Financial Constraint and Productivity: Evidence from Canadian SMEs*

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Abstract

The degree to which financial constraint is binding is often not directly observable in commonly used business data sets (e.g., Compustat). In this paper, we measure and estimate the likelihood of a firm being constrained by external financing using a data set of small and medium-sized Canadian firms. Our measure separates the need for financing from the degree of constraint, conditional on the need for financing. We find that firm size, the current debt-to-asset ratio and cash flow are robust indicators that can be used as a proxy for financial constraint. The total debt-to-asset ratio is not, however, a statistically significant indicator of financial constraint. In addition, firms with higher cash flow are less likely to need external financing and to be constrained if they do need it. We then estimate firm-level total factor productivity by taking into account the measured likelihood of binding financial constraint. Estimates of the coefficients for labor and capital in the structural estimation of the production function can be downward biased if financial constraint is omitted, because production inputs are negatively correlated with the likelihood of being constrained by external financing. This in turn leads to an upward bias in total factor productivity, which is about 4 per cent according to our estimation. Finally, both investment and employment growth are negatively affected by the measured degree of financial constraint, pointing to the contribution of financial constraint to misallocation.

Keyword: productivity, financial constraint, production function.

JEL codes: D24, G32, L25

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1 Introduction

The extent to which financial constraint from frictions in credit markets contributes to misallocation and reduces aggregate productivity is an issue with important policy implications. For example, many governments provide financing assistance to small businesses, often rationalized by the imperfect credit markets. Despite its importance, financial constraint has been poorly measured and often not properly identified in previous studies. In equilibrium models with financial frictions, the external-finance-to-output ratio is often used to calibrate the parameters of financial constraint. Empirical studies using firm-level data rely on financial conditions (e.g., debt-to-asset ratio and cash flow) and firm characteristics (e.g., size and age) to indirectly approximate the likelihood of a firm being financially constrained. These proxy variables may fail to measure the true likelihood of being financially constrained. For instance, the empirical finding of the cash-flow sensitivity of investment is taken as evidence of imperfect capital markets.[1] However, studies show that the cash-flow sensitivity of investment does not necessarily imply that firms are financially constrained.[2] The lack of proper measurement and identification makes it challenging for existing models to provide a credible quantification on the role of financial constraint as a form of distortion, regardless of the plausible mechanisms prescribed in the models.

Further, at the micro level, there is a surprising lack of evidence on the financial constraint-productivity nexus. In commonly used firm-level data (e.g., Compustat), neither total factor productivity nor financial constraint is readily observed and measured. Total factor productivity is usually measured through the estimation of the production function, and financial constraint is replaced with proxy variables. If a firm's investment and employment are constrained by external financing, a proper estimation of total factor productivity must take into account financial constraint, which in turn needs to be properly measured and estimated.

In this paper, we study the linkage between financial constraint and productivity using data on small and medium-sized enterprises in Canada. First, we measure and estimate the degree to which firms are financially constrained by exploiting information on financing activities and outcomes. We then estimate the firm-level production function (henceforth productivity) by taking into account the measured degree of financial constraint, overcoming biases of production function estimation if this constraint is omitted from the model.

Our measure of the likelihood of a business being financially constrained separates the financial condition (whether or not external financing is needed) and the degree of constraint, conditional on the need for financing. We find that firm size, the current debt-to-asset ratio and cash flow are robust indicators that can

[1] See Fazzari, Hubbard, and Peterson (1988) and Gilchrist and Himmelberg (1995).

[2] See Kaplan and Zingales (1997), Cooper and Ejarque (2003), Alti (2003), and Abel and Eberly (2011), among others.

be used to proxy for financial constraint. The total debt-to-asset ratio is not, however, statistically significant as an indicator of financial constraint. In addition, firms with higher cash flows are both less likely to need external financing and less likely to be constrained if they do need it.

In estimating the production function, coefficient estimates can be biased if financial constraint is omitted from the estimation, because data show that both investment and employment are negatively correlated with measured financial constraint. Our results show that this negative correlation leads to a downward bias of the coefficient estimates for capital and labor, if financial constraint and external financing are omitted from the structural estimation of production function. The resulting total factor productivity estimates in turn are upward biased. We also find that measured financial constraint and estimated total factor productivity are negatively correlated.

