixed previous to the realization of $\sigma^2_{\omega,t}$.

Market clearing.—We have four markets to consider in the economy: two labor markets, the capital goods market, and the consumption good market (the numeraire good). Competition in the factor market implies that wage and rental rates in terms of capital are equal to their respective marginal products in the production of the consumption good:

$$r_t = F_{1,t}, \quad w_t^l = F_{2,t}, \quad w_t^e = F_{3,t}. \tag{25}$$

The expected supply of capital goods is given by the expectation of equation (20), which depends on μ_t and the financial contract $\bar{\omega}_t$. How does the expected supply depend on q_t? Entrepreneurs maximize (17), which can be rewritten as the maximization of

$$i_t f(\bar{\omega}_t, \mu_t) = i_t[m_\omega - E_{\mu_t}\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)\gamma - g(\bar{\omega}_t, \mu_t)].$$

Since an increase in q_t relaxes the constraint of the lender's return, $i_t f(\bar{\omega}_t, \mu_t)$ is increasing in q_t. Since $i_t g(\bar{\omega}_t, \mu_t)$ is also increasing in q_t, the previous equation implies that $i_t[m_\omega - E_{\mu_t}\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)\gamma]$ increases in expectation, and from equation (20), the expected supply of capital goods is increasing in q_t. The demand for capital is given by the lenders' Euler equation, which is decreasing in q_t. Market clearing happens when households decide how much money to put in the CMF and thus determine q_t.

The conditions to clear the other three markets are the following:

$$H_t = 1 - \eta, \tag{26}$$

$$H_t^e = \eta, \tag{27}$$

$$c_t + c_t^e + \eta i_t = Y_t = F(K_t, H_t, H_t^e). \tag{28}$$

Definition 2 (Recursive equilibrium). A recursive equilibrium is a set of decision rules K_{t+1}, i_t, $\bar{\omega}_t$, c_t, c_t^e; prices r_t, w_t^l, w_t^e, q_t; and belief μ_{t+1}, which are expressed as functions of the two states of the economy (K_t and μ_t) such that lenders maximize their utility subject to information and budget constraints (problem [22]), entrepreneurs maximize their utility subject to their budget constraints (24), financial contracts are optimal (proposition 3), beliefs are updated using Bayes's rule (eqq. [12] and [13]), and markets clear (eqq. [25], [26], [27], and [28]).

The challenge in solving this equilibrium is the need for a global solution. In online Appendix C, I discuss how to compute the model using projection methods. A local solution, as the log linearization that Carlstrom and Fuerst (1997) use, is not suitable for our purposes since a steady state does not exist for one of our state variables, beliefs μ. In fact, we are interested in the model dynamics when beliefs are allowed to vary widely over the whole support $[0,1]$ in order to capture the levels of asymmetries observed in the data. When the model is perturbed around a fixed μ, it is not able to match the sudden and large jumps in empirical default rates, lending rates, and economic activity. The next section discusses the calibration, simulation results, and their implications.

B. A Quantitative Assessment

1. Parameters

I calibrate the model to monthly data. As in Carlstrom and Fuerst (1997), I assume a utility function $u(c) = \log(c)$ and a production function $F(K, H, H^e) = K^\alpha H^\psi (H^e)^{1-\alpha-\psi}$. The monthly discount rate is set to $\beta = 0.9959$ (which corresponds to a 5 percent yearly risk-free interest rate), the monthly depreciation rate is 2 percent, and the production function parameters are $\alpha = 0.3$ and $\psi = 0.6275$. Finally, the fraction of entrepreneurs η is just a normalization.

The parameters that are specific to our model are $\phi = 10.7$, $\sigma_\sigma^2 =$ 4.1e–14, $M_H = 0.17$, and $M_L = 0.14$. I calibrate them to match monthly default rates, in both good and bad times (0.35 percent and 0.85 percent, respectively), the time-series standard deviation of defaults during bad times (0.5 percent), and the skewness of lending rates among emerging markets since 1985 (1.77) for their average bankruptcy costs (16.6 percent), as I did to compute N in the partial equilibrium model. Intuitively, M_H pins down default in bad times, M_L pins down default in good times, and ϕ and σ_σ^2 pin down the skewness of lending rates and the time-series variance of defaults during bad times. Even though I do not target the standard deviation of default rates during good times, which is 0.3 percent, the calibrated model generates 0.25 percent, showing that the calibration of risk shocks accommodates well the process of default over time.[20]

2. Implications for Asymmetry

The general equilibrium model improves the ability of the model to match the cross-country differences in lending rates' asymmetry, in particular, for developed countries. It also matches better investment skewness and its relation with output skewness: investment is more asymmetric than output, but still both investment and output are more negatively skewed when bankruptcy costs are larger.

Table 7 shows the performance of the general equilibrium model. First, the model is successful in replicating the negative relation between bankruptcy costs and the skewness of lending rates and economic activity. Second, it delivers levels of asymmetry for developed countries that are more in line with those observed in the data. Intuitively, the calibrated parameter ϕ induces a stronger reaction of the precision of signals to changes

[20] Even though the calibrated σ_σ^2 seems very small, investment for the targeted income group 3 is, on average, 0.091, which implies that $\sigma_{\sigma,t}^2$ (from eq. [11]) is, on average, $4.1\text{e–}14/0.091^{10.7} = 0.005$. So, e.g., in bad times the variance of ω is distributed lognormal with mean $M_H = 0.17$ and standard deviation 0.07.

TABLE 7
Skewness from the General Equilibrium Model

Country Classification	Bankruptcy Costs	Skewness from Data			Skewness from Partial Equilibrium Model		
		Lending Rates	Investment	Output	Lending Rates	Investment	Output
Income group 1 (richest)	7.2	.28	−.14	.07	.90	−.47	.41
Income group 2	15.8	1.55	−.48	−.40	1.76	−.62	.39
Income group 3	16.6	1.77	−.68	−.42	1.77	−.63	.39
Income group 4 (poorest)	24.4	2.91	−1.09	−.49	2.00	−.68	.30
OECD	8.8	.87	−.28	−.05	1.10	−.49	.34
Non-OECD	19.2	1.98	−.44	−.30	1.78	−.65	.30
High contract enforcement	10.9	.45	−.19	−.01	1.20	−.55	.30
Low contract enforcement	23.3	2.44	−.21	−.20	2.00	−.68	.32
Private bureau	11.5	.87	−.19	−.06	1.30	−.55	.30
No private bureau	21.1	2.25	−.71	−.56	1.98	−.67	.34

Note.—Income classifications are from the World Bank (WDI). Contract enforcement indicator is from Levine et al. (2000). Existence of a private bureau is from Djankov et al. (2007). Bankruptcy costs are from Djankov et al. (2008).

in lending rates. Third, it is more successful in matching the observed skewness in investment than the partial equilibrium counterpart, even when no moment of investment has been targeted. Finally, it is more successful in breaking the link between investment and output in the direction suggested by the data. When the economy moves to bad times, investment and output decline. However, since households prefer to smooth consumption, the decline in output is not as large as the decline in investment, moderating its asymmetry.

