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LIQUIDITY NEEDS AND VULNERABILITY TO FINANCIAL UNDERDEVELOPMENT*

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Abstract

This paper provides evidence of a causal and economically important effect of financial development on volatility. In contrast to the existing literature, the identification strategy is based on the differences in sensitivities to financial conditions across industries. The results show that sectors with larger liquidity needs are more volatile and experience deeper crises in financially underdeveloped countries. At the macro level, the results suggest that changes in financial development can generate important differences in aggregate volatility. An additional finding of this paper is that financially underdeveloped countries partially protect themselves from volatility by concentrating less output in sectors with large liquidity needs. Nevertheless, this insulation mechanism seems to be insufficient to reverse the effects of financial underdevelopment on within-sector volatility. Finally, this paper provides new evidence that: (i) financial development affects volatility mainly through the intensive margin (output per firm); (ii) both, the quality of information generated by firms, and the development of financial intermediaries, have independent effects on sectoral volatility, (iii) the development of financial intermediaries is more important than the development of equity markets for the reduction of volatility.

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1 Introduction

The frequency and extent of macroeconomic fluctuations vary enormously across countries. During the period 1980-1997, the most volatile country was twenty times more volatile than the least volatile one when volatility is measured by the standard deviation of real GDP per capita growth. Moreover, countries in the highest quartile of volatility experienced a fall in real GDP per capita every two years on average, while the frequency for countries in the lowest quartile was once every five years. These marked differences provide good reasons for trying to understand the determinants of macroeconomic volatility.

A wide range of theoretical models and informal arguments suggest that the quality of financial institutions may be a key determinant of volatility: with good financial institutions, potentially profitable companies survive through rough times, while under bad financial institutions these same companies have their production severely reduced or may even go bankrupt. In fact, aggregate data seems to indicate that financial development might be a first order determinant of volatility. Figure 1, which plots the standard deviation of real per capita GDP growth versus private credit as a fraction of GDP, shows a clear negative correlation between a measure of financial development and macroeconomic volatility.

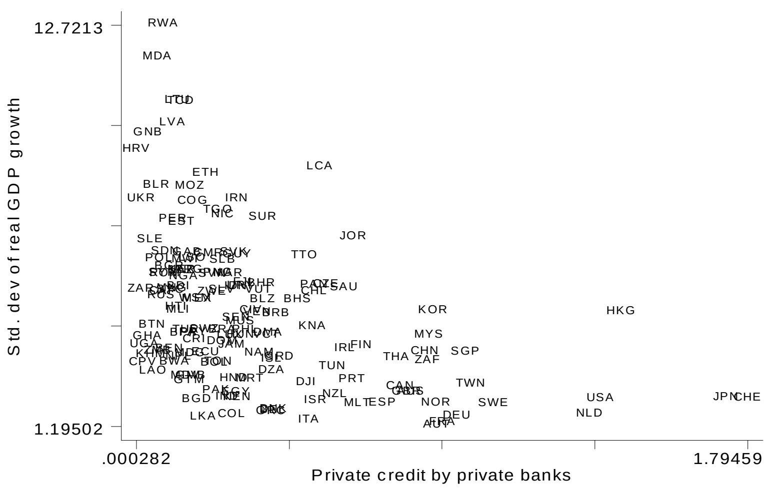

Figure 1: Financial development and volatility

Of course this correlation does not imply that financial development has a causal effect on volatility because the observed correlation may be explained either by reverse causality or omitted variable bias. These problems make difficult to find evidence of a causal relation using cross country data because of the large number of possible omitted variables and the scarcity of exogenous instruments.

This paper provides evidence of a causal and economically important effect of financial development on volatility using industry level data. The strategy exploits the idea that financial development should affect differently the volatility of sectors with different needs for liquid funds. This idea is based on the following intuition. Underdeveloped financial markets are characterized by their inability to reallocate resources efficiently across firms. This inability becomes more important during bad times as profitable firms experiencing temporary cash problems may not find enough resources to operate. This problem will be especially relevant for industries that, for technological reasons, require larger amounts of liquid funds to produce. Therefore, an increase in financial development should have a larger relative effect on the volatility of these industries.

This hypothesis is tested estimating a regression of industry volatility on the interaction between an industry's liquidity needs and a country's financial development. The sign of the coefficient of this interaction indicates whether industries with larger liquidity needs are relatively more volatile in less financially developed countries and its magnitude indicates whether the mechanism is economically important. The liquidity needs of an industry are measured using the methodology developed by Rajan and Zingales (1998).

Compared to cross country regressions, this methodology reduces considerably the concerns about reverse causality and omitted variable bias: using industry level data and controlling for country and industry effects, the methodology accounts for the potential feedback from aggregate volatility to financial development and imposes considerable restrictions on potential relevant omitted variables.

The results show that sectors with large liquidity needs, measured by the relative importance of inventories, are indeed more vulnerable to financial underdevelopment. Underdeveloped financial institutions increase the relative volatility (standard deviation of value added growth) and depth of crises (minimum value added growth) of these sectors.

The estimated effects are both statistically and economically significant. Consider for example the difference in standard deviation of real value added growth between the Electric Machinery and Paper Boxes industries (industries located at the 75th and 25th percentile level of liquidity needs respectively). According to the results presented in this paper, this difference would be 4.1 percentage points larger in a country with the financial development of Egypt than in a country with the financial development of Spain (countries located at the 25th and 75th percentile level of financial development respectively). This increase in relative volatility corresponds to 59 percent of the aggregate interquartile range of volatility across sectors. Similarly, the results imply that the difference between the worst output drop experienced by Electric Machinery and Paper Boxes would be 6.1 percentage points larger in Egypt than in Spain. This difference corresponds to 49 percent of the interquartile range of worst output drop across industries. Additional evidence suggests that, within active sectors, the effect on volatility operates mainly through the intensive margin (output per firm) instead of the extensive margin (number of firms).

A back of the envelope calculation suggests that the effect of financial development on volatility through the provision of liquidity is important at the macroeconomic level. Under plausible assumptions, the sectoral effects determined in this paper imply that an increase in financial development would significantly reduce aggregate volatility. For example, if Egypt achieved the financial development of Spain, the standard deviation of its aggregate manufacturing value added would fall from 6.8 to 5.8 percentage points; a 15% fall in volatility that would close 56% of the volatility gap between Egypt and Spain (1.8 percentage points). In this sense, the difference in aggregate volatility between Egypt and Spain could be largely explained by their difference in financial development.

This paper also reports evidence of an endogenous insulation mechanism. Regression results suggest that financially underdeveloped countries tend to protect themselves by allocating fewer resources to sectors with large liquidity needs. However, estimations of the macroeconomic relevance of this mechanism suggest that this partial insulation is insufficient to offset the effect of financial development on sectoral volatility.

The importance of different aspects of financial development in sectorial volatility is analyzed in additional regressions. The results suggest that the development of financial intermediaries is more important than the development of stock markets to reduce the relative volatility of sectors with large liquidity needs. This finding is consistent with the important role of banks as liquidity providers, especially in less developed countries. The main results are robust to changes in the specific measure of liquidity needs, volatility, and financial development. More importantly, they are also robust to the consideration of alternative explanations of the basic findings.

Overall, this paper shows that financial underdevelopment increases the volatility of sectors that are more dependent on the availability of liquid funds to finance their operations. This finding is consistent with the hypothesis that financial development reduces volatility by improving the provision of liquidity to firms during periods of crisis.

This paper is part of a recent literature that tries to determine the effect of the development of financial institutions on economic volatility. Using a panel of countries, Easterly et al. (2000) find a U-shaped relation between financial development (measured as credit to the private sector) and aggregate volatility after controlling for a set of volatility determinants. The authors interpret their findings as evidence that the development of the financial system helps to smooth fluctuations up to a point. Beyond this point financial development reduces stability because of the higher risk of a more leveraged economy. Using a similar methodology, but different controls and aggregation periods, Denizer et al. (2001) find that the relative importance of banks (measured as bank credit over total credit) reduces consumption and investment volatility, and that the relative importance of private credit (private credit over total credit) reduces output volatility. In contrast to the Easterly et al. (2000) paper, they do not find private credit as a fraction of GDP to be a significant determinant of output, consumption, or investment volatility. In summary, in its current state this literature does not provide robust evidence of a relation between financial development and volatility. The results are sensitive to the measure of financial development and to details such as the periods used to pool the data, the set of controls and instruments used, and the estimation technique. The instability of the results is very likely to be related to the omitted variables and endogeneity problems typically present in cross country regressions, as well as to the problems of estimating a stable relation between financial development and volatility without controlling for a specific transmission channel. Beck et al. (2001b) recognize the difficulty of finding an stable aggregate relation and attempt to estimate the effect of financial institutions in the propagation of different types of shocks. They build a stylized theoretical model based on Bachetta and Caminal (2000), predicting that the development of financial institutions should amplify productivity shocks and dampen monetary shocks. However, they are unable to provide strong evidence of the mechanism. Finally, Acemoglu et al. (2002) find in a recent paper that in a cross country regression financial development, measured as the ratio of M2 over GDP, has no effect on volatility after controlling for measures of the quality of institutions. This paper adds to this literature by using an econometric approach that reduces significantly the scope of the omitted variable bias and endogeneity problems and that tests the implications of one particular mechanism relating financial development and volatility.

On the theoretical side, this paper is related to Caballero and Krishnamurty (2001) who present a model that shows that underdeveloped financial markets reduce the availability of liquid funds during crises and exacerbate their impact on output. This paper provides evidence consistent with this type of mechanism, showing that sectors with larger liquidity needs are those that are relatively more volatile in financially underdeveloped countries. In a broader perspective, this paper is also related to the literature on financial development and volatility (e.g. Greenwood and Jovanovic (1990); Acemoglu and Zilibotti (1997); Aghion et al. (1999); Bachetta and Caminal (2000)), and to the literature on credit market imperfections and output fluctuations (Bernanke and Gertler (1989); Kiyotaki and Moore (1997)).

The rest of the paper is organized as follows. Section 2 presents a simple model that formalizes the intuition behind the hypothesis that financial development reduces the relative volatility of sectors with large liquidity needs. Section 3 describes the empirical strategy used to estimate the effect of financial underdevelopment on the volatility of sectors with different degrees of liquidity needs. Section 4 discusses the assumptions that are required to build a measure of an industry's liquidity needs using data from U.S. corporate firms, and describes how the measure is built. Section 5 briefly describes the data and the procedure used to build the measures of volatility, depth of crises, and financial development. Section 6 presents the main results, which document the relation between financial development and liquidity needs across sectors and shows that sectors with larger liquidity needs are relatively more volatile in less financially developed countries. Section 7 investigates the robustness of the effect of financial development on sectorial volatility, and explores some mechanisms via which this effect might be working. Section 8 concludes.

2 A stylized model of liquidity needs and volatility

This section presents a partial equilibrium model of volatility and financial development in an economy with sectors with different liquidity needs. This model formalizes the intuition that financial development should have a relatively larger effect on the volatility of sectors with large liquidity needs, and provides a framework to understand the results that will be presented in the empirical analysis.

The world lasts two periods ($t = 1, 2$). At $t = 1$, a firm has cash flow $N(\theta_1)$, which is determined by a random cash flow shock θ_1 revealed at the beginning of $t = 1$. Assume $N'(\theta) > 0$, and $N(0) = 0$.

There is only one good in the economy.[3] Firms invest an amount of this good as working capital (W_2) at $t = 1$ to produce output at $t = 2$ according to $Y_2 = F(W, \phi) = (aK^\alpha + \phi W^\alpha)^{\frac{1}{\alpha}}$ $0 < \alpha < 1$, $\phi < 1$; where K represents physical capital which is fixed in the period of analysis. The condition $\alpha < 1$ is necessary for concavity in W, and it implies that the elasticity of substitution between fixed capital and working capital is greater than 1.

The parameter ϕ indexes the relative importance of working capital for the firm, and it is common to every firm in a sector. Under perfect credit markets, sectors with a larger ϕ will have a higher working capital to output ratio (W/Y); therefore, sectors with a larger ϕ are naturally identified as sectors with large *liquidity needs*. In this model it will be assumed that there are only 2 sectors: $\phi \in \{\underline{\phi}, \overline{\phi}\}$, $\overline{\phi} > \underline{\phi}$. Firms in sector $\overline{\phi}$ have high liquidity needs, while firms in sector $\underline{\phi}$ have low liquidity needs.

Firms face a financial constraint. This constraint manifests itself in a maximum amount that a firm can invest in working capital as a function of its net worth and the development of financial markets:

$$W_2 \leq \lambda N(\theta),$$

where $\lambda > 1$ represents the development of financial markets –a more developed financial market has a higher λ.[4] The gross market interest rate on borrowing and lending is given at R.

The problem of the firm at $t = 1$ is:

$$\begin{aligned} &\max_{W_2} F(W_2, \phi) - RW_2, \\ \text{s.t.} \quad &W_2 \leq \lambda N(\theta_1). \end{aligned}$$

[3] As this is a partial equilibrium model, introducing different goods and relative prices do not add any insight to the result.

[4] This is a standard reduced form representation of financial constraints that can be obtained under different microeconomic settings. For example, a constraint like this can be easily derived from ex-post moral hazard considerations. See Aghion et al. (2000).

If the financial constraint is not binding, the firm will choose $W_2^*(\theta_1, \phi)$ so that:

$$\frac{W_2^*(\phi)}{Y_2} = \left(\frac{\phi}{R}\right)^{\frac{1}{1-\alpha}}.$$

Under the assumptions of the model, $F_{W\phi} > 0$; therefore, an unconstrained firm with a high ϕ will choose a large W_2^*. When the financial constraint is active, the firm will choose

$$\widetilde{W}_2(\theta_1) = \lambda N(\theta_1).$$

The solution to the firm's problem can then be summarized as:

$$W_2 = \min\{W_2^*(\phi), \widetilde{W}_2(\theta_1, \lambda)\},$$

where $\widetilde{W}_2(\theta_1, \lambda)$ is increasing in θ_1. As $N(0) = 0$, the financial constraint will be binding at low values of θ_1, but it will not bind at high levels of θ_1. The solution of the firm's problem as a function of the shock θ_1 is depicted in Figure 2, where $\tilde{\theta}(\lambda, \phi)$ denotes the value of θ_1 at which the financial constraint stops binding.