In this paper, we make two contributions to better understanding financial constraint and productivity. First, measured financial constraint here more accurately reflects the degree of financial constraint than earlier studies such as Kaplan and Zingales (1997). Hennessy and Whited (2007) pointed out that the Kaplan-Zingales index of financial constraint measures the firm's "need" for external financing, rather than the degree of constraint due to credit market frictions. In this paper, the data allow us to separate financial constraint from the need for external financing. Further, we examine to what extent variables reflecting financial conditions and firm characteristics used in earlier empirical studies fail or succeed in indicating the true degree of financial constraint faced by firms.

Secondly, we contribute to an understanding of the financial constraint-productivity nexus at the firm level, based on productivity estimation in which we take into account financial constraint. To this end, we extend the structural estimation of the production function. Accounting for financial constraint can correct (to some degree) an upward bias of the parameter estimates of firm-level productivity shocks due to the omission of financial constraint. In quantitative theories of financial constraint with heterogeneous agents, such as Caggese (2007) and Midrigan and Xu (2014), the firm's productivity process is usually estimated without taking into account the impact of financial constraint.

Our results have important implications for quantitative models of financial frictions and misallocation. Particularly, our estimation suggests that such models need to calibrate the parameters of productivity and financial frictions to target the negative correlation between the two, as well as moments that are informative about the true degree of financial constraint.

In the rest of the paper, in Section 2 we review related literature. In Section 3 we measure and estimate the degree to which firms are constrained by external financing. In section 4 we estimate production function, taking into account the measured degree of financial constraint. In Section 5, we estimate to what extent investment and employment growth are affected by financial constraint and total factor productivity. Finally, we conclude in Section 6.

2 Related Literature

The literature on productivity growth and financial frictions is voluminous. This paper is associated with two streams of research. The first studies the estimation of productivity using firm- and establishment-level data. In their seminal paper, Olley and Pakes (1996) estimate total factor productivity by overcoming two biases arising from the reduced-form estimation of the production function: simultaneity bias and selection bias. The simultaneity problem is caused by the fact that input choices (e.g., labor) are endogenously determined by the underlying productivity process. The selection bias arises because the reduced-form estimation does not take into account the impact of productivity shocks on a firm's exit decision. Ackerberg, Benkard, Berry, and Pakes (2007) provide a comprehensive review of the Olley-Pakes approach and its extensions.

The other stream of research relates to the estimation and quantification of the importance of financial frictions in affecting real variables, such as investment, employment, and productivity. Recent studies, including Buera, Kaboski, and Shin (2011), Midrigan and Xu (2014) and Moll (2014), obtain mixed results. However, in these studies, the parameters of the firm's financial constraint are unobserved, and authors usually choose values for these parameters to match the aggregate-external-financing-to-aggregate-output ratio, a moment that does not clearly indicate whether financial constraint is binding or not. Moreover, these models, which focus on mechanisms through which financial constraint affects aggregate productivity, do not attempt to identify the empirically relevant relative roles played by productivity and financial constraint in, for example, investment dynamics at the firm level.

Whether investment sensitivity with respect to cash flow suggests a binding financial constraint is not conclusive in empirical studies on investment and financial constraint. See, for example, Fazzari, Hubbard, and Peterson (1988) and Kaplan and Zingales (1997) for the debate. In these studies, whether a firm is financially constrained is not directly observable in the data. Typically, the investment-to-capital ratio is estimated in regressions using measures of the average value of investment (e.g., Tobin's q), cash flow, and firm characteristics. Neither the underlying productivity process nor the degree of financial constraint is estimated in these models. Instead, financial constraint is approximated with a set of observables that are assumed to suggest the firm's (in)ability to borrow.