Why is the skewness of output positive? In the model, depreciation hardwires an artificial positive level of skewness. To gain intuition, assume that investment is symmetric. When investment suddenly declines, capital declines gradually depending on depreciation, and output does not drop one-for-one with investment. In contrast, when investment suddenly increases, capital and output increase one-for-one with investment. In this example, output has positive skewness even though investment is symmetric. Still, conditional on this positive bias, the skewness of output declines when γ increases, with a slope similar to the empirical one.

In Appendix C, I show that the general equilibrium model also improves in matching the volatility of lending rates, investment, and output with respect to the partial equilibrium model. I also discuss in that appendix that the general equilibrium model is particularly successful in matching the cross-country differences in skewness and the volatility levels of lending rates and investment when default rates are slightly larger than the ones calibrated using speculative grade US bonds, specifically, 0.5 percent in good times and 3 percent in bad times, which seems consistent with evidence from crises in emerging markets.

Caveats.—An important caveat of the model is the short life of entrepreneurs and the absence of net worth accumulation that may allow them to rely less on external finance over time. Here I argue that net worth accumulation is unlikely to have an important effect for asymmetry, but it introduces important complications in terms of tractability, given the need to find a global solution for the problem. In essence, net worth accumulation introduces a new state variable, namely, entrepreneurs' capital, increasing substantially the dimensionality of the vector of coefficients to find, both directly through the addition of a new state variable and indirectly through an additional function to approximate. I discuss in detail the modeling choices and the difficulties of adding net worth in Appendix C.

Still, to get a sense of the potential effects of net worth on asymmetry, I compute the global solution of a version of the model with net worth accumulation but without learning, which remains tractable. I directly impose a 2 percent negative shock to the stock of capital, the largest reduction that capital experiences in the model with learning. This shock induces net worth to drop by 2.8 percent and generates skewness of lending rates equal to 0.14. Thus, net worth alone does not generate enough asymmetry to explain the large empirical differences across countries without resorting to implausibly large shocks to the stock of capital and net worth.

V. Plausibility of an Endogenous Learning Mechanism

Here I bring together two independent pieces of evidence to illustrate the plausibility of the mechanism and to answer the following questions. First, do lending rates just replicate asymmetric fundamentals, in this case default probabilities? The answer is no. Changes in default are in fact negatively, not positively, skewed in the data. Then, if lenders learn fast about default, lending rates would reflect them closely and would also be negatively skewed, not positively as in the data. Second, if learning is the right story, does the precision of learning really recover slowly after a sudden decline? The answer is yes. Uncertainty, measured by the volatility of the stock market and interpreted as the inverse of signals' precision, is positively skewed (it increases fast and recovers slowly). The first answer reveals the economic relevance of asymmetries since they may be the reflection of inefficiencies. The second answer reveals the potential relevance of learning as the mechanism behind asymmetries.

Default rates.—To compute true default probabilities, I use data on Moody's monthly trailing 12-month issuer default rates for different regions and samples with available data. I summarize the specific samples and types of bonds I consider in table 8. In all cases, default rates are either symmetric or negatively skewed, which implies that declines in default are in fact more likely than increases of the same magnitude. If lending rates were just reflecting true default, their decline would be more likely than increases of the same magnitude, and then they would be negatively skewed, or symmetric at most.

TABLE 8
DEFAULT RATES

Region	Moody's Rated Bonds	Sample	Skewness of Log Changes
United States	All corporations	1/70–6/08	−1.71
United States	Speculative grade	1/70–6/08	−1.39
Europe	All corporations	1/99–6/08	.06
Asia	All corporations	1/98–6/08	−1.44
Latin America	Speculative grade	1/96–6/08	−.29
Argentina	Speculative grade	1/96–6/08	−2.39
Brazil	Speculative grade	1/96–6/08	−.14
Mexico	Speculative grade	1/96–6/08	−.10

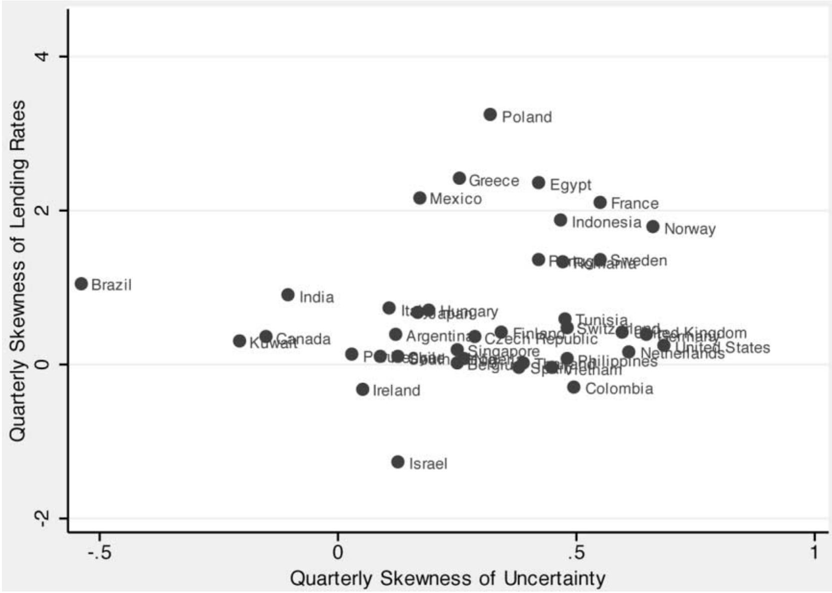

FIG. 3.—Asymmetry of lending rates and uncertainty

Uncertainty.—Following Baker and Bloom (2012), I use quarterly stock market volatility as a measure of uncertainty. From 40 countries in the sample, only four exhibit uncertainty with negative skewness, with only Brazil showing a significant degree of negative asymmetry. In figure 3, I show the relation between the skewness of uncertainty and the skewness of quarterly real lending rates. The relation is clearly positive, and if not considering the extreme case of Brazil, the slope is also statistically significant such that an increase of 1 in the skewness of uncertainty induces an increase of 0.83 in the skewness of lending rates.

All these results are consistent with the model. After a sudden increase in lending rates, investment declines and takes time to recover (negative skewness), making the uncertainty in the economy and lending rates decline slowly as well (positive skewness). Since this asymmetric pattern of movements in lending rates does not reflect the evolution of real default probabilities, which are in fact negatively skewed, it generates an inefficient reallocation of resources out of productive activities during times in which default probabilities are in fact low, but lenders keep learning and charging high rates in the meantime.