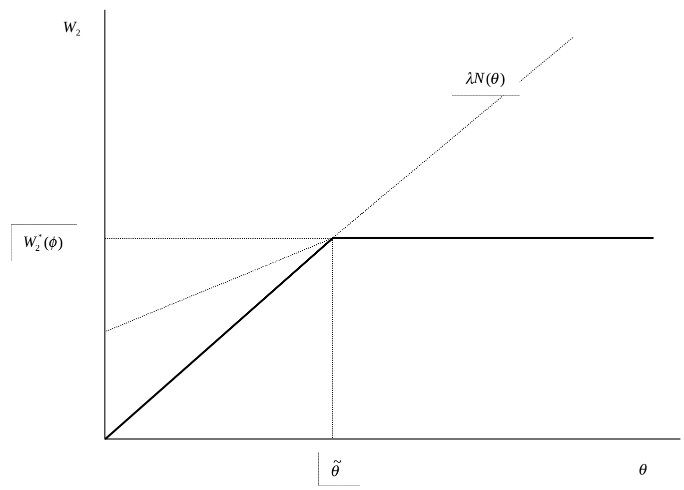

Figure 2: Optimal working capital investment as a function of the shock θ

In what follows, it will be assumed that the cash flow shock (θ_1) can take only 2 values: "good" or "bad". The good state is characterized as a situation in which none of the sectors is financially constrained. Formally, θ_1 has the following discrete distribution:

$$\theta_1 = \begin{cases} \overline{\theta} & \text{pb} \quad p \\ \underline{\theta} & \text{pb} \quad (1-p) \end{cases},$$

where $\overline{\theta} > \underline{\theta}$, so $\bar{\theta}$ represents the good state and $\underline{\theta}$ represent the bad state. The assumption that the financial constraint does not bind in the good state corresponds to assume that, for any level of financial development λ, $\max\{\widetilde{\theta}(\lambda, \overline{\phi}), \widetilde{\theta}(\lambda, \underline{\phi})\} < \overline{\theta}$. This assumption is crucial for the results and will be discussed in detail later. The situation is represented in Figure 3, assuming that both sectors are financially constrained in the bad state and have the same function $N(\theta_1)$.

In Figure 3, $\Delta\overline{W}_2$ represents the difference between the good and bad times levels of working capital investment of a firm with high liquidity needs. The analogous measure for a firm with low liquidity needs is represented by $\Delta\underline{W}_2$. Because $\Delta\overline{W}_2 > \Delta\underline{W}_2$, it is clear that $\overline{W}_2$ will be more volatile than $\underline{W}_2$ for any value of p.

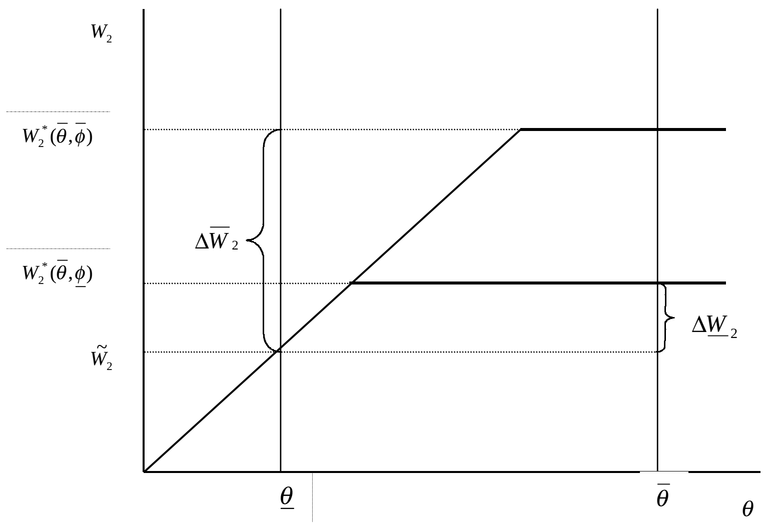

Figure 3: Difference in working capital investment between good and bad state

How does financial development affects working capital investment in the two sectors? The situation is depicted in Figure 4. An increase in λ increases the slope of $\lambda N(\theta)$ and rotates the line to the left. As a result, working capital investment in the bad state increases in both sectors, while working capital investment in the good state remains unaffected. The change in the volatility of working capital investment of sector ϕ resulting from a change in λ from $\underline{\lambda}$ to $\bar{\lambda}$ corresponds to:

$$\sigma^2_{W_2}(\bar{\lambda}) - \sigma^2_{W_2}(\underline{\lambda}) = -p(1-p)(\tilde{W}_2(\bar{\lambda}) - \tilde{W}_2(\underline{\lambda}))(2\bar{W}_2^*(\phi) - (\tilde{W}_2(\bar{\lambda}) - \tilde{W}_2(\underline{\lambda}))),$$

where $\tilde{W}_2(\bar{\lambda})$ is the constrained investment ($\theta = \underline{\theta}$) at high financial development, and $\tilde{W}_2(\underline{\lambda})$ is the constrained investment at low financial development, and $\bar{W}_2^*(\phi)$ is the unconstrained working capital investment of sector ϕ in the good state ($\bar{\theta}$).

As $\bar{W}_2^*(\bar{\phi}) > \bar{W}_2^*(\underline{\phi})$, it is easily verified that the fall in the volatility of W_2 in the high liquidity needs sector ($\bar{\phi}$) is larger than in the low liquidity needs sector ($\underline{\phi}$). Moreover, as $F_{W\phi} > 0$, *output* volatility also falls relatively more in the high liquidity needs sector. In conclusion, an increase in financial development would reduce the relative volatility of the sector with high liquidity needs.

As previously mentioned, this result depends on the assumption that sectors are not financially constrained in the high state. Three comments are in place regarding this assumption. First, the assumption can be slightly relaxed without affecting the main result. Second, no restriction has been imposed on the probability with which the high state occurs (p), so it is still possible to define this state as the state in which the assumption holds and adjust the probability instead. Third, the assumption is equivalent to assume that the degree of financial development is not too low ($\lambda \geq W_2^*(\bar{\phi})/N(\bar{\theta})$). As data on sectoral output is not typically available for countries with extremely low levels of financial development, this assumption is likely to hold in the empirical setup.

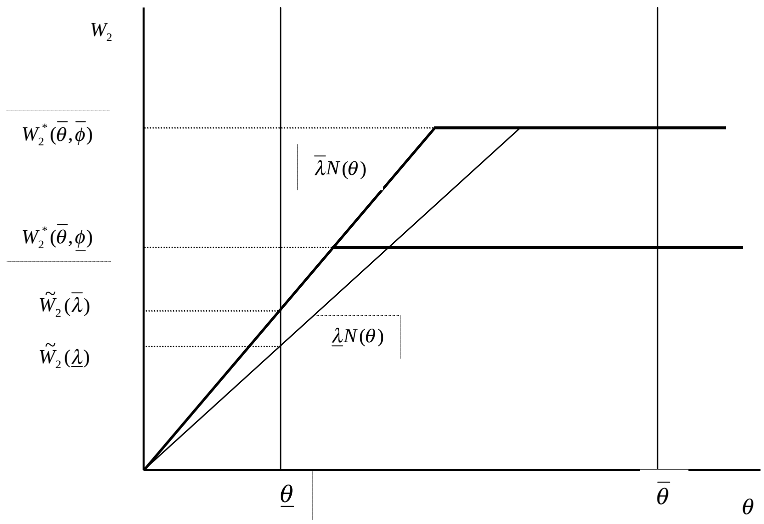

Figure 4: Financial development and sectoral volatilities

3 Empirical strategy

The model discussed in the previous section provided a rationale to expect sectoral differences in the effect of financial development on volatility. The empirical strategy is based precisely on these differences, which provide the necessary source of variation to identify the relation between financial development and volatility in the empirical analysis.

Consider the effect of an increase in financial development from $\underline{\lambda}$ to $\bar{\lambda}$ on the output volatility of two sectors with different liquidity needs: $\underline{\phi}$ and $\bar{\phi}$ ($\underline{\phi}> \bar{\phi}$). The model says that, if financial development is not too low, financial development will reduce volatility, and the sectoral difference on the effect of financial development will be negative. That is,

$$(\sigma(\bar{\lambda}, \bar{\phi}) - \sigma(\underline{\lambda}, \bar{\phi})) - (\sigma(\bar{\lambda}, \underline{\phi}) - \sigma(\underline{\lambda}, \underline{\phi})) < 0.$$

In a continuous version, this prediction corresponds to:

$$\frac{\partial^2 \sigma}{\partial \lambda \partial \phi} = \gamma < 0,$$

where the cross derivative is assumed to be constant for simplicity. Integrating this partial difference equation and grouping terms according to the source of variation, the following expression for σ can be obtained:

$$\sigma_{ik} = A_k + B_i + \gamma \lambda_k \phi_i + H_{ik}, \tag{1}$$

where σ_{ik} is the volatility of sector i in country k. The variables A_k, B_i, and H_{ik} group all the determinants of volatility different from the interaction term: A_k contains those determinants that depend only on country variables, B_i those that depend only on industry variables, and H_{ik} those depending simultaneously on both country and industry variables different from λ and ϕ.[5]

Equation (1) can be easily transformed into an estimable equation. Assuming that the H_{ik} component corresponds to linear combinations of variables that vary with country and industry, equation (1) can be written in terms of observable variables as:

$$V_{i,k} = \alpha_k + \beta_i + \gamma L_i \mathrm{x} F_k + X_{i,k}\delta + \varepsilon_{i,k}, \tag{2}$$

where $V_{i,k}$ is the volatility of industry i in country k, α_k is a country specific effect, β_i is an industry specific effect, L_i is the measure of liquidity needs of the industry, F_k is the measure of financial development of the country, $X_{i,k}$ is the set of additional determinants of sectorial volatility, ε_{ij} is a random error, and δ and γ are parameters to be estimated.

The empirical strategy consists on estimating the parameters of equation (2) using data on volatility, liquidity needs, and financial development across industries and countries. The parameter of interest is γ: the effect of the interaction of financial development and liquidity needs on volatility. If financial development reduces the relative volatility of sectors with larger liquidity needs γ should be negative, and economically significant. Two different measures of volatility will be used: overall volatility and depth of crises. The first corresponds to the standard deviation of output growth, and the second to the minimum growth rate observed. More detail on these variables is left for Section 5.

The simplest way of proceeding is to estimate the parameters of equation (2) by OLS. However, as explained in the following sections, both the measures of liquidity needs and financial development are likely to contain a significant amount of noise.

[5]This derivation assumes that financial development is a country characteristic and liquidity needs is an industry characteristic. The specification is still valid if both financial development and liquidity needs vary across countries and industries. However, if this is the case, the base specification will be affected by endogeneity resulting from the measurement error. This problem can be addressed by using appropriate instruments as described below.

To the extent that this noise corresponds to classical measurement error, the OLS estimator of γ will be biased towards zero. To solve this problem, the parameters of equation (2) will also be estimated by Two Stages Least Squares (2SLS) using standard instruments for the measure of financial development (a country's legal origin). This should reduce the bias towards zero, but the bias would persists because of the noise in the measure of liquidity needs. This part of the problem will be partially addressed using an alterative measure of liquidity needs as an instrument for the base measure.

The strategy outlined above reduces considerably the concerns about reverse causality and omitted variable bias that are common to cross-country regressions. The reason is that the results would be biased by an omitted variable only if this variable is correlated with the *interaction* of liquidity needs and financial development. This is clearly less plausible than having an omitted variable that is correlated with the *level* of financial development, which is sufficient to bias the results in the cross-country case. With respect to reverse causality, the problem would only be present if there were some feedback from the *differences* in volatility across industries to the aggregate *level* of financial development. This feedback is very unlikely, and it is clearly less plausible than the condition for reverse causality in cross country regressions, which only requires a feedback from the aggregate level of volatility to the aggregate level of financial development. In addition, the instruments used to solve the measurement error problem should also take care of the endogeneity problem if they are not correlated with other determinants of sectorial volatility.[6]

Despite its apparent simplicity, the interpretation of the differences in differences coefficient γ can generate some confusion. It is important then to emphasize what can be said about the relation between financial development and volatility using the parameters of this specification. First, the specification exhibits perfect collinearity, therefore only the relative country and industry effects (α_k and β_i parameters) can be identified.[7] Second, this specification cannot identify the slope of the aggregate relationship between financial development and volatility (assuming that there is such a relation). Only the *cross derivative* of volatility with respect to financial development and liquidity needs can be identified (γ). The *total derivative* should also consider the direct effect of financial development on volatility contained in α_k, which cannot be identified without further assumptions.

[6]Even though the instruments are compelling and widely used in the literature, there may still be a concern that a country's legal origin may be correlated with other determinants of volatility such as the institutional quality (see Acemoglu et al. (2001)). Regressions that attempt to control for the quality of institutions are presented in the robustness section.

[7]For a discussion, see Baltagi (2001)

4 Measuring liquidity needs

The liquidity needs of a firm are determined by the relative importance of working capital in its production process: firms in industries that normally require a relatively large investment in working capital will typically need relatively more liquid funds to operate. So, in principle, a measure of an industry's liquidity needs could be constructed by measuring the relative importance of working capital for that industry. There are, however, two problems to build such a measure. First, there is no comprehensive data that could be used to build a country specific measure, so the use of a benchmark is necessary. Second, even if data were available, the actual level of working capital observed for firms in an industry will be affected by the characteristics of the financial markets in which they operate. This data would then be contaminated precisely by the effect of financial markets that I attempt to test for.

The lack of data and the endogeneity problem make it necessary to follow an indirect approach to estimate an industry's liquidity needs. In a similar situation, Rajan and Zingales (1998) devised a novel method to estimate an industry's dependence on external financing, which under some assumptions allows them to measure the external dependence of an industry using data on U.S. corporations. Their approach is followed in this paper to measure an industry's liquidity needs. First, it is assumed that there is a technological reason why some industries demand relatively more working capital than others. As long as there are significant differences across industries in the length of the production process or the mode of operation (batch versus continuous), this assumption is plausible.[8] Under the further assumption that these technological differences persist across countries, a measure of the liquidity needs of an industry in the U.S. can be extrapolated to other countries. Note that this assumption does not require technologies in other countries to be identical to the U.S., but only requires a positive correlation between the measure of liquidity needs obtained for U.S. industries and the liquidity needs of other countries' industries.[9] Moreover, the analysis will focus on manufactures, which is a traditional productive sector with relatively standard technologies, and the measures will be built for nar-

[8]For example, in 1930 Keynes wrote:

> "It is evident that the amount of working capital required per unit value of output varies enormously between different products, corresponding to variations in the length of the process..."

More recent papers emphasizing the role of the length of the production process and other technological characteristics as determinants of working capital demand include Ramey (1989), Kim and Srinivasan (1988), and Nunn (1981)

[9]Rajan and Zingales (1998) assume the stronger condition that the relative ranking of liquidity needs is preserved across countries. Assuming only positive correlation, the measure of an industry's liquidity needs in the US can be interpreted a noisy measure of the liquidity needs of that industry in other countries. To the extent that this corresponds to classical measurement error, the coefficient of interest will be biased towards zero, which stacks the cards against the hypothesis of this study.

rowly defined industries (4 digit ISIC), so the scope for variations in technology across countries is significantly reduced.