Cooper and Ejarque (2003) estimate a structural model of investment with market power. Their simulated model without a borrowing constraint can replicate the cash flow sensitivity of investment in the q regression by Gilchrist and Himmelberg (1995), suggesting that a strong correlation between investment and cash flow may not indicate the importance of financial frictions. Abel and Eberly (2011) and Alti (2003) also show that the investment-to-capital ratio is positively correlated with both Tobin's q and cash flow in environments without financial frictions. They provide both theoretical arguments and empirical evidence to suggest that a high degree of sensitivity of investment to cash flow is not an indirect measure of financial constraint. However, all these studies do not identify and quantify to what extent financial constraint affects investment. Caggese (2007) shows that, indeed, financial frictions are theoretically important in investment dynamics. But in his estimation, the average debt-to-asset ratio is again used to calibrate the parameter of collateral constraint.

Focusing on investment only (without estimating the production function), Whited and Wu (2006) estimate the Euler equation for investment with financial constraint. Since neither the non-negative dividend constraint nor the borrowing constraint is observed in data, the authors use observed variables as a proxy for the Lagrangian multipliers for these constraints in the Euler equation (i.e., by replacing multipliers with a linear function of the long-term debt-to-asset ratio, cash-flow-to-asset ratio, sales growth, firm size, etc.). The drawback is that the estimated Euler equation does not identify whether the firm is financially constrained or not. Hennessy and Whited (2007) explicitly model the cost of equity financing and endogenous default, but again do not directly measure the financial constraint.

Our paper, in measuring financial constraint, is close to Kaplan and Zingales (1997). They use a sample of firms and rank them by the extent to which they are financially constrained. The authors classify the financially constrained firms with qualitative information such as the firm's annual report, as well as financial statements. They find that firms classified as being less financially constrained exhibit a significantly greater cash-flow sensitivity of investment than firms that are more financially constrained. Ferrando and Ruggieri (2015) also measure financial constraint, but they use the firm's balance sheet and income statements, similar to Kaplan and Zingales.

Levine and Warusawitharana (2014) study the impact of financing on the firm's productivity growth. In their model, productivity is endogenously determined by investment in research and development. But they do not relate financial constraint to productivity within their model. Instead, they estimate the total factor productivity in reduced form or without taking into account financial constraint. They then examine how estimated productivity growth is affected by the change in debt level. The degree of financial constraint is not measured in their data.

3 Estimating Financial Constraint

To measure financial constraint due to financial frictions, we define a firm as being financially constrained if its realized external financing is lower than the desired amount when there were no frictions. Sources of frictions can be asymmetric information on project quality, incomplete financial contracts, limited enforcement of financial contracts, and even search frictions in the loan market. This concept is similar to Kaplan and Zingales (1997), who define that a firm is financially constrained if there is a wedge of costs between internal and external funds, by which any firm is possibly constrained. These various forms of financial frictions facing small firms are not readily observed in reality. Nevertheless, data on the activities and outcomes related to external financing can provide evidence on the impact of those frictions.

We use the Survey on Financing and Growth of Small and Medium Enterprises (SFSME) in Canada, and additional information from the administrative data for those firms surveyed. Appendix A describes the data in more detail. The SFSME, a cross-sectional data set, reports detailed information on the activities and outcomes of financing among small and medium-sized businesses. Data are available for 2004, 2007 and 2011. We use only the 2011 data because they provide richer information on financing. Information on balance sheets, income statements, and employment for firms surveyed in the SFSME is from the longitudinal administrative data. This information is available for the period 2008 to 2013.

3.1 Measure of financial constraint

We measure the likelihood of firms being financially constrained by assigning scores to firms using their information on the activities and outcomes related to external financing. Firms in the SFSME data report whether they requested external financing and the outcomes if they did. Types of financing instruments include short-term and long-term loans, equity, trade credit, lease financing, and government financing. Also reported are reasons for not requesting external financing. We assign the highest score to firms reporting that they did not request external financing although they needed it, assuming that these firms are the most likely to be constrained by external financing. On the other end, we assign the lowest score to firms that requested external financing and obtained the requested amount for the requested types of external financing. For these firms with the lowest score, interest rates associated with external financing need to be within reasonable ranges relative to the average interest rates for the same type of financing. In between the lowest and the highest scores are firms that requested financing but the outcomes were lower than requested. For example, financing requests were rejected for some firms and approved with a partial amount for others. Some firms resorted to the government for direct loans or loan guarantees, while others paid extraordinarily high interest rates relative to the majority for the same types of financing. Details on score assignment are described in Appendix B.