VI. Concluding Remarks

Business cycle movements in lending rates, investment, and output are usually asymmetric—sudden and sharp during crises but slow and gradual during recoveries—inducing lengthy processes of financial distress and inefficient allocation of resources. I have documented and offered an explanation for a new, related fact: this well-known asymmetry is stronger in countries with less developed financial systems or those with larger financial frictions. I explain this new cross-country fact using a learning model with financial frictions and endogenous flows of information. Financial frictions not only magnify crises but also restrict the generation of information after crises, which leads to slower, more gradual recoveries in countries less developed financially. Calibrations of partial and general equilibrium versions of the model successfully match quantitatively the observed cross-country differences in asymmetry.

My analysis has some nontrivial policy implications. It uncovers new gains from reducing financial frictions directly or improving mechanisms that are used to deal with those frictions. Policies that reduce financial frictions include inducing relationship lending and enhancing the operation of bureaus that offer public information about the credit standing of borrowers. Policies that improve mechanisms to deal with financial frictions include reductions in the complexity of bankruptcy procedures and financial liberalizations, which improve competition and the efficiency of bankruptcy courts and codes. The analysis also has a more subtle policy implication. Starting a venture has a positive externality, that of providing information about economic conditions, which is not internalized when an entrepreneur decides to borrow. Hence, countercyclical Pigouvian subsidies to borrowing can potentially align incentives, inducing more activity and faster learning during recoveries.

At least three possible extensions to my work seem worth mentioning. One is to expand the study beyond overall country data into data on individual industries. That may prove to be a very rich source of heterogeneity with which to test the relationship between bankruptcy costs and the asymmetry of lending rates and economic activity. Another reasonable extension is to add to the model additional public signals or private signals that induce dispersed information. Even though such an extension should not overturn my results, which depend purely on the speed of information generation, it may uncover new policy recommendations. A third extension is to expand the sources of shocks, from shocks to default rates and risk shocks to sudden stops, shocks to aggregate demand, and productivity shocks.

Finally, I have focused here on the period preceding the recent financial turmoil in developed economies, which started with a subprime crisis in the United States and was followed by a sovereign debt crisis in the Euro area. I have excluded these events for two main reasons. One is methodological: the data are not complete because countries have not experienced full recovery yet. The other is conceptual: recently developed highly structured financial products seem more difficult to evaluate than credit products, which have more accumulated know-how. This implies that the information environment for these newer assets in developed financial systems may be characterized by high monitoring costs. Mixing the use of different financial products in different economies may contaminate cross-country comparisons.

Recent financial developments do, however, suggest other extensions to this paper. One could accommodate learning about default of newly structured products and study its implications for economic activity, crises, and recoveries. Gorton and Souleles (2007) and Ordoñez (2013), for example, argue that important components of the so-called shadow banking, such as special-purpose vehicles, have been created to circumvent bankruptcy costs. If this is correct, then bankruptcy costs may discontinuously start to matter after crises, which would induce even larger asymmetries. Additional efforts to uncover the effects of the new financial landscape on the asymmetry of economic activity are likely fruitful endeavors.

Appendix A

Data Description

To measure unconditional asymmetry, I compute the unconditional skewness of log changes. First, I construct the distribution of log changes for real lending rates, real investment, and real GDP per capita in each country. Then I compute the unconditional skewness for each one of these distributions:

$$\text{Skewness} = \frac{T\sqrt{T-1}}{T-2}\,\frac{\sum_{t=1}^{T}(x_t-\bar{x})^3}{\left[\sum_{t=1}^{T}(x_t-\bar{x})^2\right]^{3/2}}, \tag{A1}$$

where T is the number of observations (number of months or quarters in the sample), $x_t = \ln(X_t) - \ln(X_{t-1})$, X_t is the variable measured in period t, and $\bar{x}$ is the sample mean of the time series.

I use monthly data on real lending rates and quarterly data on real investment and real GDP per capita from the IMF's International Financial Statistics (IFS), for 100 counties during the period 1960–2008. I obtain real lending rates by subtracting the Hodrick-Prescott (HP) trend of inflation (IFS series 64P. .ZF . . .) from nominal lending rates (IFS series 60P. .ZF . . .). The IFS descriptions of variables defines the lending rate as "the bank rate that usually meets the short- and medium-term financing needs of the private sector. This rate is normally differentiated according to creditworthiness of borrowers and objectives of financing." Most available data are based on mortgage and firms' loans rates applied to the private sector.

For real output I use real GDP per capita (IFS series 99B divided by population 99Z. .ZF), and for real investment I use gross capital formation (IFS series 93. .ZF) deflated by the GDP deflator (IFS series 99BIIZF). Unfortunately, comparable monthly data for these two real variables across countries are not available, which makes skewness somewhat less informative: not only are there fewer observations but the lower frequency of data hides potential large changes, which are relevant in measuring asymmetries.

Three caveats are relevant. First, I choose the HP filter to deflate nominal rates in order to capture both backward- and forward-looking components in the formation of inflation expectations. The alternative use of ex post real lending rates (using current inflation as a deflator) delivers similar results but has the disadvantage of losing informative months with large shocks in expected inflation when computing log changes. Second, even when the definition of lending rates is not exactly the same across countries, it is unlikely that differences in this definition bias the measure of skewness, which is based on changes over time for a given country.

Finally, I use data only up to the first half of 2008 to avoid capturing the recent global crisis. Otherwise very large crises would appear in the sample but not their respective recoveries, biasing the estimates toward even larger skewness levels. Furthermore, the unprecedented intervention of governments and the large role of recently developed structured financial products would likely contaminate the comparison with countries in previous years and thus all the results. I leave for future research the study of the asymmetric effects of recent financial innovations during recent crises.

The groups in table 2 are defined as follows:

- Level of domestic income per capita: I use the World Bank's WDI classification, where the richest countries belong to group 1 and the poorest countries belong to group 4.
- Membership or not in the OECD.
- Level of contract enforcement: I classify countries between those with low and high contract enforcement using the *contract enforcement* indicator of Levine, Loayza, and Beck (2000), which is an average between *rule of law* (an assessment of the law and order tradition of the country) and *government risk* (an assessment of the risk that the government will modify a contract after it has been signed) from La Porta et al. (1998). In both cases, the indices go from 1 (the lowest possible level) to 10 (the highest possible level). I use 5 as the relevant cutoff to separate countries evenly between the two groups.
- Availability of information in the financial system: I classify countries between those with and without a *private bureau*, defined by Djankov, McLiesh, and Shleifer (2007) as a private commercial firm or nonprofit organization that maintains a database on the standing of borrowers in the financial system and facilitates the exchange of information among banks and financial institutions.[21]

[21] Similar results hold when using the existence of either a public or private bureau from Djankov et al. (2008).