The previous two assumptions guarantee that a measure of liquidity needs can be built for different industries in the U.S., and extrapolated to other countries. However, these assumptions do not deal with the potential relation between financial markets and observed levels of working capital. This concern will be reduced because the data used to build the measures of liquidity needs comes from relatively large U.S. companies. The reason is twofold: first, the U.S. is among the most developed financial markets in the world so financial constraints should be less important for U.S. firms than for firms in other countries; second, within the U.S., relatively large firms are likely to be the less constrained in their access to external liquid funds (Fazzari et al. (1988); Gertler and Gilshrist (1994)). In other words, by focusing on large U.S. corporations we can assume that the supply of liquid funds is almost perfectly elastic, and, therefore, the observed differences in relative working capital levels across industries are mainly demand driven.

The measure of liquidity needs was built using balance sheet data for U.S. public manufacturing firms from Compustat. Balance sheet data does not provide information on the ongoing amount of liquid assets that a firm invests to finance its operations, which corresponds to the economic concept of working capital, but it only reports the different components of the stock of liquid assets and liabilities of a firm. So, only a proxy of the relative importance of working capital can be obtained.

The proxy used in the main results of this paper is the relative importance of inventories for each industry. It was computed as the median ratio of *inventories over sales* (Compustat #3 over Compustat #12) across all Compustat firms belonging to that industry during the period 1980-1989. Nevertheless, the results are robust to the use of alternative measures of liquidity needs.[10]

There is a clear link between the relative importance of inventories, working capital, and technology: firms need working capital because goods take time to produce, and it is reasonable to expect that firms with long production processes will have a large value of inventories.[11,12] On the contrary, it is very difficult to argue for a role of technology in the determination of other components of a firm's current assets, like cash stocks. These components are more likely to be determined by market conditions rather than technology, and, as long as market conditions vary more from country to country than technologies, measures of liquidity needs based mainly on these other components would be less easily extrapolable from U.S. firms to other countries.

[10] The details of industry aggregation are described in appendix A.

[11] This relationship was noted long ago by Keynes, who defined working capital as the cost of the aggregate of goods in course of production, manufacture, transport, etc., including the stocks required to avoid risks of interruption of process or to tide over seasonal irregularities.

[12] Other important determinant of the level of inventories is the degree of demand uncertainty. Under this interpretation, the relative importance of inventories may not only be capturing the average level of liquidity needs of a sector, but also the volatility of these needs. This interpretation is formally tested in the robustness section (Section 7.1).

There are two problems with the use of the relative importance of inventories as a measure of an industry's liquidity needs. The first problem is that this ratio is higher for durable goods. Given that durable goods sectors are in general more volatile than the average, using this measure of liquidity needs to estimate equation (2) may erroneously attribute the relation between durability and volatility to liquidity needs. This concern will be addressed by adding appropriate controls to the estimation of equation (2) and it will prove to be unimportant. The second problem is that there is wide macroeconomic evidence that the ratio of inventory to sales has been decreasing in the U.S. since the early 80's (see Blanchard and Simon (2000), and Kahn et al. (2001)). This trend may be a problem not only because it makes difficult to define a typical value of the ratio, but also because it may affect the relative ranking of liquidity needs across sectors. However, the data shows that the trend is widespread within manufactures and does not significantly affect the relative ranking of liquidity needs: the correlation between the measures of inventories over sales across industries built for different years is very high and significant. For example, the correlation between the measure of inventories over assets across industries in 1980 and 1995 is 0.7, and even between 1971 and 1999 is 0.6 and significant at the 1% level.[13] The relative stability of the ranking of inventories to sales ratio across industries indicates that the effect of the trend in the results is likely to be minor.[14]

Table 1 presents the value of inventories over sales for the 70 4 digit ISIC sectors considered in the analysis.[15] This measure is summarized in column (1). Columns (2) to (4) show some alternative measures of liquidity needs for comparison.[16] Column (2) shows the ratio of total inventories over assets. Column (3) reports the *Cash Conversion Cycle* (henceforth CCC), which estimates the length in days between the moment a firm pays for its raw materials and the moment it is paid for the sale of its final output during the normal course of operations (see Richards and Laughlin (1980))[17]. Finally, column (4) reports the median of the labor cost to shipments

[13]The rank correlations are 0.72 between 1980 and 1995, and 0.64 between 1971 and 1999

[14]In order to check the importance of the trend in inventories, the measure of inventories over sales was also built for the periods 1970-1979, and 1990-1999. The use of these different periods to estimate a sector's liquidity needs does not affect the conclusions (the results of these regressions are contained in appendix D).

[15]There are 81 non-inclusive 4 digit ISIC sectors; for 11 of them either there is no data available in Compustat or there are fewer than 5 firms in the sector.

[16]The robustness of the results to the use of these alternative measures is reported in appendix D.

[17]The CCC is defined as the average age of inventories ($inventories \, \mathrm{x}\, 365/cost\, of\, goods\, sold$) plus the average age of accounts receivable ($account\, receivables \, \mathrm{x}\, 365/sales$) minus the average age of accounts payable ($accounts\, payable \, \mathrm{x}\, 365/cost\, of\, goods\, sold$).

ratio.[18,19] The table is sorted by the inventories to sales ratio, so sectors with low liquidity needs are presented at the top of the table.

A comparison of the top and bottom halves of the table shows that, as previously mentioned, sectors with low liquidity needs are mainly non-durable goods industries, while sectors with high liquidity needs are mainly durable goods industries. In fact, 27 out of 36 non-durable industries are among the 35 sectors with lowest liquidity needs, while 27 out of 34 durable industries are among the 35 sectors with highest liquidity needs. This distribution is consistent with the idea that industries with longer and more expensive productive processes have higher liquidity needs, as the durable goods sectors produce more elaborate goods that are more likely to require expensive inputs and longer processes. The only exceptions to the rule is the presence of some non-durable industries at the very bottom of the table among those sectors with the highest liquidity needs. Most of these cases correspond to sector 3200, which includes Textiles, Wearing Apparel, and Leather industries. A possible explanation for this finding is that if these sectors have a very seasonal demand, measuring the level of inventories in December may overestimate the average liquidity needs of the sectors. However, these sectors remain at the bottom of the table when the average level of inventory over assets during a year is measured using quarterly data. Nevertheless, the results are not affected by the exclusion of these sectors.

Another sector that is somewhat problematic is sector 3530, which corresponds to petroleum refineries. This sector appears as one of the industries with lowest liquidity needs for various alternative measures. Even though this is not necessarily wrong, this sector is very particular because of its association with the fluctuations in the price of oil; therefore, its presence at one extreme of the distribution of liquidity needs may affect the results. However, as in the case of the Textile sector, the results are not significantly affected by the inclusion or exclusion of this sector.

[18]This measure was built using data from the NBER Productivity Database (Bartelsman et al. (2001)). The reason to use a different source of data to build the measure is that most of the Compustat firms do not report data on wage payments or labor expenditures. So, when Compustat data was used, a large number of sectors was dropped from the estimation for lack of data. Moreover, even in the sectors with enough observations, the number of firms used to build the typical industry measure is significantly smaller than in the case of inventories, which significantly increases the noise of the measure. These problems are avoided by using the NBER data. However, the trade-off is that the argument that large corporate firms are less affected by financial constraints does not apply to the NBER sample, which includes small firms. So, the concern about endogeneity (financial constraints affecting the technology choice of the firms) is more important in this case.

[19]The basic intuition for the relation between this measure and an industry's liquidity needs is that a good fraction of the working capital a firm typically needs is devoted to pay wages and salaries. For this reason, sectors where labor costs are relatively more important are likely to be sectors with larger liquidity needs. An additional motivation for the use of this measure comes from Kremer (1993), who argues that it is likely that firms producing more complex products (requiring more tasks) will use more workers and that the average quality of the workers will be higher. Therefore, there is a potential correlation between the length of the production process and the relative importance of labor expenses.

Table 1: Measures of liquidity needs for 4 digit ISIC industries

Different measures of liquidity needs are reported in columns (1) to (4). Columns (1) and (2) (I/S and I/A) show the median of total inventories (Compustat #3)over annual sales (Compustat #12) and over total assets (Compustat #6) across U.S. firms in each sector. Column (3) (CCC) is the cash conversion cycle, in hundreds of days, which is defined as: (inventories*365/(cost of goods sold))+(account receivables*365)/(total sales)-(account payables*365)/(cost of goods sold). The values in the table are the median of this measure across US firms in each sector. Finally, column (4) (wL/S) shows the median of average yearly short term debt (Compustat #104) over annual sales (Compustat #12). The universe of firms was all the manufacturing firms included in Compustat during the period 1980-1989. The SIC code, used to determine the industry in which a firm operated, was obtained from CRSP. The correspondence between SIC and ISIC classification systems was made by the author.

		Measures of liquidity needs			
ISIC	DESCRIPTION	I/S	I/A	CCC	wL/S
3112	Dairy products	0.05	0.15	0.20	0.06
3530	Petroleum refineries	0.06	0.08	0.19	0.02
3134	Soft drinks	0.06	0.10	0.41	0.12
3117	Bakery products	0.06	0.12	0.44	0.16
3133	Malt liquors and malt	0.07	0.12	0.27	0.09
3111	Slaughtering and preserv. meat	0.08	0.23	0.43	0.10
3420	Printing, publishing and allied	0.08	0.12	0.78	0.28
3411	Pulp, paper and paperboard	0.11	0.12	0.68	0.16
3121	Food products n.e.c	0.11	0.17	0.55	0.09
3116	Grain mill products	0.11	0.19	0.54	0.07
3513	Synthetic resins and plastic	0.11	0.19	0.73	.
3843	Motor vehicles	0.11	0.22	0.56	0.18
3699	Non-metallic mineral prod. n.e.c.	0.12	0.12	0.84	0.19
3419	Pulp, paper and paperboard n.e.c	0.13	0.21	0.83	0.17
3551	Tyre and tube industries	0.13	0.20	0.88	0.20
3529	Other chemical products	0.13	0.17	0.96	0.13
3412	Boxes of paper and paperboard	0.13	0.22	0.74	0.17
3119	Chocolate and sugar confect.	0.14	0.23	0.82	0.10
3311	Sawmills and other wood mills	0.14	0.22	0.78	0.19
3512	Fertilizers and pesticides	0.14	0.18	0.96	0.10
3560	Plastic products n.e.c	0.14	0.19	0.84	0.18
3511	Basic industrial chemicals	0.14	0.13	0.96	0.09
3115	Vegetable and animal oils	0.14	0.26	0.82	0.05
3559	Rubber products n.e.c.	0.15	0.20	0.98	0.25
3720	Non-ferrous metal basic ind.	0.15	0.21	0.89	0.17

Continue next page

Table 1 continued

ISIC	DESCRIPTION	Measures of liquidity needs I/S	I/A	CCC	wL/S
3523	Soap and cleaning prep.	0.15	0.24	1.22	0.10
3214	Carpets and rugs	0.15	0.30	0.92	0.11
3813	Structural metal products	0.15	0.24	0.96	0.22
3521	Paints, varnishes and lacquers	0.15	0.25	0.91	0.12
3842	Railroad equipment	0.15	0.25	0.82	0.19
3540	Misc. prod. of petroleum	0.15	0.15	0.69	0.09
3692	Cement, lime and plaster	0.16	0.13	1.06	0.18
3211	Textiles spinning and weaving	0.16	0.27	1.01	0.20
3522	Drugs and medicines	0.16	0.11	1.12	0.18
3710	Iron and steel basic ind.	0.16	0.22	0.90	0.24
3320	Furniture and fixtures	0.16	0.28	1.07	0.26
3118	Sugar factories and ref.	0.16	0.23	0.88	0.09
3620	Glass and glass prod.	0.16	0.20	0.96	0.24
3841	Ship building and repair	0.17	0.24	0.80	0.30
3812	Metal furniture and fixtures	0.17	0.22	1.12	0.23
3610	Pottery, china and earthenware	0.17	0.21	1.23	0.35
3219	Textiles n.e.c.	0.18	0.21	0.93	0.16
3833	Electrical appliances	0.18	0.24	1.25	0.17
3819	Fabricated metal prods.	0.18	0.25	1.06	0.24
3821	Engines and turbines	0.19	0.27	1.27	0.24
3691	Structural clay prods	0.19	0.22	1.11	0.27
3212	Textile goods exc. apparel	0.19	0.34	1.13	0.23
3131	Distilling spirits	0.19	0.22	1.37	0.08
3220	Wearing apparel exc. footwear	0.20	0.38	1.23	0.24
3825	Office and computing mach.	0.20	0.22	1.51	0.23
3811	Cutlery and hand tools	0.20	0.28	1.39	0.25
3909	Industries n.e.c.	0.20	0.28	1.41	0.23
3831	Elect. ind. machinery	0.20	0.27	1.54	0.25
3113	Fruits and veg. canning	0.20	0.34	0.86	0.11
3822	Agric. mach. and equip.	0.21	0.28	1.45	0.16
3832	Radio, TV. and comm. eqp.	0.21	0.24	1.46	0.27
3903	Sport and athletic goods	0.21	0.34	1.29	0.19
3839	Elect. app. and supp. n.e.c.	0.21	0.26	1.41	0.21
3829	Machinery and eqp. n.e.c.	0.21	0.29	1.32	0.25
3851	Scientific equipment	0.21	0.24	1.67	0.27
3240	Footwear	0.22	0.39	1.33	0.23
3845	Aircraft	0.22	0.29	1.35	0.31

Continue next page

Table 1 continued

ISIC	DESCRIPTION	Measures of liquidity needs I/S	I/A	CCC	wL/S
3823	Metal and wood wkg. mach.	0.23	0.30	1.51	0.30
3140	Tobacco manufactures	0.24	0.28	1.40	0.08
3852	Photo. and optical goods	0.25	0.24	1.71	0.30
3824	Special indus. mach. and eqp.	0.25	0.28	1.53	0.26
3853	Watches and clocks	0.26	0.36	1.42	0.20
3902	Musical instruments	0.28	0.35	1.89	0.28
3233	Leather products	0.30	0.29	1.57	0.25
3901	Jewellery	0.30	0.46	1.98	0.16
Correlations: levels – ranks					
Total Inventories over assets		–	0.78	0.91	0.50
Total Inventories over sales		0.78	–	0.66	0.34
Cash Conversion Cycle		0.93	0.68	–	0.51
Short term debt over sales		0.50	0.34	0.40	–

The rank correlations between the 4 measures are reported at the bottom of Table 1. It can be observed that, in general, the rankings generated by the different measures are highly correlated.[20]

5 Data

5.1 Volatility

The main data source used to determine the volatility of an industry in a given country was the Industrial Statistics Database 2000, 4 digit ISIC, created by the United Nations (UNIDO). This database contains information on nominal value added, employment, number of establishments, wages and salaries, gross output, and gross capital formation, for a set of 114 countries and 81 4 digit ISIC industries during the period 1980-1998. However, there is plenty of missing information and the real scope of the data is considerably smaller.[21] The final sample used in the analysis consists of an unbalanced panel including 48 countries (plus the U.S. which is the benchmark

[20]The only exception is the correlation between inventories over assets and labor costs

[21]In addition, several countries do not report data for every 4 digit ISIC industry, but only for groups of them. As the grouping varies from country to country, this data is not comparable and has to be dropped.

country) with data on at least 2 of 70 4-digit ISIC industries. The average number of industries per country is 54. The criteria used to select the sample and the effect of this criteria on the results are discussed in appendix B.