We also assign scores based on the types of external financing firms requested. The pecking-order theory of financing suggests that firms usually first use internal funds, followed by loans, then by equity. This suggests that firms issuing new equity are more likely to be constrained than those that only requested loans. It turns out that only a tiny fraction of firms requested equity financing, leading to few firms that are constrained by this criteria.

In the end, there are three categories of financial constraint: most likely constrained, likely constrained, and unlikely constrained. Scores among the likely constrained firms are different from each other: we pool them together because the sample size is small for this middle category.

Score assigning in our data differs from that in Kaplan and Zingales (1997) because we do not use information from the firm's balance sheets and income statements. Neither do we use the firm's annual reports to shareholders (and they are not available). The resulting likelihood of being financially constrained can be different between this paper and Kaplan-Zingales because we rely on different sets of information. The Kaplan-Zingales index is more about the firm's need for external financing, and less about the degree of financial constraint from frictions in the capital market. The need for external financing depends on the demand for investment as well as the firm's cash flow and cash stock. In the Kaplan-Zingales measure, businesses are unlikely to be financially constrained if their cash stock and cash flow (relative to the total assets) are high. In our measure, these businesses can be constrained if their requests for external financing are rejected or only partially approved.

Two issues arise from score assigning. First, scores are a relative measure of financial constraint. A firm that requested external financing can be constrained even if its requests were fully met, because the firm, under a rational manager, could have taken into account financial frictions when requesting financing. In that case, a full approval of a request also can be an outcome reflecting the impact financial frictions. No direct information is available in the SFSME data on reasons for requesting a particular amount of a particular type of external financing. Because of this, our measure of financial constraint may underestimate the degree of a firm's financial constraint.

The second issue is that we are unable to assign scores for businesses that did not request external financing and indicated that they did not need it. The financial condition of these firms can be sound (e.g., high cash flow), so that they truly did not need external financing. It could also be that the firm's demand for investment is low because of low expected productivity. The lack of information on whether these firms are financially constrained had they needed or requested financing is thus a limitation on the accuracy of our measure.

In 2011, 43 per cent of small and medium-sized firms needed or requested external financing (see Table 4).[3] In total, 22 per cent of firms are likely or most likely constrained. About 9 per cent of all firms were most likely constrained—most of them needed, but did not request, financing for reasons indicating financing costs, and a small fraction had their requests for external financing rejected. "Most likely constrained" firms account for 20 per cent of the firms that needed external financing. Among firms that needed or requested external financing, more than half are likely constrained by financing to a certain extent.

It is important to emphasize that, in measuring financial constraint, we do not use information from the firm's balance sheets and income statements. This information is frequently used in earlier studies to indirectly measure a firm's financial constraint (see Ferrando and Ruggieri (2015) for a recent example).

[3] All tables are in Appendix C Tables.

Table 5 summarizes the average values of firms' financial variables and firm characteristics measured by the degree of financial constraint. The relative median values between different degrees of financial constraint are qualitatively similar to the relative mean values. Overall, financial conditions are relatively poor for firms that are likely constrained by financing. Constrained firms are small and young, and have low cash flow and high debt. Their sales growth is slow, and their demand for investment is low, relative to unconstrained firms. Among firms without assigned scores, investment-to-capital ratio is close to the value for firms being mostly likely constrained, while they have high cash flows and low debt, suggesting that these firms may not have high demands for both investment and external financing. Solely relying on the financial condition to indicate whether firms without scores are financial constrained does not appear to accurately capture financial frictions, because their demand for external financing tends to be low due to a low demand for investment.