The independent variables of the regressions reported in table 3, which measure the difficulty for lenders to go through bankruptcy procedures, are taken from Djankov et al. (2008):[22]

- Cost of bankruptcy: Estimated costs of debt enforcement proceedings for Mirage, reported as a percentage of the value of the estate borne by all parties. Costs include court/bankruptcy authority costs, attorney fees, bankruptcy administrator fees, accountant fees, notification and publication fees, assessor or inspector fees, asset storage and preservation costs, auctioneer fees, government levies, and other associated insolvency costs.
- Bankruptcy duration: Estimated duration, in years, of the time to resolve the insolvency case of Mirage; measures the duration from the moment of Mirage's default to the point at which the fate of Mirage is determined.
- Recovery rate: A measure of foreclosure efficiency. The recovery rate shows how many cents on the dollar claimants (creditors, tax authorities, and employees) recover from an insolvent firm. The calculation takes into account whether the business is kept as a going concern during the proceeding, the discounted value due to the time spent closing down, court costs, attorneys, and so on (eq. [3] in Djankov et al. [2008]).

All 100 countries in the sample fulfill two minimum requirements: Their data have more than 4 years of continuous observations and show a defined cyclical pattern. In tables A1 and A2, I report these countries on the basis of income classification and ordered by the skewness level of lending rates. I also report for each country its classification in terms of whether (1) it belongs to the OECD, (2) it has high contract enforcement, or (3) it has a private bureau that manages information about borrowers. In the column Class, the triplet (1, 2, 3) represents whether the country belongs to the respective group (Y), the country does not belong to the respective group (N), or there is no information to classify the country (*).

[22] When information was not available from Djankov et al. (2008), I completed it with data from Djankov et al. (2005). Two caveats are in order. First, these variables are measured in 2004, the end of our sample period. Second, they are constructed on the basis of surveys to insolvency practitioners in different countries, not by direct measures. Hence, these variables should be interpreted merely as a guidance about financial frictions that involve costly state verification.

TABLE A1

COUNTRIES, CLASSIFICATIONS, AND SKEWNESS, 1960–2008, BY INCOME LEVEL: PART I

Country	Class	Lending Rates	Investment	GDP	Country	Class	Lending Rates	Investment	GDP
					Income Group 1 (Richest)				
Singapore	(N,*,Y)	−.64		−.25	Spain	(Y,Y,Y)	.77	−.54	−.51
Hong Kong	(N,*,Y)	−.22	−.48	−.50	Netherlands	(Y,Y,Y)	.78	1.30	1.30
Macao	(N,*,*)	−.21	−.42	.04	Iceland	(Y,*,*)	1.20	−1.51	−.31
Israel	(N,Y,Y)	−.07	.54	.50	Germany	(Y,Y,Y)	1.41	.76	.73
Switzerland	(Y,Y,Y)	−.04	1.41	1.45	United Kingdom	(Y,Y,Y)	1.58	−.45	.47
Belgium	(Y,Y,N)	.12	−.19	.44	Norway	(Y,Y,Y)	1.79	−.05	−.05
United States	(Y,Y,Y)	.31	−.40	−.27	Portugal	(Y,Y,Y)	2.11	.28	.30
Canada	(Y,Y,Y)	.43	−.53	.05	Sweden	(Y,Y,Y)	2.99	.14	.57
Finland	(Y,Y,Y)	.58	−.85	−.85	Korea	(Y,Y,Y)	3.47	−.23	−.24
Italy	(Y,Y,Y)	.59	−.18	−.17	France	(Y,Y,N)	4.30	−.37	−.38
Japan	(Y,Y,Y)	.60	−.31	−.35	Greece	(Y,Y,Y)	4.51	−.60	−.34
Slovenia	(N,*,N)	.60	.31	.31	Kuwait	(N,*,Y)	5.50		
Ireland	(Y,Y,Y)	.76	−1.06	−1.05	Cyprus	(N,*,*)	6.82	.19	.89
					Income Group 2				
Chile	(N,Y,Y)	−.50	.21	−.08	Argentina	(N,Y,Y)	1.46	−.96	.07
Estonia	(N,*,*)	−.36	−.48	.07	Croatia	(N,*,N)	1.48	.01	−.39
Uruguay	(N,Y,Y)	−.30		−.41	Venezuela	(N,Y,N)	1.73		
Slovak Republic	(N,*,N)	.19	−.74	−.74	Mexico	(Y,Y,Y)	1.80	−.76	.12
Barbados	(N,*,*)	.69			Brazil	(N,Y,Y)	2.92	.17	−.85
South Africa	(N,N,Y)	.80	−.02	−.05	Czech Republic	(Y,*,Y)	3.65	−.17	−.17
Hungary	(Y,*,Y)	.85	−1.12	−.97	Poland	(Y,*,Y)	5.70	−.99	−.82
Romania	(N,*,*)	1.03	−.92	−.92	Gabon	(N,N,*)	6.38		

TABLE A2
COUNTRIES, CLASSIFICATIONS, AND SKEWNESS, 1960–2008, BY INCOME LEVEL: PART II

Country	Class	Lending Rates	Investment	GDP	Country	Class	Lending Rates	Investment	GDP
					Income Group 3				
Latvia	(N,*,N)	−.42	−.72	−.67	Bolivia	(N,*,Y)	1.14	.46	.40
Namibia	(N,N,Y)	−.34			Jordan	(N,*,N)	1.83		−.38
Thailand	(N,Y,Y)	−.26	−1.12	.29	Jamaica	(N,*,N)	2.01		−.50
Russia	(N,*,N)	−.23	−1.12	−.15	El Salvador	(N,*,Y)	2.35		
Lithuania	(N,*,N)	−.14	−.52	−.52	Egypt	(N,*,N)	2.82	−.62	−.62
Dominican Rep.	(N,*,*)	−.08			Equ. Guinea	(N,N,*)	3.61		
Colombia	(N,N,Y)	−.05	−.06	.05	Guatemala	(N,*,Y)	3.86	−.72	−.51
Grenada	(N,*,*)	.10			Botswana	(N,N,Y)	4.54	.38	−.03
Peru	(N,N,Y)	.20	−.75	−.20	Indonesia	(N,*,N)	4.62	−2.77	−2.77
Philippines	(N,N,Y)	.22		−.02	Cape Verde	(N,N,*)	6.22		
Sri Lanka	(N,N,*)	.44			Morocco	(N,*,N)	8.14		−.45
Swaziland	(N,N,*)	.45			Guyana	(N,*,*)	10.25		
Paraguay	(N,*,Y)	.75		.44					