Two different measures of volatility, which capture two different aspects of fluctuations, were built for each industry in every country: the standard deviation of real value added growth (*overall volatility),* and the minimum growth rate of real value added observed during the period (*depth of the cycle).*

The growth rate of real value added, on which the two measures above are based, was computed using data on nominal value added from UNIDO and the following three deflators: (i) the Producer Price Index from the International Financial Statistics; (ii) the Index of Industrial Production, also from IFS; (iii) the ratio of nominal to real manufacturing value added from the World Development Indicators. Following Rajan and Zingales (1998), (i) was used as the main deflator, and (ii) was used for high inflation countries.[22,23]

5.2 Financial Development

Three measures of financial development are used throughout this paper. The main measure is private credit as a fraction of GDP, which includes the credit by banks and other financial institutions but excludes the credit allocated by the Central Bank. The reason to exclude the latter is that the credit allocated by the Central Bank is likely to be determined by political rather than economic considerations. The level of private credit captures the development of financial intermediaries and it is closely related to the mechanism emphasized in this paper because of the important role played by financial intermediaries in the provision of liquidity. Data for this measure was obtained from Beck et al. (2001a).

The two other measures of financial development are the quality of accounting standards and the stock market capitalization. These measures are less related to the particular mechanism of this paper, but are included in the analysis for two reasons: (i) to explore the different channels by which financial development affects sectorial volatility, especially the role of information and market structure (banks versus markets); (ii) to check the robustness of the results to the use of measures that capture different dimensions of financial development.

The quality of accounting standards, obtained from La Porta et al. (1998), captures the quality of the information available to outside investors, and it is probably correlated with the characteristics of the contracting environment in which firms develop. This measure should not only be relevant for market based systems, as it is reasonable to expect that the monitoring costs incurred by a bank should be decreasing in the quality of the information typically produced by firms.[24]

[22] Within the final sample of countries and period of analysis, the only case of hiper-inflation corresponds to Peru.

[23] Deflators (ii) or (iii) were also used for countries lacking information on (i).

Finally, the stock market capitalization is a measure of the size of equity markets in a country with respect to GDP. This measure has two important advantages: it is comparable with the measure of size of the intermediary sector, and it has been extensively used in comparison to private credit to investigate the effects of financial market structure on economic growth. The main disadvantage of this measure is that it does not contain information about the level of activity of stock markets.[25] The data of the stock market capitalization was also extracted from Beck et al. (2001a).

As previously mentioned, any available measure of financial development is likely to contain a significant amount of measurement error. Intuitively, financial development is broad economic concept whose different aspects can hardly be captured in a single measure: some measures will be just better proxies than others. Moreover, even if only one aspect of financial development is relevant for the mechanism under analysis, idiosyncratic differences across countries can introduce significant amounts of noise. For example, assume that the only relevant aspect of financial development for our mechanism is the ability of firms to obtain short term financing. Even assuming that the ratio of private credit to GDP is a perfect measure of the development of financial intermediaries, the existence of unobservable alternative sources of working capital financing, such as trade credit or large ownership structures, whose importance may vary from country to country, will affect the precision of the measure.[26]

In order to address the potential problem of measurement error, the measures of financial development will be instrumented using dummy variables representing a country's legal origin (English, French, German, or Scandinavian). These instruments, which are standard in the literature of law and finance, were extracted from La Porta et al. (1998) and complemented with data from the World Bank growth network database.

The list of countries used in the analysis and the value of the different measures of financial development for each one of them, is summarized in Table 2. The coverage is better when private credit is used as a measure of financial development because

[24]A criticism that has been raised against the use of accounting standards is that the results obtained when using this measure are highly influenced by a small set of countries at the bottom of the distribution of accounting standards. Even though this is true, this critique is unfair because the information on accounting standards is strongly biased towards developed countries: the sample of countries in which the measure is available includes most of the OECD countries, but only a few developing countries. So, a significant fraction of the variation in the measure of accounting standards is lost when we exclude the few developing countries in the sample.Therefore, it is not surprising to find that the capacity of the variable to identify the effects of financial development is severely reduced when these countries are excluded.

[25]The results are also not significantly affected when a measure of activity is used instead of stock market capitalization (results not reported).

[26]In particular, an important source of short term credit for firms is the trade credit provided by suppliers. As the relative importance of trade credit may vary from one country to another for reasons unrelated to the development of financial intermediaries, the measure of financial development will only capture part of the story. The same is true for firms that belong to a holding firm, and have access to a pool of resources that is managed without the intervention of intermediaries.

the measures of accounting standards and stock market capitalization are available for a smaller set of countries. The correlation between the measures of financial development is reported at the bottom of the table. The measures are positively correlated between each other; nevertheless, the correlations are not extremely high especially with respect to accounting standards.

6 Financial development and sectoral volatility

This section reports the parameters estimated for the model presented in equation (2) with overall volatility and the depth of crises as the dependent variables. The results, presented in Table 3, show that financial development reduces the relative volatility and depth of crises of sectors with high liquidity needs. After presenting these results, it is showed that, under plausible assumptions, the magnitudes of the coefficients are economically significant not only at the sectoral level but also at the macroeconomic level (tables 4 and 5). Finally, the mechanism by which financial development affects sectoral volatility is explored in further detail in tables 6 and 7. The results, suggest that the main effect of financial development in volatility operates through the intensive margin, that the quality of information is important for the availability of liquid funds, that the development of stock markets does not play an important role in the provision of liquidity, and that the development of privately owned financial intermediaries is the main determinant of the availability of liquid funds.

6.1 Overall Volatility

Panel A of Table 3 presents the results obtained using the standard deviation of real value added growth (overall volatility) as dependent variable. The results correspond to the parameters of four different specifications that were estimated both by OLS (columns (A1) to (A4)) and by 2SLS (columns (A5) to (A9)). In all the 2SLS regressions, financial development was instrumented by the legal origin of the country, and, in the case of column (A9), liquidity needs were also instrumented using the ratio of labor costs over shipments. The White estimator of variance was used in all regressions because of the presence of heteroscedasticity in the data.[27]

The first row of the table reports the coefficient of the interaction between financial development and liquidity needs (γ). The coefficient is negative and significant at

[27] All the regressions reported in Table 3 assume that the relation between financial development and relative volatility is linear. Regressions allowing for the possibility of non-monotonicity presented problems of multicolinearity (unstable coefficients, meaningless magnitudes) and no useful conclusion could be extracted from them.

Regressions splitting the sample according to income level were estimated as an alternative way of addressing the non-monotonicity issue avoiding the multicolinearity problems. Results from these regressions show no evidence of a change in the coefficient across groups of countries.

Table 2: Financial development of countries included in 4 digit ISIC sample

Sample corresponds to those countries included in the UNIDO 2000 database (4 digit ISIC) that passed the following requirements: (1) data started no later than 1985, (2) had at least 5 observations of real value added growth rate in at least two industries, (3) at least one of the main measures of financial development used in the analysis was available around 1981. The measures of financial development are: Column(1) shows the quality of accounting standards in 1990 built by CIFAR and extracted from Laporta et al.(1996). Countries with a larger index have better quality of accounting standards. Column (2) presents the level of private credit by domestic banks and other financial institutions as a fraction of GDP in 1980, obtained from Beck et al (1999). Column (3) presents the level of stock market capitalization as fraction of GDP (also extracted from Beck et al (1999)). Finally, column (4) reports the number of sectors at 4 digits ISIC used in the estimation.

COUNTRY	Pvt. Credit (1)	Acc. Std. (2)	Mkt. Capit. (3)	No sect. (4)	COUNTRY	Pvt. Credit (1)	Acc. Std. (2)	Mkt. Capit. (3)	No Sect (4)
Australia	0.90	0.75	0.32	60	Jordan	0.46	.	0.45	45
Austria	0.80	0.54	0.03	48	Korea	0.54	0.62	0.06	70
Bangladesh	0.08	.	0.00	56	Malaysia	0.54	0.76	0.54	64
Belgium	0.28	0.61	0.10	9	Malta	0.30	.	.	34
Cameroon	0.27	.	.	10	Mauritius	0.20	.	.	44
Canada	0.77	0.74	0.38	60	Mexico	0.17	0.60	0.05	52
Chile	0.42	0.52	0.26	65	Netherlands	1.10	0.64	0.19	17
Colombia	0.29	0.50	0.04	69	New Zealand	0.33	0.70	.	3
Costa Rica	0.22	.	0.04	56	Norway	0.77	0.74	0.05	64
Cote d'Ivoire	0.41	.	0.04	13	Panama	0.54	.	.	36
Cyprus	0.57	.	.	45	Peru	0.12	0.38	0.04	69
Ecuador	0.18	.	.	64	Philippines	0.41	0.65	0.07	63
Egypt	0.21	0.24	0.01	67	Portugal	0.80	0.36	0.01	69
Fiji	0.21	.	.	25	Singapore	0.83	0.78	2.14	54
Finland	0.45	0.77	0.07	67	Spain	0.76	0.64	0.09	70
France	1.00	0.69	0.08	15	Sri Lanka	0.16	.	.	62
Germany	0.86	0.62	0.10	54	Sweden	0.86	0.83	0.13	64
Ghana	0.02	.	.	51	Trinidad	0.34	.	0.15	34
Greece	0.49	0.55	0.07	42	Turkey	.	0.51	0.01	67
Honduras	0.28	.	.	55	U.K.	0.29	0.78	0.38	70
Hong Kong	.	0.69	1.29	54	U.S.A.	1.06	0.71	0.46	70
Iceland	0.25	.	.	28	Uruguay	0.34	0.31	0.01	57
India	0.26	0.57	0.03	70	Venezuela	0.54	0.40	0.04	67
Indonesia	0.09	.	0.00	69	Zimbabwe	0.28	.	0.05	25
Japan	1.30	0.65	0.34	70					

Correls.			
Pvt. Cred.	1.00		
Acc. Std.	0.44	1.00	
Mkt. Capit.	0.29	0.42	1.00

the 1% level across all specifications, which is consistent with the hypothesis that financial development *reduces* the relative volatility of sectors with high liquidity needs. Column (A1) reports the coefficient obtained when no additional controls are included in the regression. That is, when the only country-industry variable is the interaction between liquidity needs and financial development. Columns (A2) to (A4) include additional controls. Column (A2) includes the initial share of a sector in a country's manufacturing value added; column (A3) adds the average growth rate of the industry in each country; column (A4) introduces the interaction between a measure of an industry's intrinsic volatility and a country's aggregate volatility. The first two controls are included because a sector that is initially large or is growing fast may be relatively less volatile.[28] The interaction between an industry's volatility and a country's aggregate volatility is included to control for the possibility that some industries may be more volatile than the average in every country.[29,30] Columns (A5) to (A8) report the 2SLS parameters of the same regressions reported in columns (A1) to (A4). Finally, the specification in column (A9) is identical to column (A5), but in this case an alternative measure of liquidity needs is used as an instrument for the base measure.

The negative coefficient of the initial share of a sector in total manufacturing output shows that, as expected, larger or more mature sectors are relatively less volatile (see columns (A2) and (A6)). Columns (A3) and (A7) show that the rate of growth of an industry is not significantly related to its relative volatility. Finally, the evidence suggests that relatively volatile industries are not relatively more volatile in unstable countries (columns (A4) and (A8)).[31] Overall, it is clear that the inclusion of these additional variables in the specification (corresponding to the X_{ij} variables in equation (2)) does not affect the sign, magnitude, or significance of the coefficient of the interaction of financial development and liquidity needs.[32]

A comparison of the first and second half of the table shows that the 2SLS coefficient of the interaction between liquidity needs and financial development is always

[28] For the relation between growth and volatility see Ramey and Ramey (1995).

[29] This is especially relevant because of the relation between the measure of liquidity needs and the durability of the goods. As it has been documented, durable goods industries tend to be relatively more volatile than non-durable goods industries.

[30] Under the assumption of technological similarities across countries (see Section 4), the intrinsic volatility of an industry was measured by the standard deviation of real value added growth of that industry in the U.S.. The aggregate volatility of a country was measured as the volatility of the aggregate manufacturing sector.

[31] This result also holds if the β of each industry in the U.S. (covariance of that industry with aggregate manufacturing volatility) is interacted with each country's volatility instead of using the interaction of each industry's volatility in the US with each country's aggregate volatility.

[32] As the results are based on a subset of country-industries from UNIDO and that there are missing years within this subset, there is a legitimate concern about the presence of sample selection bias on the coefficients. The effect of this bias on the coefficients is analyzed in appendix E. The results indicate that the explicit consideration of sample selection bias either does not significantly affect the coefficients or biased them toward zero.

significantly larger in absolute value than the OLS coefficient (about twice as large). This finding is consistent with the presence of measurement error in the financial development variable. Moreover, within the 2SLS regressions, the magnitude of the coefficient in column (A9) is also larger than the coefficient in column (A5), which is consistent with the presence of measurement error in the liquidity needs variable. In light of this evidence, the 2SLS coefficients should be consider as closer to the true value of the parameter than the OLS coefficients.

The economic significance of the coefficients can be determined by estimating the effect of a change in financial development in the difference in volatility between two industries with different liquidity needs. Consider for example the effect that an increase in financial development from the 25th to the 75th percentile level would have in the difference in volatility between the industries located at the 25th and 75th percentile levels of liquidity needs. Within the sample of countries and industries used, this corresponds to the effect that moving from the financial development of Egypt to the financial development of Spain would have in the difference in volatility between the Electric Industrial Machinery industry (ISIC 3831) and the Paper Boxes industry (ISIC 3412). Using the 2SLS coefficient reported in column (A5) as a compromise between the OLS coefficients and the coefficient of column (A9), this exercise suggests that the difference in standard deviation between these two industries would fall in 4.1 percentage points as a result of the increase in financial development.