3.2 Estimating financial constraint

We now examine to what extent firms' financial conditions and firm characteristics may be used as a proxy for measured degree of financial constraint. This allows us to examine whether and which proxy variables used in earlier studies are informative enough to infer whether the degree of financial constraint is binding. To this end, we estimate the likelihood of firms being financially constrained using a firm's observables. In doing so, we take into account that the firm's measured financial constraint is conditional on its need for external financing, and this need is endogenous. We therefore estimate the probability of being financially constrained using the observed firm variables in an ordered probit model with sample selection. The underlying latent variable is the cost of external financing relative to internal funds, which is unobserved but its impact can be inferred from the firm's observed variables.

Let f^*_{jt} be the cost of external financing (relative to that of internal funds), conditional on having requested external financing. This cost wedge is assumed to be a linear function of observables, including the ratio of current debt (short-term debt and current portion of long-term debt) to total assets $\frac{B^s_{jt}}{A_{jt}}$, the ratio of long-term debt to total assets $\frac{B^l_{jt}}{A_{jt}}$, the ratio of current (liquid) assets to total assets $\frac{CA_{jt}}{A_{jt}}$, total assets $\ln(A_{jt})$, dividends $1_{\{\text{Div}_{jt}>0\}}$, ratio of cash flow to total assets $\frac{CF_{jt}}{A_{jt}}$, and firm age Age_{jt}. These not only are variables available in the data, but also have often been used in earlier studies. We have

$$f^*_{jt} = a_1\frac{B^s_{jt}}{A_{jt}} + a_2\frac{B^l_{jt}}{A_{jt}} + a_3\frac{CA_{jt}}{A_{jt}} + a_4\frac{CF_{jt}}{A_{jt}} + a_5\ln A_{jt} + a_6 1_{\{\text{Div}_{jt}>0\}} + a_7\text{Age}_{jt} + \varepsilon_{jt}. \tag{1}$$

We observe $f_{jt} = 0, 1,$ or 2, which reflects the underlying cost of external financing f^*_{jt}. A value of zero indicates that the firm is unlikely constrained, a value of one indicates that the firm is likely constrained, and a value of two indicates that the firm is most likely constrained. An ordered probit model can be estimated to predict the probability of being constrained and the marginal effects.

Previous studies, for example, Kaplan and Zingales (1997) and Whited and Wu (2006), have also used other variables such as Tobin's q. There is a lack of information for calculating Tobin's q since most firms in the sample are small and private.

Since f_{jt} is unobserved for more than half of the firms, we add a sample selection equation to the ordered probit estimation. Let $D^f_{jt} = 0$ if the firm reported that it did not need external financing, and 1 otherwise. The decision as to whether a firm needs external financing is determined by the firm's demand for investment and its financial position, as well as the condition of credit markets. Variables affecting how binding the financial constraint is, f_{jt}, should also affect the demand for external financing. Further, the firm's cash flow and sales growth (g^o_{jt}) should affect the demand for external financing through their effects on the demand for investment. Therefore, the demand for external financing is given by:

$$D^f_{jt} = 1, \text{if } (b_0 + b_1 \frac{B^s_{jt}}{A_{jt}} + b_2 \frac{B^l_{jt}}{A_{jt}} + b_3 \frac{CA_{jt}}{A_{jt}} + b_4 \frac{CF_{jt}}{A_{jt}} + b_5 \ln A_{jt} + b_6 1_{\{\text{Div}_{jt}>0\}} + b_7 \text{Age}_{jt} + b_8 g^o_{jt} + \mu_{jt}) > 0. \quad (2)$$

Equations (1) and (2) also include the interaction between a firm's age and its asset size. In addition, we assume that equation (2) includes dummy variables for sector, which are omitted from equation (1). This allows the system of equations to be estimated because the identification of parameters requires that there are more variables in equation (2). Also we think that sector dummies may capture differences in productivity growth across sectors, while financial constraint is not dependent on which sector the firm is in. We estimate the above two equations using the method described in Luca and Perotti (2011).

Two issues are worth noting. First, the estimation and identification of the selection equation rely on the firm's answers to the question as to why the firm did not request external financing. Two answers were given: first, firms reported that they did not request external financing because they did not need it; and second, they did not request external financing because it was too costly. Thus, in the selection equation, we assume that financial frictions do not affect the need for external financing.