	Income Group 4 (Poorest)								
Angola	(N,*,N)	−.61			Zambia	(N,N,N)	3.22		
Mozambique	(N,N,N)	−.52			Tanzania	(N,N,N)	3.30		
Moldova	(N,*,N)	−.47			Tunisia	(N,*,*)	3.49		.12
Nigeria	(N,N,N)	−.46			Malawi	(N,N,N)	3.91		
Nicaragua	(N,*,N)	−.39			Cameroon	(N,N,N)	4.31		
Kenya	(N,N,Y)	−.08			Chad	(N,N,N)	4.43		
Armenia	(N,*,N)	.14			Lao People's DR	(N,*,N)	4.73		
Burundi	(N,N,N)	.49			Congo	(N,N,N)	4.99		
Lesotho	(N,N,N)	.70			Senegal	(N,*,*)	5.13		
Solomon Islands	(N,*,*)	1.00			C.A.R.	(N,N,N)	5.73		
Sierra Leone	(N,N,N)	1.01			Madagascar	(N,N,N)	8.01		
Haiti	(N,*,N)	1.09			Albania	(N,*,N)	8.01		
Vietnam	(N,*,N)	1.95			Ethiopia	(N,N,N)	8.44		
Rwanda	(N,*,*)	2.17			Bangladesh	(N,*,N)	8.80		
Honduras	(N,*,N)	2.64			Gambia	(N,*,*)	9.01		
India	(N,Y,N)	2.91	−1.09	−1.10	Mauritania	(N,*,*)	10.16		
Uganda	(N,N,N)	2.95							

Appendix B

Proofs of Propositions

Proof of Proposition 1

Entrepreneurs' ex post decisions.—If lenders take defaulting borrowers to bankruptcy, then successful borrowers prefer to repay the loan ($z_{it} = 1$), obtaining $v_{it} - (1 + \rho_t) > 0$ rather than zero if defaulting. If lenders do not take defaulting borrowers to bankruptcy, then successful borrowers always default ($z_{it} = 0$). Unsuccessful borrowers always default.

Investors' decisions.—As in Townsend (1979) and Gale and Hellwig (1985), here the standard debt contract is optimal. In my setting, this result is even more trivial because cash flows in the case of success are known and only failure is not. If lenders do not monitor a default, borrowers always default and lenders never lend. Hence, lenders prefer to monitor ($\pi_{jt} = 1$), borrowers always report the truth, and there are no payoffs to seize in case of default. Since investors are competitive ($M > N$), expected profits from lending equalize expected profits from the riskless bond:

$$(1 - \theta_t)(-\gamma) + \theta_t(1 + \rho_{ijt}) = 1 + r.$$

Since the expected probability of success is the same for all ventures and the above condition is independent of the cash flow of a given venture v_{it}, all investors j choose to charge the same lending rate (eq. [4]) to all entrepreneurs i (i.e., $\rho_{ijt} = \rho_t$ for all i and all j).

Entrepreneurs' ex ante decisions.—Since all lenders offer the same lending rate, borrowers are indifferent about taking the loan from any lender, and then they are assigned randomly to investors. The only choice left to obtain in equilibrium is whether entrepreneurs borrow or not (i.e., $b_{it} \in \{0, 1\}$). This choice is given by a cutoff value over v_{it} such that an entrepreneur i borrows in period t whenever $\theta_t[v_{it} - (1 + \rho_t)] \geq w$. From equation (4) it is clear that $b_{it} = 1$ if equation (5) is fulfilled.

Proof of Proposition 2

The proof proceeds in three steps. First, I introduce the concept of time reversibility and explain the symmetric nature of lending rates and investment in a constant information economy.[23] Second, I sketch out why lending rates and investment are time irreversible and asymmetric in an endogenous information economy. Finally, I show that bankruptcy costs make lending rates and investment more asymmetric if the bad news depresses economic activity relatively more the larger the bankruptcy costs.

Step 1: Time Reversibility in a Constant Information Economy

Time reversibility is defined as the property of a stochastic process under which it is not possible to determine, given the states at a number of points in time after

[23] Veldkamp (2005) contains the full-fledged formal proof of belief time irreversibility in a frictionless economy.

running the stochastic process, which states came first and which states arrived later. In our case, beliefs of being in good times are time reversible if their increase when all signals are positive has the same magnitude as their decrease when all signals are negative. Assume that the prior of a good state is $\mu_t = x$. If all n_t ventures fail ($s_t = 0$), then $\mu_{t+1} = y < x$. If in the next period all n_{t+1} ventures succeed ($s_{t+1} = n_{t+1}$) and the process is time reversible, then $\mu_{t+2} = z = x$ and it is not possible to tell whether successes preceded or followed failures.

In a constant information economy, the number of signals n is given exogenously. Without loss of generality, assume that the economy has equally informative signals ($\theta = \theta_g = 1 - \theta_b > 1/2$) and no state change ($\lambda = 0$).[24] If initial beliefs in period t are $\mu_t = x$ and all n signals fail ($s = 0$), then from equations (1) and (2) we know that

$$\mu_{t+1} = y = \frac{(1-\theta)^n x}{(1-\theta)^n x + \theta^n (1-x)}. \tag{B1}$$

If in the next period $t + 1$ all n signals are successful ($s = n$), then

$$\mu_{t+2} = z = \frac{\theta^n y}{\theta^n y + (1-\theta)^n (1-y)}. \tag{B2}$$

Substituting (B1) into (B2) gives $\mu_{t+2} = z = x$. Hence, in a constant information economy, beliefs follow a time-reversible stochastic process.

Step 2: Time Irreversibility in an Endogenous Information Economy

In an endogenous information economy, the number of signals depends on the beliefs of being in a good state. A higher probability of being in good times μ_t represents a lower cutoff $\tilde{\nu}_t$ and more signals n_t. In this framework, beliefs are no longer time reversible. Assume that in period t, $\mu_t = x$ and all n_t^x signals fail ($s_t = 0$). The subscript t is now necessary because n varies with time and the superscript x because n_t depends on beliefs $\mu_t = x$. Then

$$\mu_{t+1} = y = \frac{(1-\theta)^{n_t^x} x}{(1-\theta)^{n_t^x} x + \theta^{n_t^x} (1-x)}. \tag{B3}$$

Now, given that $y < x$, agents are less confident about being in good times, which reduces the number of ventures, $n_{t+1}^y < n_t^x$. Assuming that, in the following period, all n_{t+1}^y signals are successful ($s_{t+1} = n_{t+1}^y$), then

$$\mu_{t+2} = z = \frac{\theta^{n_{t+1}^y} y}{\theta^{n_{t+1}^y} y + (1-\theta)^{n_{t+1}^y} (1-y)}. \tag{B4}$$