The importance of this fall in volatility with respect to the normal differences in standard deviation across industries can be determined by comparing its magnitude with the interquartile range of volatility (henceforth IQRV). The IQRV is calculated computing the average standard deviation of each industry across countries, ranking the industries according to this average from more volatile to less volatile, and then measuring the difference in this average between the industry ranked at the 75th and 25th percentile levels. Within the sample, the IQRV is 7 percentage points. Hence, the 4.1 percentage point drop in standard deviation between Electric Machinery and Paper Boxes corresponds to 59% of the IQRV.

The section “Differential in volatility”,at the bottom of both panels of Table 3 and all the tables presented thereafter, reports the results of this exercise, both in percentage points and as a fraction of the corresponding IQRV, for all the columns of the table. Overall, these magnitudes indicate that the differences in relative volatility induced by differences in financial development are economically significant.

6.2 Depth of the crises

Panel B of Table 3 shows the results obtained for the same regressions reported in Panel A when the depth of the crises–the minimum growth rate achieved during the period–is used as dependent variable. The results are qualitatively similar to those reported in Table 3. As expected in this case, the coefficient of the interaction between financial development and liquidity needs is positive, which means that an increase

Table 3: Financial development and sectorial volatility

In Panel A, the dependent variable is the standard deviation of the rate of growth of real value added for each 4 digit ISIC industry in each country. In Panel B, the dependent variable is the minimum rate of growth of real value added observed in the period 1981-1997 for each 4 digit ISIC industry in each country. Regressions included a country and industry specific effect. Liquidity needs is the ratio of total inventories over annual sales for U.S. corporate firms in the same industry between 1980 and 1989. The section "Differential in volatility" reports how much volatile is an industry at the 75th percentile level of liquidity needs with respect to an industry at the 25th percentile level when it located in a country at the 75th percentile of financial development rather than in one at the 25th percentile, both in percentage points, and as a fraction of the interquartile range of volatility. In both panels, columns (1) to (4) reports OLS regressions, while columns (5) to (8) report the 2SLS results obtained when the measure of financial development is instrumented using a country's legal origin. Column (9) reports the 2SLS results obtained when the measure of liquidity needs is instrumented using the ratio of labor costs over shipments and financial development is instrumented using a country's legal origin

PANEL A: OVERALL VOLATILITY: Dep. var. is the std. dev. of real VA growth

	OLS				2SLS				
Variables	(A1)	(A2)	(A3)	(A4)	(A5)	(A6)	(A7)	(A8)	(A9)
Interaction:	-0.57*	-0.44*	-0.58*	-0.56*	-1.21*	-1.14*	-1.21*	-1.20*	-1.79*
Liq. needs X pvt. credit	(0.13)	(0.12)	(0.13)	(0.13)	(0.23)	(0.22)	(0.23)	(0.23)	(0.55)
Initial share on		-0.79*				-0.77*			
manuf. VA		(0.13)				(0.13)			
Avg. growth rate			-0.05				-0.06		
			(0.05)				(0.05)		
Interaction:				0.56				0.14	
Indus. vol. X Coun. vol.				(1.27)				(1.31)	
Differential in volatility									
Percentage points	2.0	1.5	2.0	1.9	4.1	3.8	4.2	4.1	6.1
Fraction of IQR	28	21	28	28	59	55	59	59	88

PANEL B: DEPTH OF THE CRISES: Dependent variable is worst output drop

	OLS				2SLS				
Variables	(B1)	(B2)	(B3)	(B4)	(B5)	(B6)	(B7)	(B8)	(B9)
Interaction (Liq. needs	0.69*	0.65*	0.90*	0.66*	1.77*	1.81*	1.91*	1.73*	2.82*
X private credit)	(0.25)	(0.25)	(0.25)	(0.25)	(0.47)	(0.46)	(0.46)	(0.47)	(1.09)
Initial share on		0.98*				0.95*			
manufact. VA		(0.23)				(0.23)			
Avg growth rate			1.06*				1.07*		
			(0.08)				(0.08)		
Industry volatility X				-0.49				-0.38	
Country volatility				(0.38)				(0.38)	
Differential in volatility									
Percentage points	2.4	2.2	3.1	2.3	6.1	6.2	6.5	5.9	9.7
Fraction of IQR	19	18	25	18	49	50	53	48	78
Obs.	2301	2078	2301	2301	2301	2078	2301	2301	2273

Note:*=Significant at 5% confidence. Robust standard errors in parenthesis.

in financial development increases the relative minimum growth rate of sectors with large liquidity needs. Shortly, financial development reduces the relative depth of the crises in these sectors.

As in the case of overall volatility, Panel B shows that the coefficient of the interaction between financial development and volatility is not significantly affected by the inclusion of additional controls. It also shows that the magnitude of the 2SLS coefficients is larger than the magnitude of the OLS coefficients, and that instrumenting for the measure of liquidity needs increases the magnitude of the coefficients even further.

In terms of economic significance, according to column (B5), the difference in the minimum growth rate between the Electric Machinery and the Paper Boxes industries would be 6.1 percentage points larger in a country with the financial development of Egypt than in a country with the financial development of Spain. This corresponds to 49% of the interquartile range of minimum growth rates. In general, the magnitudes implied by the 2SLS coefficients reported in Panel B are economically significant.

6.3 Macroeconomic relevance

The results reported in Table 3 provide indirect evidence of the relation between financial development and volatility. They suggest that, to the extent that more developed financial markets do a better job reallocating liquidity towards distressed firms, financial development reduces both macroeconomic volatility and the depth of crises. Of course, there are other possible channels by which financial development can affect aggregate volatility, and the total effect is going to depend on the balance between those different forces. This section provides evidence that the channel analyzed in this paper can generate quantitatively important differences in aggregate volatility across countries.

A sense of the effect of financial development in aggregate volatility implied by the previous results can be obtained computing the change in aggregate volatility indicated by the coefficient γ when a country moves from the 25th to the 75th percentile level of financial development. This change can be determined as follows. By definition, the standard deviation of a country's aggregate manufacturing sector corresponds to

$$\sigma = \sqrt{\sum_i \sum_j w_i w_j \sigma_{i,j}}, \tag{3}$$

where w_i is the share of sector i on manufacturing value added, σ_i^2 is the variance of sector i, and σ_{ij} is the covariance between sector i, and sector j. From this expression, the effect of an increase in financial development (F) on aggregate manufacturing volatility corresponds to

$$\frac{d\sigma}{dF} = \frac{1}{2\sigma} \sum_i \sum_j w_i w_j \rho_{ij} \left(\frac{d\sigma_i}{dF} \sigma_j + \sigma_i \frac{d\sigma_j}{dF} \right), \tag{4}$$

where it has been assumed that a change in F does not affect the productive structure (the w_i's) or the correlations across sectors (ρ_{ij}). This expression cannot be directly evaluated using the regression coefficients obtained above (γ). An additional assumption about the effect of financial development on the *level* of volatility of the sector with lowest liquidity needs is needed to determine $\frac{d\sigma_i}{dF}$ for every other sector.[33] In fact, it can be easily showed that:

$$\frac{d\sigma_i}{dF} = \gamma(L_i - L_0) + \frac{d\sigma_0}{dF}, \tag{5}$$

where the sub-index 0 represents the sector with lowest liquidity needs, so the effect of financial development on aggregate volatility corresponds to

$$\frac{d\sigma}{dF} = \frac{\gamma}{2\sigma}\sum_i\sum_j w_i w_j \rho_{ij}\left(\,(L_i - L_0)\sigma_j + \sigma_i\,(L_j - L_0)\right) + \frac{\sigma_{0F}}{2\sigma}\sum_i\sum_j w_i w_j \rho_{ij}\left(\,\sigma_j + \sigma_i\right), \tag{6}$$

and it is clear that an assumption on the value of $\frac{d\sigma_0}{dF}$ is required. A plausible, and probably conservative, assumption is that financial development has no effect on the volatility of the sector with the lowest liquidity needs: $\sigma_{0F} = 0$. Under this assumption, and evaluating equation (6) at the average productive structure and sectoral variance-covariance, an increase in financial development from the 25th to the 75th percentile level would reduce the standard deviation of manufacturing value added in 2.2 percentage points. This decline in volatility corresponds to 58% of the average difference in aggregate volatility among countries around those levels of financial development (3.8 percentage points).[34]

Table 4 reports, for a sample of financially underdeveloped countries[35], the expected fall in volatility achieved by moving from their current position to the 75th percentile level of financial development. Columns (1) and (2) report the level of financial development in 1980 and the standard deviation of manufacturing value added growth. Column (3) shows the standard deviation of each country after increasing

[33] The reason why the coefficients obtained in the base regressions cannot be used to evaluate equation (4) is that, as stated in Section 3, the empirical specification identifies only the *cross derivative* of sectoral volatility with respect to liquidity needs and financial development (γ). According to the model, the coefficient γ is the solution to the following partial differential equation:

$$\frac{d}{dL_j}\left(\frac{d\sigma_j}{dF}\right) = \gamma.$$

The solution to $\frac{d\sigma_i}{dF}$ from this differential equation corresponds to equation (5).

[34] More conservative estimations can be obtained by using the 2SLS point estimator of γ minus one or two standard deviations or by using the OLS estimator of γ. These estimations generate falls in volatility corresponding to between 25% to 47% of the average difference in aggregate manufacturing volatility.

[35] The countries included are those that reported data for at least 60 of the 81 manufacturing sectors. All 81 manufacturing sectors were considered in the computation in order to make the computed aggregated standard deviations closer to the real ones.

its level of financial development to the 75th percentile according to equation (6). Column (4) reports the drop in volatility that would be achieved for each country, as a fraction of the initial volatility. It is evident that, in every case, the reductions in volatility would be economically significant.[36] For example, if Egypt increased its financial development up to the 75th percentile, it would reduce the standard deviation of its annual manufacturing value added growth from 6.8 to 5.8 percentage points: a 14% fall in volatility.

The results presented in Table 4 assume that the productive structure of a country is not affected by a change in financial development. This assumption can be easily challenged because countries with underdeveloped financial markets may be expected to move away from industries that require lots of liquid funds to operate. If this is the case, the previous results would be overestimating the effect of financial development in aggregate volatility. In other words, there may exist an endogenous insulation mechanism by which financially underdeveloped countries protect themselves from fluctuations by adjusting their productive structure. Regressions reported in Table 5 provide partial support to this idea but also suggest that the effect on aggregate volatility is second order.

Results reported in Panel A of Table 5 suggest that less financially developed countries may concentrate less value added in sectors with high liquidity needs, but the evidence is inconclusive. This panel presents two cross-country regressions of the importance of high liquidity needs sectors in a country versus its level of financial development. The coefficient in column (A1) implies that the share of industries in the top quartile of liquidity needs is 15% larger in a country around the 75th percentile of financial development than in a country around the 25th percentile of financial development. This is a large difference compared with the average share of high vulnerability sectors across countries (18%). However, the coefficient in column (A2), which uses as dependent variable a country's share weighted value of its liquidity needs, is not statistically significant.

Besides providing inconclusive evidence of the effect of financial development in productive structure, the results of Panel A may be affected by the usual omitted variable bias of cross-country regressions. In order to gather additional evidence and address the concern about omitted variable bias, a more structural approach is taken in the regressions reported in panel B. This panel presents the OLS and 2SLS coefficients obtained from the estimation of the following equation:

$$S_{i,k} = \eta_k + \chi_i + \upsilon L_i x F_k + \varepsilon_{i,k},$$

[36] It might be argued that the change in financial development considered in the exercise is too large. However, increases in financial depth corresponding to 50% of GDP over the course of a decade have been observed in some successful financial liberalization episodes, like in Australia and New Zealand. A more conservative exercise could consider an expansion in financial depth of 20% of GDP, which corresponds approximately to the average increase in financial depth achieved in liberalization experiences. In this case the fall in volatilities would be around 10% for every country, which is still a considerable magnitude.

Table 4: Aggregate effect of financial development on developing countries

Countries included are developing countries that reported data for at least 60 of the 81 4 digit ISIC industries. Column (1) reports the value of private credit as a fraction of GDP in 1980 (the main measure of financial development). Column (2)presents the standard deviation of manufacturing value added growth computed using each countries average productive structure and sectoral variance-covariance. Column (3) shows the standard deviation of manufacturing value added growth that would be observed if each of these countries moved to the 75th percentile level of financial development. The fall in volatility as a fraction of the initial level is reported in column (4). The estimated change in volatility was computed using equation (5), and the coefficient for the interaction between financial development and liquidity needs (γ) reported in column (5) of Table (4).

Country	Financial Development (% GDP) (1)	Current Std. Dev. (pct. points) (2)	Std. Dev. after moving to 75th ptile (pct. points) (3)	Change in Std. Dev. (% of current Std. Dev.) (4)
Bangladesh	8	4.5	3.2	27
Chile	42	3.5	3.0	14
Colombia	29	6.1	4.8	22
Costa Rica	22	9.1	7.4	18
Ecuador	18	11.8	10.7	10
Egypt	21	6.8	5.8	14
Honduras	28	4.6	3.4	27
India	26	6.4	4.7	27
Indonesia	9	13.1	9.1	31
Korea	54	6.6	5.2	22
Malaysia	54	5.3	4.2	21
Peru	12	13.2	10.8	18
Philippines	41	13.2	11.5	13
Sri Lanka	16	10.2	6.5	37
Turkey	14	9.3	6.7	29
Uruguay	34	12.6	11.3	10
Venezuela	54	11.3	10.8	4

where $S_{i,k}$ is the average share of sector i in country k. Both the OLS and the 2SLS estimators of υ, reported in columns (B1)and (B2) respectively, have the right sign.[37] The 2SLS coefficient is significant at conventional levels, while the OLS is only significant at the 10% level. Considering the 2SLS coefficient, the results imply that the difference in shares between the sectors at the 75th and 25th percentile levels of liquidity needs would increases by 0.3 percentage points if the country in which they operate moved from the 25th to the 75th percentile level of financial development. This increase represents only 18% of the interquartile range of average shares. So, even though the results support the presence of an insulation mechanism, the implied magnitude is small both in absolute and relative terms.