Now substituting (B3) into (B4) gives

$$\mu_{t+2} = z = \frac{[\theta^{n_{t+1}^y} (1-\theta)^{n_t^x}] x}{[\theta^{n_{t+1}^y} (1-\theta)^{n_t^x}] x + [(1-\theta)^{n_{t+1}^y} \theta^{n_t^x}] (1-x)},$$

[24] As shown by Veldkamp (2005), the proof extends to signals that are not equally informative and $\lambda > 0$.

and we can compute

$$z - x = \frac{[\theta^{n_{t+1}^y}(1-\theta)^{n_t^x} - (1-\theta)^{n_{t+1}^y}\theta^{n_t^x}]x(1-x)}{[\theta^{n_{t+1}^y}(1-\theta)^{n_t^x}]x + [(1-\theta)^{n_{t+1}^y}\theta^{n_t^x}](1-x)}. \tag{B5}$$

It is straightforward to check that $z < x$ when $\theta > 1/2$ and $n_{t+1}^y < n_t^x$.[25] This implies that the greatest possible decrease in beliefs (from x to y) is more likely than an increase of the same magnitude (since beliefs just go from y to z).

Given equation (4), the greatest possible increase in lending rates is more likely than a decrease of the same magnitude, which is a necessary and sufficient condition for the existence of positive unconditional asymmetry in lending rates. Hence, in an endogenous information economy, beliefs follow a time-irreversible stochastic process that translates into a positive asymmetry in lending rates changes.

Given equation (5), the time irreversibility of lending rates translates into time irreversibility of cutoffs $\tilde{\nu}$ linearly and, given equation (6), translates into time irreversibility of investment and output, since $n(\tilde{\nu}(z)) < n(\tilde{\nu}(x))$, but in a degree that depends on the shape of the distribution of payoffs ν_{it}. In the extreme, for example, if there is no density mass between $\tilde{\nu}(z)$ and $\tilde{\nu}(x)$, then there is no time irreversibility in such a range of beliefs.

Step 3: The Effects of Bankruptcy Costs on Asymmetry

Now we study the degree of irreversibility of beliefs for two countries with different levels of bankruptcy costs, $\gamma_L < \gamma_H$. We can rewrite equations (B3) and (B4) as

$$y_i = \left[1 + \frac{1-x}{x}\left(\frac{\theta}{1-\theta}\right)^{n_t^{x_i}}\right]^{-1} \tag{B6}$$

and

$$z_i = \left[1 + \frac{1-y_i}{y_i}\left(\frac{1-\theta}{\theta}\right)^{n_{t+1}^{y_i}}\right]^{-1} \tag{B7}$$

for $i \in \{L, H\}$. Why the subscripts i? Because even when having the same belief x about the good state, from equations (5) and (6) the two countries have different cutoffs

$$\tilde{\nu}_t(x|\gamma_i) = \frac{1}{x}[1 + r + w + (1-x)\gamma_i]$$

and different numbers of active firms $n_t^{x_L} \geq n_t^{x_H}$.

It is straightforward from equation (B7) that $z_L > z_H$ when

$$\frac{y_H}{1-y_H}\frac{1-y_L}{y_L} < \left(\frac{1-\theta}{\theta}\right)^{n_{t+1}^{y_H} - n_{t+1}^{y_L}}.$$

Since, from equation (B6),

[25] The same conclusion is obtained when reversing the order of successes and failures.

$$\frac{1-y_i}{y_i} = \frac{1-x}{x}\left(\frac{\theta}{1-\theta}\right)^{n_t^{x_i}},$$

then $z_L > z_H$, and hence the degree of irreversibility is larger with higher costs, when

$$n_t^{x_H} - n_{t+1}^{y_H} > n_t^{x_L} - n_{t+1}^{y_L}$$

or, which is the same,

$$F(\tilde{\nu}_{t+1}(y|\gamma_H)) - F(\tilde{\nu}_t(x|\gamma_H)) > F(\tilde{\nu}_{t+1}(y|\gamma_L)) - F(\tilde{\nu}_t(x|\gamma_L)), \tag{B8}$$

where $F(\nu)$ is the cumulative distribution of business opportunities' payoffs ν_{it}.

In words, the time irreversibility of beliefs increases with bankruptcy costs when the decline in activity after bad news is more severe in countries with higher bankruptcy costs. This condition is satisfied when

$$\frac{\partial F(\tilde{\nu}_{t+1}(y|\gamma_i)) - F(\tilde{\nu}_t(x|\gamma_i))}{\partial \gamma_i} > 0,$$

$$f(\tilde{\nu}_{t+1}(y|\gamma_i))\frac{1-y_i}{y_i} > f(\tilde{\nu}_t(x|\gamma_i))\frac{1-x}{x},$$

$$\frac{f(\tilde{\nu}_{t+1}(y|\gamma_i))}{f(\tilde{\nu}_t(x|\gamma_i))} > \left(\frac{1-\theta}{\theta}\right)^{n_t^{x_i}}, \tag{B9}$$

where $f(\nu)$ is the density of the business opportunities' payoffs ν_{it}. However, this is the condition for an arbitrary initial belief x. Define $R = \min_{\nu \le \nu'} f(\nu')/f(\nu)$ and $\underline{n} = n_t^{\theta_b}$. Then, a condition for time irreversibility of beliefs, for all possible beliefs $y < x$ (that induce $\tilde{\nu}_t(x|\gamma_i) \le \tilde{\nu}_{t+1}(y|\gamma_i)$), is

$$R > \left(\frac{1-\theta}{\theta}\right)^{\underline{n}}. \tag{B10}$$

Time irreversibility of beliefs that increases with bankruptcy costs immediately translates into asymmetry of lending rates that increases with bankruptcy costs. Since lending rates are both increasing in bankruptcy costs and decreasing in beliefs, through equation (4) and assuming the same starting belief x, then

$$\rho_{t+2}(z|\gamma_L) - \rho_t(x|\gamma_L) < \rho_{t+2}(z|\gamma_H) - \rho_t(x|\gamma_H).$$

The same reasoning can be applied for investment and output. The asymmetry of economic activity also increases with bankruptcy costs, given equations (5) and (6). The reason is that the differences in lending rates translate into a difference in cutoffs that is larger for γ_H than for γ_L. Since we assume that the distribution of payoffs ν_{it} has mass in all its points, it implies that the difference in activity is larger for γ_H than for γ_L.