In addition to the results presented in Table 5, it is possible to assess the potential effect of the insulation mechanism by performing two counterfactual experiments. In these experiments the following two counterfactual variances are computed for every country with data on most of the 4 digit industries:[38] (1) the aggregate variance that would be observed if the country had the average productive structure ($\hat{\sigma}_k^2$); (2) the aggregate variance that would be observed if the country had the average variance-covariance structure ($\tilde{\sigma}_k^2$). These counterfactual variances are then compared to the observed variance σ_k^2.[39,40] This decomposition shows that most of the variation in volatility across countries can be explained by their differences in *sectoral variance-covariances*. In fact, the volatility under fixed productive structure ($\hat{\sigma}_k^2$) explains 83% of the variation of actual volatility (σ_k^2) in a cross-country regression. In a similar exercise, the variation of $\tilde{\sigma}_k^2$ explains only 1% of the variation in σ_k^2.

In summary, differences in productive structure across countries do not seem to be responsible for a significant part of the observed differences in volatility; so it is unlikely that the insulation effect could significantly reduce the effect of financial development on aggregate volatility.

6.4 Increase in volatility: intensive versus extensive margin.

Table 3 presented evidence that underdeveloped financial markets increased the relative volatility of sectors with large liquidity needs. This section explores whether the effect of financial underdevelopment on sectorial volatility operates mainly through the intensive or the extensive margin. The results are reported in Table 6.

[37] As the sum of the shares is necessarily equal to 1, the estimation procedure allowed for correlation of the errors within a country.

[38] These are 26 of the 41 countries used in Table 3.

[39] The details of this computation are presented in the appendix C.

[40] Because of the limited amount of observations available for each country-industry, the estimated sectoral covariances will not be independent . In other words, the estimated variance covariance matrix of each country is short rank. This consideration may be important because the degrees of freedom of the data may be considerably smaller than the number of observations. Nevertheless, this consideration is second order for the present calculations because the regressions considered at most 2 explanatory variables.

Table 5: Financial Development and Productive Structure

In Panel A, the dependent variable is the share of total manufacturing value added in sectors at the top quartile of inventory over sales in column (A1), while in column (A2) the dependent variable is the share-weighed value of liquidity needs. In Panel B, the dependent variable is the share of total manufacturing value added of each sector in every country. Regressions in Panel A include a non-reported constant. Regressions in Panel B include a country and industry specific effect (non-reported). Regressions in Panel A are 2SLS where the measure of financial development (private credit) has been instrumented by a country's legal origin. Panel B reports both the OLS (B1) and 2SLS results (B2). The instruments in 2SLS are the same as in Panel A. Standard errors are robust to heteroskedasticity in both Panels, while Panel B also allows for correlations in the errors within countries.

Panel A: Cross-country regressions

	Dependent Variable	
Variables	Share of most vulnerable (A1)	Share weighed liquidity needs (A2)
Private Credit	0.289*	0.029
	(0.087)	(0.020)
Obs	58	52

Panel B: Productive structure regressions

Dependent variable is the share of each industry in every country

	OLS (B1)	IV (B2)
Interaction (Liquidity needs X Private credit)	0.060	0.134*
	(0.032)	(0.051)
Obs	4035	4035

Note:*=Significant at 5% confidence. Robust standard errors in parenthesis.

Panel A decomposes the variance of value added growth into (i) the variance of value added per firm growth, and (ii) the variance of the growth of the number of firms. The covariance term is disregarded. Column (A1) is analogous to column (A1) of Table 3 except that the dependent variable is the variance of value added growth instead of the standard deviation. Columns (A2) and (A3) show that an increase in financial development reduces both the relative volatility of output per firm (intensive margin) and the volatility of the number of firms (extensive margin) in industries with higher liquidity needs. However, the effect on the intensive margin is considerably larger than the effect on the extensive margin. So, the evidence suggests that most of the effect of financial development on sectorial volatility comes from the reduction of fluctuations in the output of existing firms rather than the smoothing of fluctuations in the number of firms.

In Panel B, the minimum growth rate observed for an industry in a country is decomposed into (i) the growth rate of value added per firm and (ii) the growth rate of the number of firms. This decomposition shows to what extent the lowest observed growth rate is caused by a fall in the growth rate of output per firm or by a fall in the growth rate of the number of firms. The conclusions are consistent with those of panel A. The effect of financial underdevelopment on the depth of crises is mainly due to the fall in the growth of value added per firm. In fact, the coefficient obtained when the growth rate of the number of firms is used as dependent variable (column (B2)) is not statistically significant.

6.5 Financial structure and information

So far, only the development of financial intermediaries (as captured by its size relative to GDP) has been considered relevant for the relative volatility of sectors with different levels of liquidity needs. Even though this is a natural choice given the importance of intermediaries as liquidity providers, there are other aspects of financial development that may also be relevant. Some natural questions that arise in this context are the following: Is the ability of firms to raise liquidity during periods of distress affected by the quality of the information they normally provide to outside investors? Does the development of stock markets affect a firms' ability to raise liquidity independently of the development of its intermediaries? This section attempts to provide some indirect answers to these questions by exploring the effect of these different aspects of financial development on the relative volatility of industries with high liquidity needs. The results, which are reported in Table 7, are discussed below.

Columns (2) and (3) show the results obtained when the quality of accounting standards and stock market capitalization are used as measures of financial development. Column (1) reproduces the base regression presented in column (A5) of Table 3 for comparison. The results obtained for accounting standards (column (2)) are qualitatively similar to those previously reported for private credit. This can be observed by looking at the "Differential in volatility" section of the table, which shows that,

Table 6: Intensive versus extensive margin

All regressions included a country and industry specific effect. The results reported correspond to those obtained when private credit is instrumented using a country's legal origin and degree of rule of law. Panel A reports the (partial) decomposition of the variance of the effect of financial development on the variance of real value added growth. The dependent variable is the variance of real value added growth in column (A1), the variance of the growth in the number of firms in column (A2), and the variance in the growth of real value added per firm in column (A3). Analogously, Panel B decomposes the effect of financial development on the depth of crises. Column (B1) uses the minimum growth rate as dependent variable (see Panel B Table 3, column (B5)), column (B2) uses the growth rate in the number of firms observed in the year of minimum growth rate, and column (B3) uses the growth rate in the growth of real value added per firm in the year of the minimum growth rate. All the coefficients were estimated by 2SLS, using a country's legal origin to instrument for its level of financial development.

Panel A: Overall volatility

Variables Dependent Variable	Variance output growth (A1)	Variance firms growth (A2)	Variance output/firm growth (A3)
Interaction (Liquidity needs X private credit)	-0.990* 0.175)	-0.392* (0.094)	-1.187* (0.223)
Obs.	2301	2136	2132

Panel B: Depth of the crises

Variables Dependent Variable	Minim. output growth (B1)	Firm growth at minim. (B2)	output/firm growth at minim. (B3)
Interaction (Liquidity needs X private credit)	1.769* (0.467)	0.357 (0.423)	1.001 (0.528)
Obs.	2301	1972	1972

Note:*=Significant at 5% confidence. Robust standard errors in parenthesis.

when using accounting standards, the differential in volatility is 2.7 percentage points (39% of interquartile range). In contrast, the coefficient obtained using stock market capitalization (column (3)) is statistically but not economically significant.[41] These results show that, without controlling for the development of financial intermediaries, the relative volatility of sectors with high liquidity needs is affected by the quality of accounting information but not for the development of stock markets. This suggests that the ability of firm's to raise liquidity during periods of distress is affected by the quality of information they generate, but it is not significantly affected by the development of equity markets.

Columns (4) and (5) repeat the exercises performed in columns (2) and (3) controlling for the development of financial intermediaries. Both the coefficients of the interaction with accounting standards and the development of financial intermediaries are not very different from those obtained in columns (1) and (2). So, these different aspects of financial development seem to have a largely independent effect on sectoral volatility. The results in column (5) confirm that financial intermediaries play a much more important role for sectoral volatility than equity markets, which is consistent with a more important role of financial intermediaries than equity markets in the provision of liquidity during periods of distress.[42]

7 Robustness

The previous section presented evidence in favor of the hypothesis that financial development reduces the relative volatility of sectors with high liquidity needs. This section analyzes the robustness of this evidence. The section is divided into two parts. The first part explores whether the measure of liquidity needs is capturing the effect of other industry characteristics. The second part attempts to disentangle the effects of financial development and the overall institutional environment on volatility. Overall, the results show that the main parameters (presented in the 2SLS part of Table 3) change remarkably little with the inclusion of additional variables.

7.1 Is it liquidity needs? Considering additional industry characteristics.

This section explores the effect that controlling by additional industry characteristics has on the coefficient of the interaction between financial development and liquidity needs. Intuitively, considering other characteristics may affect this coefficient either

[41] The coefficient is larger if Singapore, an outlier in stock market capitalization at the beginning of the 80's (about twice its GDP), is included in the sample, but it is still economically small: 0.8 percentage points, and 14% of the IQRV.

[42] The results are similar if value traded as a fraction of GDP –a measure of the activity of stock markets– is used instead of stock market capitalization.

Table 7: Structure and information

The dependent variable is the standard deviation of the rate of growth of real value added for each 4 digit ISIC industry in each country. Regressions included a country and industry specific effect. Liquidity needs is the ratio of total inventories over annual sales for U.S. corporate firms in the same industry between 1980 and 1989. The row "Differential in volatility" measures how much volatile (as a fraction of the interquartile range of volatility) is an industry at the 75th percentile level of liquidity needs with respect to an industry at the 25th percentile level when it located in a country at the 75th percentile of financial development rather than in one at the 25th percentile. All columns report the results obtained when the measures of financial development are instrumented using a country's legal origin.

Variables	(1)	(2)	(3)	(4)	(5)
Interact. (Liquidity needs	-1.206*			-0.964*	-1.360*
X private credit)	(0.227)			(0.301)	(0.244)
Interact. (Liquidity needs		-1.845*		-1.058*	
X accounting standards)		(0.383)		(0.427)	
Interact. (Liquidity needs			-0.446*		-0.396
X Stock Mkt. cap.)			(0.220)		(0.280)
Differential in volatility					
Private credit					
Percentage points	4.1			3.3	4.7
Fraction of IQR	59			47	67
Accounting standards					
Percentage points		2.7		1.6	
Fraction of IQR		39		22	
Stock Mo. capitalization					
Percentage points			0.5		0.4
Fraction of IQR			8		6
Obs.	2301	1670	1965	1844	2137

Note:*=Significant at 5% confidence. Robust standard errors in parenthesis.

because these characteristics are better measures of a sector's liquidity needs or because the mechanism by which financial development affects volatility is different from liquidity provision. In particular, this section explores the effect on the main coefficient (γ) of controlling by the interaction between financial development and the following industry characteristics: type of good (durable-non-durable), long run financial dependence, physical capital intensity, human capital intensity, and intrinsic volatility. The results of these regressions, which are reported in Table 8, are discussed in detail below.

An industry's measure of liquidity needs is positively correlated with the type of good it produces (durable, non-durable) (see Section 4). This correlation opens the possibility that the results reported in Section 6 may just indicate that financial development reduces the relative volatility of durable good industries. The results obtained when the interaction between financial development and a dummy for durable goods industries is added to the base specification are reported in column (2) of Table 8.[43] The coefficient of the interaction of financial development and the durable good dummy is negative and significant: durable industries are relatively more vulnerable to financial underdevelopment than non-durable industries after controlling for their average differences in liquidity needs. Nevertheless, the coefficient of the interaction between liquidity needs and financial development is not significantly affected. These findings confirm the previous results of the paper, but they also suggest that there are other industry characteristics, which vary across types of goods industries, that affect the vulnerability to financial underdevelopment. The characteristics discussed next are probably part of the explanation.

A sector's liquidity needs are not necessarily the only dimension of its dependence on financial markets. An obvious additional dimension is an industry's "external dependence" as estimated by Rajan and Zingales (1998), which captures the degree to which an industry requires external funds to finance its investment in fixed assets. Column (3) of Table 8 reports the results obtained when the interaction of external dependence and financial development is also included in the specification. The results are similar to those obtained in column (2): the coefficient of the external dependence interaction has the right sign and is statistically significant, but the coefficient of the liquidity needs interaction is not affected. This suggests that, in addition to a sector's short run need for working capital, its long run financial dependence also affects its relative volatility.[44]

More capital intensive industries may also be more vulnerable to financial underdevelopment. An industry that requires a large investment in fixed assets may need a lot of working capital for maintenance. Moreover, if the initial investment (e.g. the building of a large plant) was financed with debt, a firm in a capital intensive sector will be very vulnerable to shocks during its earlier periods of operation. The

[43]Column (1) reproduces the base regression (column (A5) in Table 3) for comparison.

[44]The effect through external dependence is, however, not robust to the inclusion of additional controls.

results obtained controlling for this mechanism, reported in column (4), show both that more capital intensive industries do not appear to be relatively more vulnerable to financial underdevelopment[45] and that the consideration of this channel does not affect the coefficient of the interaction between financial development and liquidity needs.

Differences in human capital or in the use of technology across sectors may also be related to the effect of financial development in sectorial volatility. Sectors that are more human capital intensive may have large liquidity needs because they have expensive payrolls.[46] Similarly, to the extent that technologically intensive products are complex and use expensive inputs, the use of technology will be correlated with a sector's liquidity needs. In addition, these characteristics may also affect a sector's vulnerability to financial underdevelopment independently of their relation to liquidity needs: as moral hazard and hold-up problems are probably more important in sectors that are more human capital intensive, these sectors are more likely to be financially constrained.[47] Results from including the interaction between financial development and human capital intensity and technology use are reported in columns (5) and (6) respectively.[48] Even though the coefficients of the human capital and technology interactions have the right sign and are significant at conventional levels, the coefficient of the liquidity needs interaction is largely unaffected.

Another potential cause of concern is the relation between an industry's volatility and its level of inventories. One reason why firms keep inventories is to smooth fluctuations in demand (see for example Blinder and Maccini (1990) or Ramey (1989)). So, high volatility industries are likely to have larger inventories and to depend more on financial markets to smooth demand fluctuations. In other words, the main determinant of an industry's dependence on financial markets may be the variance of its liquidity needs instead of their average. The results obtained when the interaction between a measure of an industry's intrinsic volatility and financial development is added to the main specification are reported in column (7).[49] The coefficient on the interaction of financial development and industry volatility suggests that high volatility industries increase their relatively volatility in underdeveloped financial markets, but the consideration of this effect does not affect the coefficient of the liquidity needs

[45] An industry's level of capital intensity was computed as the ratio of capital per worker for the same industry in the U.S., following the same assumptions used to compute an industry's level of liquidity needs. As in the case of the liquidity needs measure, even though the relative supply of capital and labor is surely going to affect the ratio of capital per worker for different countries, all that is needed is that the relative ranking across industries is preserved.

[46] See the argument in Section 4.

[47] The same argument would apply to the use of technology, to the extent that it is correlated with human capital intensity (see Autor et al. (1998)).