To grasp the intuition, assume that θ is close to one such that $n_t^{x_H} = n_t^{x_L}$. Then, from equation (B6), $y_H = y_L$, $\tilde{\nu}_{t+1}(y|\gamma_H) > \tilde{\nu}_{t+1}(y|\gamma_L)$, and $n_{t+1}^{y_H} < n_{t+1}^{y_L}$. This implies that lending rates increase more in a country with γ_H than in a country with γ_L, making crises more severe. Finally, from equation (B7), $z_H < z_L$, beliefs are less reversible in a country with γ_H, delaying the recovery. These two effects combined make large increases in lending rates more likely and large decreases less likely in countries with high bankruptcy costs, and so lending rates, investment, and output become more asymmetric.

Proof of Proposition 3

Following Townsend (1979) and Gale and Hellwig (1985), when commitment exists, the optimal contract takes the form of a standard debt contract. Since the true value of the variance $\sigma^2_{\omega,t}$ is unknown, the expected entrepreneurial income, given the beliefs about the true variance-generating distribution Ψ_t, is

$$q_t\Bigg(\mu_t\int\Bigg\{\int_{\bar{\omega}_t}^{\infty}\omega i_t d\Upsilon_{\sigma^2_{\omega,t}}(\omega)-[1-\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)](1+r_t^k)(i_t-n_t)\Bigg\}d\Psi_{H,\sigma^2_{\sigma,t}}$$
$$+(1-\mu_t)\int\Bigg\{\int_{\bar{\omega}_t}^{\infty}\omega i_t d\Upsilon_{\sigma^2_{\omega,t}}(\omega)-[1-\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)](1+r_t^k)(i_t-n_t)\Bigg\}d\Psi_{L,\sigma^2_{\sigma,t}}\Bigg).$$

With the definition of $\bar{\omega}_t$, this expression could be simplified to $q_t i_t f(\bar{\omega}_t,\mu_t)$, where $f(\bar{\omega}_t,\mu_t)$ is the fraction of the expected net capital output received by the entrepreneur:

$$f(\bar{\omega}_t,\mu_t)\equiv\mu_t\int\Bigg\{\int_{\bar{\omega}}^{\infty}\omega d\Upsilon_{\sigma^2_{\omega,t}}(\omega)-[1-\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)]\bar{\omega}_t\Bigg\}d\Psi_{H,\sigma^2_{\sigma,t}}$$
$$+(1-\mu_t)\int\Bigg\{\int_{\bar{\omega}}^{\infty}\omega d\Upsilon_{\sigma^2_{\omega,t}}(\omega)-[1-\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)]\bar{\omega}_t\Bigg\}d\Psi_{L,\sigma^2_{\sigma,t}}.$$

Similarly, we have that the expected payoff to the CMF is

$$q_t\Bigg(\mu_t\int\Bigg\{\int_0^{\bar{\omega}_t}\omega i_t d\Upsilon_{\sigma^2_{\omega,t}}(\omega)-\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)\gamma i_t+[1-\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)](1+r_t^k)(i_t-n_t)\Bigg\}d\Psi_{H,\sigma^2_{\sigma,t}}$$
$$+(1-\mu_t)\int\Bigg\{\int_0^{\bar{\omega}_t}\omega i_t d\Upsilon_{\sigma^2_{\omega,t}}(\omega)-\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)\gamma i_t$$
$$+[1-\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)](1+r_t^k)(i_t-n_t)\Bigg\}d\Psi_{L,\sigma^2_{\sigma,t}}\Bigg).$$

Again with the definition of $\bar{\omega}_t$, this expression could be simplified to $q_t i_t g(\bar{\omega}_t,\mu_t)$, where $g(\bar{\omega}_t,\mu_t)$ is the fraction of the expected net capital output received by the CMF:

$$g(\bar{\omega}_t,\mu_t)\equiv\mu_t\int\Bigg\{\int_0^{\bar{\omega}}\omega d\Upsilon_{\sigma^2_{\omega,t}}(\omega)-\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)\gamma+[1-\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)]\bar{\omega}_t\Bigg\}d\Psi_{H,\sigma^2_{\sigma,t}}$$
$$+(1-\mu_t)\int\Bigg\{\int_0^{\bar{\omega}}\omega d\Upsilon_{\sigma^2_{\omega,t}}(\omega)-\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)\gamma+[1-\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)]\bar{\omega}_t\Bigg\}d\Psi_{L,\sigma^2_{\sigma,t}}.$$

The total expected capital output that is produced in the economy is given by the expected return, m_ω, minus the expected monitoring cost,

$$\gamma\left[\mu_t\int\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)\,d\Psi_{H,\sigma^2_{\omega,t}} + (1-\mu_t)\int\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)\,d\Psi_{L,\sigma^2_{\omega,t}}\right].$$

Therefore, we have

$$\begin{aligned} &f(\bar{\omega}_t,\mu_t) + g(\bar{\omega}_t,\mu_t) \\ &= m_\omega - \left[\mu_t\int\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)\,d\Psi_{H,\sigma^2_{\omega,t}} + (1-\mu_t)\int\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)\,d\Psi_{L,\sigma^2_{\omega,t}}\right]\gamma. \end{aligned}$$

Since the contract is determined in expectation with respect to the beliefs of the agents and the true variance of ω is unique, there is a unique realized capital output that is either smaller or larger than the expected one, which leads to learning in the next period.

The optimal contract is given by a pair $(i_t,\bar{\omega}_t)$ that maximizes the entrepreneur's expected return subject to the CMF being indifferent between lending or not (recall that loans are intraperiod, so there is no opportunity cost of funds to take into account):

$$\begin{aligned} &\max_{i_t,\bar{\omega}_t} q_t i_t f(\bar{\omega}_t,\mu_t) \\ &\text{subject to } q_t i_t g(\bar{\omega}_t,\mu_t) \geq i_t - n_{et}. \end{aligned}$$

The first-order conditions for this problem are

$$\begin{aligned} \{i_t\}:&\quad q_t f(\bar{\omega}_t,\mu_t) + \zeta_t[q_t g(\bar{\omega}_t,\mu_t) - 1] = 0, \\ \{\bar{\omega}_t\}:&\quad \zeta_t = -\frac{f_\omega(\bar{\omega}_t,\mu_t)}{g_\omega(\bar{\omega}_t,\mu_t)}, \end{aligned}$$

which, combined with the constraint satisfied with equality in equilibrium, give

$$q_t\left(m_\omega + \gamma\left\{\frac{f(\bar{\omega}_t,\mu_t)}{f_\omega(\bar{\omega}_t,\mu_t)}E_{\mu_t}[\upsilon_{\sigma^2_{\omega,i}}(\bar{\omega}_t)] - E_{\mu_t}[\Upsilon_{\sigma^2_{\omega,i}}(\bar{\omega}_t)]\right\}\right) = 1,$$

$$i_t = \frac{n_{et}}{1 - q_t g(\bar{\omega}_t,\mu_t)},$$

where

$$E_{\mu_t}[\Upsilon_{\sigma^2_{\omega,i}}(\bar{\omega}_t)] \equiv \mu_t\int\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)\,d\Psi_{H,\sigma^2_{\omega,t}} + (1-\mu_t)\int\Upsilon_{\sigma^2_{\omega,t}}(\bar{\omega}_t)\,d\Psi_{L,\sigma^2_{\omega,t}}.$$

Equations (16) and (17) uniquely solve for $\bar{\omega}_t$ and i_t as functions of q_t, n_{et}, and μ_t. Moreover, we have an expression for the return to internal funds that is given by

$$\frac{q_t f(\bar{\omega}_t,\mu_t) i_t}{n_{et}} = \frac{q_t f(\bar{\omega}_t,\mu_t)}{1 - q_t g(\bar{\omega}_t,\mu_t)}, \tag{B11}$$

which is independent of both optimal investment i_t and entrepreneur net worth n_{et}.

References

Aguiar, Mark, and Gita Gopinath. 2007. "Emerging Market Business Cycles: The Cycle Is the Trend." *J.P.E.* 115 (1): 69–102.

Alderson, Michael, and Brian Betker. 1995. "Liquidation Costs and Capital Structure." *J. Financial Econ.* 39:45–69.

Allen, Franklin, Stephen Morris, and Hyun Song Shin. 2006. "Beauty Contests and Iterated Expectations in Asset Markets." *Rev. Financial Studies* 19:719–52.

Altman, Edward. 1984. "A Further Empirical Investigation of the Bankruptcy Cost Question." *J. Finance* 39:1067–89.

Baker, Scott, and Nicholas Bloom. 2012. "Does Uncertainty Reduce Growth? Using Disasters as Natural Experiments." Working paper, Stanford Univ.

Banerjee, Abhijit V. 1992. "A Simple Model of Herd Behavior." *Q.J.E.* 107: 797–817.

Banerjee, Abhijit V., and Andrew F. Newman. 1993. "Occupational Choice and the Process of Development." *J.P.E.* 101:274–98.

Bergoeing, Raphael, Norman Loayza, and Andrea Repetto. 2004. "Slow Recoveries." *J. Development Econ.* 75:473–506.

Bloom, Nicholas. 2009. "The Impact of Uncertainty Shocks." *Econometrica* 77 (3): 623–85.

Buera, Francisco, Joseph Kaboski, and Yongseok Shin. 2011. "Finance and Development: A Tale of Two Sectors." *A.E.R.* 101:1964–2002.

Carlstrom, Charles, and Timothy Fuerst. 1997. "Agency Costs, Net Worth, and Business Fluctuations: A Computable General Equilibrium Analysis." *A.E.R.* 87: 893–910.

Christiano, Lawrence, Roberto Motto, and Massimo Rostagno. 2012. "Risk Shocks." Working paper, Northwestern Univ.

Djankov, Simeon, Oliver Hart, Caralee McLiesh, and Andrei Shleifer. 2008. "Debt Enforcement around the World." *J.P.E.* 116:1105–49.

Djankov, Simeon, Oliver Hart, Tatiana Nenova, and Andrei Shleifer. 2005. "Efficiency in Bankruptcy." Working paper, Harvard Univ.

Djankov, Simeon, Caralee McLiesh, and Andrei Shleifer. 2007. "Private Credit in 129 Countries." *J. Financial Econ.* 84:299–329.

Gale, Douglas, and Martin Hellwig. 1985. "Incentive-Compatible Debt Contracts: The One-Period Problem." *Rev. Econ. Studies* 52:647–63.

Gilchrist, Simon, Vladimir Yankov, and Egon Zakrajsek. 2009. "Credit Market Shocks and Economic Fluctuations: Evidence from Corporate Bond and Stock Markets." *J. Monetary Econ.* 56 (4): 471–93.

Gilchrist, Simon, and Egon Zakrajsek. 2012. "Credit Spreads and Business Cycle Fluctuations." *A.E.R.* 102:1692–1720.

Gorton, Gary, and Nicholas Souleles. 2007. "Special Purpose Vehicles and Securitization." In *The Risks of Financial Institutions*, edited by Mark Carey and René Stulz. Chicago: Univ. Chicago Press.

Hsieh, Chang-Tai, and Peter J. Klenow. 2009. "Misallocation and Manufacturing TFP in China and India." *Q.J.E.* 124 (4): 1403–48.

Jacklin, Charles, Allan Kleidon, and Paul Pfleiderer. 1992. "Underestimation of Portfolio Insurance and the Crash of October 1987." *Rev. Financial Studies* 5:35–63.

Jovanovic, Boyan. 2006. "Asymmetric Cycles." *Rev. Econ. Studies* 73:145–62.

La Porta, Rafael, Florencio Lopez de Silanes, Andrei Shleifer, and Robert Vishny. 1998. "Law and Finance." *J.P.E.* 106:1113–55.

Levine, Ross. 1997. "Financial Development and Economic Growth: Views and Agenda." *J. Econ. Literature* 35:688–726.

Levine, Ross, Norman Loayza, and Thorsten Beck. 2000. "Financial Intermediation and Growth: Causality and Causes." *J. Monetary Econ.* 46:31–77.

Merton, Robert. 1987. "A Simple Model of Capital Market Equilibrium with Incomplete Information." *J. Finance* 42:483–510.

Ordoñez, Guillermo. 2013. "Confidence Banking and Strategic Default." Working paper, Univ. Pennsylvania.

Porter, Michael, Klaus Schwab, Jeffrey Sachs, Andrew Warner, and Macha Levinson. 1999. *Global Competitiveness Report.* Oxford: Oxford Univ. Press (for World Econ. Forum).

Restuccia, Diego, and Richard Rogerson. 2008. "Policy Distortions and Aggregate Productivity with Heterogeneous Plants." *Rev. Econ. Dynamics* 11 (4): 707–20.

Townsend, Robert. 1979. "Optimal Contracts and Competitive Markets with Costly State Verification." *J. Econ. Theory* 21:265–93.

Van Nieuwerburgh, Stijn, and Laura Veldkamp. 2006. "Learning Asymmetries in Real Business Cycles." *J. Monetary Econ.* 53:753–72.

Veldkamp, Laura. 2005. "Slow Boom, Sudden Crash." *J. Econ. Theory* 124:230–57.

Warner, Jerold. 1977. "Bankruptcy Costs: Some Evidence." *J. Finance* 32:337–48.

Welch, Ivo. 1992. "Sequential Sales, Learning, and Cascades." *J. Finance* 47:695–732.

Zeira, Joseph. 1994. "Informational Cycles." *Rev. Econ. Studies* 61:31–44.

———. 1999. "Informational Overshooting, Booms, and Crashes." *J. Monetary Econ.* 43:237–57.