[48] The human capital intensity measure was built using data on the school composition of the labor force from Autor et al. (1998). Technology use at the sectoral level was also obtained from Autor et al. (1998).

[49] An industry's intrinsic level of volatility was estimated using the volatility of the same industry in the U.S.

interaction.

Overall, the results reported in this section suggest that there are aspects of an industry's dependence on financial markets that are not completely captured in the measure of liquidity needs. Nevertheless, the coefficient of the liquidity needs interaction is robust to the consideration of these alternative channels.

7.2 Financial development or institutions?

This section explores the possibility that the measure of financial development captures the effect of either the general level of economic development or institutional quality. The reasons to consider this possibility are that (i) a country's financial development is correlated with the quality of its institutions (see La Porta et al. (1998)), (ii) the measure of a country's liquidity needs may be related to its "institutional dependence",[50] and (iii) countries with weak institutions are more likely to experience political crises in which the whole institutional framework is altered. By explicitly considering this channel, the regressions presented in this section attempt to disentangle the effects of financial and institutional development.

Results from this analysis are presented in Table 9. Column (1) reproduces the base regression to facilitate comparison. In column (2), the interaction of initial GDP per capita, which is a proxy for institutional development, and the measure of liquidity needs was added to the main specification. The results show that financial development bears the main responsibility for the differences in sectorial volatility, not economic development.

The specifications reported in columns (3) to (5) add to the base specification the interaction of a different measure of institutional development, the extent of *constraints on the executive* from the Polity IV dataset,[51,52] with industry characteristics that proxy for a sector's institutional dependence. Column (3) employs a measure of a sector's technology use as a proxy for its dependence on institutions, while columns (4)and (5) use measures of a sector's human and physical capital intensity respectively.[53] In contrast to the specification reported in column (2), the regressions of columns (3) to (5) explicitly consider the possibility of endogeneity and measurement error in the institutional dependence proxy. Following Acemoglu et al. (2001), a coun-

[50] For example, Section 4 discussed the relation between an industry's liquidity needs, the length of its production process, and product complexity. It is also very likely that industries that produce more complex product will have to deal with more suppliers and the quality of the inputs and outputs will be less observable. Therefore, it is probable that a sector's level of liquidity needs is going to be correlated with its dependence on the quality of the overall institutional environment, for example on the legal and contracting system.

[51] The average of the measure in the years 1960, 1970, and 1980 was used, instead of the value in 1980, to reduce the noise induced by considering a single year.

[52] This variable has been used by Acemoglu et al. (2002) in a similar manner.

[53] The measures of technology use, human capital dependence and physical capital intensity were described in Section 7.1.

Table 8: Is it liquidity needs?

The dependent variable is the standard deviation of the rate of growth of real value added for each 4 digit ISIC industry in each country. All regressions included a country and industry specific effect. Liquidity needs is the ratio of total inventories over annual sales for U.S. corporate firms in the same industry between 1980 and 1989. External dependence is the fraction of capital expenditures not financed with internal funds for US firms in the same industry between 1980 and 1989 and was build using the methodology of Rajan and Zingales (1998). Capital per worker is the average ratio of capital to total number of employees for each sector in the US between 1980 and 1997. Human capital is the measure of the share in total wage bill of workers with some college and college graduated in each industry in the U.S., obtained from Autor et. al. (1999). High technology is a measure of the use of computer technology in each industry in the U.S., also from Autor et. al.(1999). Industry volatility is the standard deviation of real value added growth in each industry in the US during the period 1981-1997. All regressions used private credit (as a fraction of GDP) as a measure of financial development. All coefficients were estimated by 2SLS using a country's legal origin as instrument of its level of financial development. Column (1) reproduces the coefficient obtained in the base case (column (5), Table 3) for comparison.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Interaction	-1.206*	-0.822*	-1.040*	-1.135*	-1.221*	-1.115*	-1.040*
Liq. Need x Pvt. Cred.	(0.227)	(0.222)	(0.219)	(0.248)	(0.229)	(0.214)	(0.222)
Interaction		-0.078*					
Durable x Pvt Cred.		(0.024)					
Interaction			-0.068*				
Ext. dep.x Pvt. Cred.			(0.026)				
Interaction				0.006			
K/L x Pvt. Cred.				(0.098)			
Interaction					-0.438*		
Human Cap.x Pvt. Cred.					(0.123)		
Interaction						-0.254*	
Tech. use x Pvt Cred.						(0.111)	
Interaction							-0.588
Indus. vol.x Pvt. Cred.							(0.308)
Differential in volatility							
Percentage points	4.1	2.8	3.6	3.9	4.2	3.8	3.6
Fraction of IQR	59	40	51	56	60	55	51
Obs.	2301	2301	2301	2301	2273	2273	2301

Note:*=Significant at 5% confidence. Robust standard errors in parenthesis.

try's degree of *constraints on the executive* is instrumented by a measure of settler's mortality.[54,55]

The reason to employ a sector's technology use as a proxy for its institutional dependence is that high-tech sectors tend to produce more complex goods which require engagement in contracts with a larger number of input suppliers (Clague (1991b,a); Cowan and Neut (2002)).[56] The comparison of the results reported in column (3) with those presented in column (1) show that the inclusion of this additional interaction increases the magnitude of the coefficient of the interaction of financial development and liquidity needs, but also increases its standard error. So, the coefficient of column (3) is statistically similar to the one in column (1). The coefficient of the interaction of computer use and institutions has the wrong sign but is not statistically significant.[57]

A sector's human capital intensity may proxy for its institutional dependence for reasons similar to those given for its technology use: industries producing more complex products require a larger number of tasks and will tend to use more skilled labor (Kremer (1993)). Under these circumstances, more human capital intensive industries will be more institutionally dependent because of their need to engage more intensively in contracts with input suppliers and also because they depend more heavily on a non-appropriable source of capital.[58] Results from considering this channel are presented in column (4). As in the previous case the main coefficient increases with the inclusion of this additional interaction, but it is not statistically different from the original one. The coefficient on the additional interaction is not statistically significant.

Finally, column (5) in Table 9 presents the results obtained when physical capital intensity is used as a proxy for institutional dependence.[59] The conclusions from this exercise are completely analogous to those obtained in columns (3) and (4).

In summary, despite the difficulties associated with disentangling the effects of a particular institution from the effect of the overall institutional environment, the results of the regressions reported in this section support the hypothesis that the coefficients reported in Table 3 are indeed capturing a mechanism that is associated with the development of financial institutions.[60]

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[54]This procedure reduces the sample to only those countries that were former colonies.

[55]See Acemoglu et al. (2002) for a detailed discussion of the reasons to use this instruments.

[56]Durable goods sectors tend to use more technology, so there is indeed a potential correlation between the measure of a sector's liquidity needs and its institutional dependence.

[57]Similar results are obtained when the measures of technology-use across industries used by Berndt and Morrison (1995) and Morrison (1997) are used instead of the Autor et al. (1998) measure.

[58]The last part of the argument, the dependence in a non-appropriable source of capital, was also used as an argument of why more human capital intensive industries may be more financial dependent. It is clear that the rationale not only applies to financial contracts but also to any other type of contract relation between the entrepreneur (or shareholders) and the owner of the human capital.

[59]For a discussion about the relation between physical capital intensity and institutional dependence see Cowan (2002).

[60]The lack of evidence for an independent institutional channel does not necessarily imply that

Table 9: Financial development or institutions.

The dependent variable is the standard deviation of the rate of growth of real value added for each 4 digit ISIC industry in each country. All regressions included a country and industry specific effect. Liquidity needs is the ratio of total inventories over annual sales for U.S. corporate firms in the same industry between 1980 and 1989. Capital per worker is the average ratio of capital to total number of employees for each sector in the US between 1980 and 1997. Human capital is the measure of the share in total wage bill of workers with some college and college graduated in each industry in the U.S., obtained from Autor et. al. (1999). High technology is a measure of the use of computer technology in each industry in the U.S., also from Autor et. al.(1999). Constraints on the executive is a measure of the level of discretion of the executive power, and was obtained from the Polity IV database. Initial GDP per capita is the log of GDP per capita in PPP adjusted dollars. All coefficients were estimated by 2SLS. A country's legal origin was used as instrument of its level of financial development. The level of constraints on the executive was instrumented using the degree of settler mortality for former colonies, therefore the sample used in columns (3) to (5) includes only countries that were colonized. Column (1) reproduces the coefficient obtained in the base case (column (5), Table 3) for comparison.

Variables	(1)	(2)	(3)	(4)	(5)
Interaction (liquidity needs	-1.206*	-0.728*	-2.562*	-2.382*	-2.825*
X private credit)	(0.227)	(0.332)	(0.898)	(0.868)	(1.127)
Interaction (liquidity needs		-0.021			
X initial GDP per capita)		(0.110)			
Interaction (technology use			0.115		
X constraints on executive)			(0.064)		
Interaction (human capital				0.005	
X constraints on executive)				(0.061)	
Interaction (capital intensity					-0.032
X constraints on executive)					(0.037)
Differential in volatility					
Percentage points	4.1	2.5	8.8	8.2	9.7
Fraction of IQR	59	36	127	118	140
Obs.	2301	2301	1316	1316	1332

Note:*=Significant at 5% confidence. Robust standard errors in parenthesis.

8 Conclusion

This paper investigates the effect of financial underdevelopment on sectoral volatility. The strategy employed takes advantage of the heterogeneous response of different industries to financial conditions to identify a causal relation between financial development and sectoral volatility. The evidence presented shows that sectors that typically require large amounts of liquid funds to operate are relatively more vulnerable to financial underdevelopment. In particular, these sectors are more volatile and suffer deeper crises in financially underdeveloped countries. These findings provide indirect support to the theory that the development of financial markets reduces macroeconomic volatility by increases the ability of intermediaries to provide liquidity during periods of distress.

At the macro level, the paper shows that the estimated effect of financial development in sectoral volatility is consistent with quantitatively important differences in aggregate volatility across countries.

An additional finding is that financially underdeveloped countries partially insulate themselves from volatility by concentrating less output on sectors with large liquidity needs. However, this insulation mechanism is unlikely to reverse the aggregate consequences of the sectoral effects of financial underdevelopment. This conclusion is confirmed by the finding that most of the cross country differences in aggregate manufacturing volatility are due to their differences in sectoral volatilities.

The paper also explores the mechanism by which financial development affects sectorial volatility. In this respect, this paper provides suggestive evidence that (i) the effect of financial development on volatility operates mainly through the intensive margin, (ii) the quality of information generated by firms and the development of financial intermediaries are aspects of financial development with largely independent effects on sectorial volatility, and (iii) the development of financial intermediaries is more important than the development of equity markets for the reduction of volatility.

The findings of this paper have implications for the aggregate relation between financial development and volatility that deserve further analysis. First, as the development of financial markets is more beneficial (in terms of reduced volatility) for some industries than for others, the productive structure of a country should be considered when assessing the short term aggregate benefits of financial reform. Analogously, the cost of financial underdevelopment will be higher for countries that, because of comparative advantages or industrial policy, concentrate their activity in sectors with high liquidity needs. Second, a country's comparative advantages may be an important determinant of its level of financial development. If these advantages are located in sectors that typically require the help of an efficient financial market, it is more likely that the consensus to generate the necessary reforms to the financial markets

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such a channel is absent, but it might only reflect that the variables used to capture a sector's institutional dependence, technology use, human capital intensity, and physical capital intensity, are not capturing this economic concept appropriately.

will be achieved. A further revision of these implications is part of future research.

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APPENDIX

A Building the measure of liquidity needs

The measure of liquidity needs was built as follows:

1. The median ratio of total inventories (Compustat #3) over total assets (Compustat #6) during the period 1980-1989 was computed for every manufacturing firm in Compustat. The manufacturing status of a firm in a given year was determined by matching data on a firm SIC classification from CRSP with the balance sheet data from Compustat.

2. The 4 digit ISIC industry to which a manufacturing Compustat firm belongs was determined by matching its SIC code with the correspondent 4 digit ISIC industry[A-1].

3. For each 4 digit ISIC industry, the median of the inventory over sales ratio across all the firms in that industry was computed and assigned to that specific industry.

B Criteria used to build the sample of countries-industries

A subset of the data was used in the analysis. The criteria used to include a country-industry in the sample were the following:

- The industry corresponds to one of the standard ISIC codes. Some countries report data with small differences in classification. In particular, several countries report data for combined sectors, that is, instead of reporting separately for 2 or 3 close sectors they report only data for the sum of them. These data were dropped from the sample.

[A-1]The relation between SIC and ISIC is not one to one. It is not unusual that a SIC sector can be assigned to more than 1 ISIC sector. The mapping between the 4 digit SIC classification, and the 4 digit ISIC classification was built by the author, based on the publications "*Correlation between the United States and international standard industrial classifications*" that tabulates a correspondence between SIC 77, and ISIC rev 2, and "*International standard industrial classification of all economic activities*" which describes the activities included in each 4 digit ISIC code. The relation is roughly that a 3 digit SIC sector corresponds to a 4 digit ISIC sector. Even though Compustat uses the 1987 version of SIC, the match based on the 1977 version is not significantly affected. The reason is that changes between the 1977 SIC and 1987 SIC are largely grouping sectors that are finally assigned to the same ISIC sector, and creation of new sectors, which were matched to the closer ISIC. Nevertheless, it is important to keep in mind that the matching is imperfect, and that classification errors are surely present.

- Observations for value added start no later than 1985. The reason is that the parameters will attempt to estimate the effect of the initial level of financial development (around 1981) on subsequent volatility. So, it is important that the series of value added used to build the measure of volatility starts close to the moment in which financial development is measured.

- There are at least 5 observations of real value added growth (the way in which real value added growth was built is explained in the main text). This requirement is a minimum standard to have a reasonable measure of growth volatility.

- The country has at least one of the main measures of financial development used in the analysis (described in Section 5) available around 1981.

C Computation of counterfactual variances

The formulas for σ_k^2, $\hat{\sigma}_k^2$, and $\tilde{\sigma}_k^2$, are the following:

$$\begin{aligned}
\sigma_k^2 &= \sum_i \sum_j \omega_{i,j,k} \sigma_{i,j,k}, \\
\hat{\sigma}_k^2 &= \sum_i \sum_j \bar{\omega}_{i,j}\, \sigma_{i,j,k}, \\
\tilde{\sigma}_k^2 &= \sum_i \sum_j \omega_{i,j,k}\, \bar{\sigma}_{i,j},
\end{aligned}$$

where the subindex k indexes a country, $\omega_{i,j,k} = w_{i,k} w_{j,k}$ is the product of the share of sectors i and j in country k, $\sigma_{i,j,k}$ is the variance of sector i in country k if $i = j$ and the covariance between sectors i and j in country k otherwise, $\bar{\omega}_{i,j}$ is the product of the average share of sectors i and j across countries, and $\bar{\sigma}_{i,j,}$ is the average covariance between sectors i and j (variance if $i = j$) observed across countries.

D Results with alternative measures of liquidity needs

The measure of liquidity needs used in the main regressions was the ratio of inventories over annual sales, as described in Section 4. However, as it was mentioned in the same section, there are alternative ways of measuring an industry's liquidity needs that are associated with the same economic concept, namely the relative importance of working capital. In particular, the level of inventories might be normalized by assets instead of sales; intermediate inventories could be used instead of total inventories; or measures like the cash conversion cycle –which also include the rotation of payables and receivables– could be used. Alternatively, measures of liquidity needs that are not based on the relative importance of inventories, such as the ratio of labor costs over shipments, could also be used. The correlations between these variables varies between 0.34 and 0.93, as reported at the bottom of Table 1. In addition, as was also discussed in Section 4, there are reasonable concerns about the effect that using a different time period to build the measure could have on the results because of the trend observed in the behavior of inventories over sales in the last decades.

Table 10 shows that the broad conclusions of the paper are largely unaffected by the use of a different measure of liquidity needs or by the time period used to build it. Columns (1) to (4) show the coefficients obtained when liquidity needs is measured as inventories over sales (the main measure), as inventories over assets, as the cash conversion cycle (CCC), and as the ratio of labor costs over shipments. All the coefficients are negative and statistically significant. Moreover, the "Differential in Volatility" section of the table shows that the magnitudes generated by the different coefficients are economically significant. Indeed, the magnitude associated with the measure of inventories over sales is not the largest one.

Columns (5) and (6) of Table 10 show the coefficients obtained for the interaction of inventories over sales and financial development when the measure of inventories over sales is built using data from the periods 1970-1979 and 1990-1999 respectively. In both cases, the coefficients have the right sign and generate differences in volatility of similar magnitude to those generated using the period 1980-1989. So, these results imply that the period chosen for the aggregation is not crucial for the base conclusions of the paper.

E Sample selection

The data used in the paper was collected from UNIDO database. The database includes 114 countries, but for a large number of countries there is information only for a small number of years and industries or there is no information on value added. Therefore, given the criteria described in appendix B, a large number of countries-industries was excluded from the final sample.

Even though the criteria described in appendix B are reasonable, they open the possibility of obtaining parameters affected by sample selection bias. In the context of this paper there are 2 different sources of sample selection that can affect the estimated parameters: the first operates in the time series dimension, and the second operates in the cross section dimension. This section discusses both sources of sample selection, and shows that the main conclusions of the paper are not likely to be affected by their consideration.[A-2]

[A-2] It is important to remark that the analysis of sample selection in panel data is a recent and active topic of research in econometrics. In this section, I do not attempt to provide general results about the estimation of parameters under sample selection in panels, but only to apply some techniques to the particular problem addressed in this paper. In particular, some of the techniques that I employ are not well suited to large panels.

Table 10: Comparing measures of liquidity needs

All regressions included a country and industry specific effect. The dependent variable is the standard deviation of real value added growth. The results reported correspond to those obtained when private credit is instrumented using a country's legal origin and degree of rule of law. Column (1), which reproduces the results of column (4) in Table 3, is included for comparison. Columns (2) to (7) report results obtained using alternative measures of liquidity needs.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Interaction (Tot. invent. sales X private credit)	-1.206*					
	(0.227)					
Interaction (Tot. invent. assets X private credit)		-0.689*				
		(0.168)				
Interaction (Cash Conver. Cycle X private credit)			-0.295*			
			(0.064)			
Interaction (Labor cost X private credit)				-2.224*		
				(0.822)		
Interaction (Invent. sales 70-79 X private credit)					-0.766*	
					(0.170)	
Interaction (Invent. sales 90-99 X private credit)						-0.795*
						(0.231)
Differential in volatility						
Percentage points	4.1	3.1	7.9	15.4	2.6	2.7
Fraction of IQR	59	44	113	220	38	39
Obs.	2301	2301	2301	2463	2232	2278

Note:*=Significant at 5% confidence. Robust standard errors in parenthesis.

The time series dimension of sample selection is associated with the possibility that the years with missing output data in a particular industry are those in which output has fallen significantly. In other words, it is possible that the data on growth rates used to estimate the variance are truncated from below. The second possibility is that the countries and industries observed are those with lower volatility. That is, it is possible that the missing countries are precisely the most volatile ones (in which case all the industries may be highly volatile) or that, within a country, the missing industries are the most volatile ones. These two different sources of sample selection are separately discussed in the next two sections.

E.1 Time series dimension

The presence of truncation in the growth rate data generates serious econometric problems. In particular, it induces a complicated type of endogeneity. The reason is that the sample variance of the growth rates underestimates the real population variance and the bias is a complicated nonlinear function of the variance itself. To fix ideas, assume that the growth rates are distributed normally with mean μ and variance σ^2. Assume also that the growth rate of industry i at time t (g_{it})is observed only if $g_{it} > z$, where z is a known cutoff value. Let $\tilde{\sigma}^2$ denote the sample variance of g_{it}. The following relation holds between $\tilde{\sigma}^2$ and σ^2:

$$\tilde{\sigma}^2 = Var(g_{it} \,|\, g_{it} > z) = \sigma^2 \left(1 - \frac{\phi\left(\frac{z-\mu}{\sigma}\right)}{1 - \Phi(\frac{z-\mu}{\sigma})} \left(\frac{\phi\left(\frac{z-\mu}{\sigma}\right)}{1 - \Phi(\frac{z-\mu}{\sigma})} - \frac{z-\mu}{\sigma}\right)\right),$$

where $\phi(\,)$, and $\Phi(\,)$ represent the pdf and cdf of the standard normal distribution. As it can be observed from the expression above, the variance of the truncated data is a nonlinear function of the true variance. Under the assumption that the true model is given by $\sigma_{ik} = \alpha_k + \beta_i + \gamma X_{ik} + \varepsilon_{ik}$, the measured standard deviation will be a nonlinear function of the parameters and, more problematically, of the errors. Under these conditions, the estimation of the parameters, or the determination of their bias is extremely difficult. Nevertheless, it is possible to get a sense of the direction of the bias by performing some Monte Carlo simulations as follows:

1. Generate values for α_k, β_i, X_{ik}, and ε_{ik} using a random numbers generator with the number of countries and industries set at the values of sample used in the paper.

2. Set a value for the parameter γ and build $\sigma_{ik} = \alpha_k + \beta_i + \gamma X_{ik} + \varepsilon_{ik}$.[A-3]

[A-3] As the standard deviation has to be a positive number, the values for α_k, β_i, X_{ik}, and ε_{ik} were drawn from a uniform (0,1) distribution instead of a normal, and a constant was added depending on the value of γ.

3. Generate values for $g_{i,k,t}$ as random draws from a normal distribution with mean zero and standard deviation σ_{ik}, with the number of observations (T) set as the maximum possible number of observations that could have been obtained for a country-industry (20 observations).

4. Compute the sample standard deviation of $g_{i,k,t}$ using all the observations: $s_{ik} = \sqrt{(1/T)\sum_{t=1}^{T}(g_{i,k,t} - \bar{g}_{i,k})^2}$

5. Compute the sample standard deviation of $g_{i,k,t}$ using only the observations above the 25th level percentile of the sample:

$$\tilde{s}_{ik} = \sqrt{(1/T_{ik})\sum_{t=1}^{T}(g_{i,k,t} - \tilde{g}_{i,k})^2 I(g_{i,k,t} \geq z)},$$

where T_{ik} is the number of observations above the truncation value z in industry i and country k, and $\tilde{g}_{i,k}$ is the average of the truncated sample.[A-4]

6. Run the following two regressions:

$$\begin{aligned} s_{ik} &= a_k + b_i + cX_{ik} + e_{ik} \\ \tilde{s}_{ik} &= \tilde{a}_k + \tilde{b}_i + \tilde{c}X_{ik} + \tilde{e}_{ik} \end{aligned}$$

7. Compare the estimators c and $\tilde{c}$

The simulations were performed 100 times each for values of γ between -2 and 2. Figure A-1 show the estimators obtained when using the whole sample (c) and only the truncated sample ($\tilde{c}$). The figure clearly shows that, in every case, the estimator obtained using the truncated sample ($\tilde{c}$) is biased towards zero with respect to the true value. In summary, the simulation results strongly suggest that the time series dimension of the sample selection problems biases the estimated coefficients towards zero.

E.2 Cross section dimension

The cross section dimension of the problem is associated with the probability of observing a particular individual (country-industry) in the panel. As mentioned above, it is possible that only those countries or industries that are relatively stable may be observed in the data. In other words, the sample may be truncated from above. Assuming that the underlying model corresponds to

$$s_{ik} = \alpha_k + \beta_i + \gamma X_{ik} + \varepsilon_{ik},$$

[A-4] Barr and Sherrill (1999) show that the sample moments of the observed data are better estimators of the true moments of the truncated sample than the analytical moments computed as functions of the ML estimators of the moments of the non-truncated data.

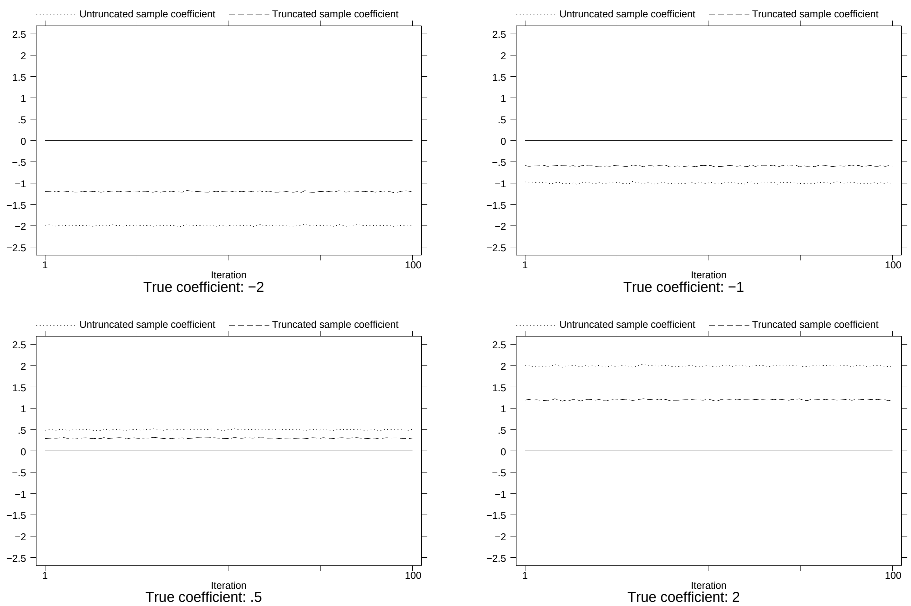

Figure A-1: Montecarlo simulations. Sample selection bias.

and that the errors are normally distributed with mean μ and variance σ^2, the distribution of the truncated data corresponds to:

$$f(s_{ik}|s_{ik} > z) = \frac{\frac{1}{\sigma}\phi\left(\frac{s_{ik}-\alpha_k-\beta_i-\gamma X_{ik}}{\sigma}\right)}{\Phi\left(\frac{z-\alpha_k-\beta_i-\gamma X_{ik}}{\sigma}\right)}.$$

Under these assumptions, the parameters of the model can be estimated by Maximum Likelihood. The following three remarks are in order regarding the estimation of the parameters:

- A usual problem with the ML estimation of parameters in non-linear panel models is that the fixed effects cannot be eliminated by a simple transformation of the data. This implies that a large number of parameters must be estimated, which significantly affects the convergence and accuracy of the ML procedures. In the model of the paper the number of fixed effects is not unusually large (approximately 120) so the direct estimation of the parameters by ML is feasible.

- In addition to the fact that the total number of fixed effects in the model is not large, the two dimensions of the data are almost symmetrical and contain a relatively large number of observations (50 and 70 respectively). So, the problem under analysis corresponds approximately to a "large N, large T" kind of problem, which significantly reduces the asymptotic bias associated with the incidental parameter problem.[A-5]

[A-5] The incidental parameter problem is that the estimators of the fixed effects are inconsistent

Table 11: Maximum likelihood estimation of main regressions

The dependent variables is the standard deviation of the rate of growth of real value added for each 4 digit ISIC industry in each country. Models included a country and industry specific effect. Coefficients were estimated by maximum likelihood assuming that the data corresponded to a truncated sample of the population. The truncation point was assumed to be the sample maximum of the standard deviation. For simplicity, errors were assumed to homoskedastic. Columns (1) to (4) reports standard maximum likelihood coefficients, while columns (5) to (8) report the coefficients obtained following the 2 step procedure proposed by Blundell and Smith (1986). The last row corresponds to the ML coefficient of the first stage residuals, which are added to the model according to the Blundell and Smith (1986) method. The significance of these residuals indicates the presence of endogeneity.

	OLS				2SLS			
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Interaction:	-0.570*	-0.435*	-0.580*	-0.564*	-1.204*	-1.107*	-1.211*	-1.196*
Liq. needs X pvt. credit	(0.142)	(0.132)	(0.142)	(0.142)	(0.265)	(0.243)	(0.265)	(0.266)
Initial share on		-0.785*				-0.771*		
manuf. VA		(0.098)				(0.097)		
Avg. growth rate			-0.050				-0.049	
			(0.033)				(0.033)	
Interaction:				0.578				0.507
Indus. vol. X Coun. vol.				(1.107)				(1.105)
First stage residuals					0.884*	0.950*	0.880*	0.881*
					(0.313)	(0.288)	(0.313)	(0.313)
Obs.	2301	2078	2301	2301	2301	2078	2301	2301

Note:*=Significant at 5% confidence. Robust standard errors in parenthesis.

- The results obtained in the paper have shown that the measurement error problem has significant effects on the parameters. To address this problem, this paper follows Blundell and Smith (1986) and builds a two stage estimator. In the first stage, the reduced form model is estimated; in the second stage, the residuals from the first stage are included as explanatory variables. Blundell and Smith (1986) show that this procedure produces consistent estimators of the model's parameters.

Table 11 reports the parameters obtained by truncated ML for the same regressions presented in Table 3, Panel A. It can be clearly seen that the coefficients are not significantly affected by the explicit consideration of truncation.[A-6]

when the time series dimension of the data is small. In non-linear problems, the inconsistency of the fixed effects generate inconsistency on the estimators of the slope parameters, which are functions of the fixed effects.

[A-6]The truncation level (z) was assumed to be equal to the maximum volatility level observed in the data.