In addition, it is noted that productivity is a main factor determining the demand for investment and employment, and, hence, the need for financing. We do not use measures of productivity because productivity has to be estimated, which in turn should take into account financial constraint. Instead, cash flow, sales growth and other similar variables can reflect underlying productivity and its growth.

Table 6 reports the main estimation results. Estimates of the ordered probit with sample selection are in the two columns under "Full model." column (2) shows estimates of the likelihood of being financially constrained with the sample of firms that needed external financing, and column (3) shows the estimates using the full sample and assuming that firms that did not need financing were unconstrained.

Overall, although for some variables, the parameter estimates in our model are consistent with previous studies, the estimation results in our model provide new findings with important implications. Size and age, which are often used in the literature, matter for indicating financial constraint. Larger and older firms are less likely to be financially constrained, conditional on the need for external financing. Larger firms are also more likely to need external financing, while age does not appear to be important in determining the demand for external financing. The marginal effects of asset size on firms being likely and most likely constrained are both negative and statistically significant, as shown in Table 7. On the age side, marginal effects are negative when the firm's age is 10 years or older, but only statistically significant if the firm is 20 years or older.

A high cash flow is indeed a sign of being less likely constrained. Firms with a higher ratio of cash flow to assets are less likely to need external financing, and less likely to be constrained if they do need it. This finding reconciles two arguments in earlier studies—one using the cash-flow sensitivity of investment as indirect evidence of financial frictions, the other showing that such sensitivity can be an outcome in models without financial frictions. Our estimation suggests that both of these arguments partially capture the importance of cash flow. A high cash flow may indicate that the productivity level is high, so the firm's investment is also high. These firms may not need external financing since high productivity and high cash flow suggest that the firm's financial condition is sound and able to support a high level of investment. On the other hand, a high cash flow may indicate or reveal the quality of the firm's project and overall performance, making the firm unlikely to be constrained if it requests external financing. Regardless of being statistically significant and having a similar magnitude as in the full model, the coefficient for cash flow in column (3) in Table 6 represents an estimation that does not distinguish between the need for external financing and the likelihood of being constrained.

The debt-to-asset ratio is widely used as an indicator of financial constraint in both empirical studies and quantitative models. The conventional view is that the higher the debt-to-asset ratio, the more likely the firm is to be constrained by external financing. Despite this, our estimation suggests that the firm's balance sheets are somehow of limited use in indicating the magnitude of financial constraint. The current debt-to-asset ratio (not the long-term debt-to-asset ratio) is statistically significant in indicating the degree of financial constraint. Firms with a higher current debt-to-asset ratio are more likely to be constrained than otherwise, and they are also more likely to request external financing. Firms with a higher long-term debt-to-asset ratio, though more likely to need external financing, do not appear to be significantly constrained. In an alternative estimation, using the total debt-to-asset ratio, the coefficient for total indebtedness in the probability equation is statistically insignificant. The significance of the current debt-to-asset ratio points to the liquidity constraint.

On the equity side, the firm's ratio of current assets to total assets, a measure of liquidity, is not a statistically significant indicator of financial constraint, though firms with larger current assets tend to be less likely to need external financing. Overall, the coefficient estimates for both the debt and equity variables suggest that balance sheets are not a robust indicator of financial constraint for small and medium-sized firms.

The full-model estimation separates the roles played by independent variables in indicating the firm's need for financing and the firm's likelihood of being constrained. The correlation coefficient between the error terms of the two latent dependent variables, estimated at 0.625, is statistically significant. This correlation says that unobserved variables that increase the need for external financing also increase the probability of being financially constrained, justifying the ordered probit estimation with sample selection instead of the simple ordered probit model, as shown in columns (2) and (3) in Table 6.

The above estimation of financial constraint is similar to that in Kaplan and Zingales (1997), in that the degree of financial constraint, before being estimated, is first assigned to the firm based on its activities. The key difference is that our measure of financial constraint uses only information on the outcomes and activities related to external financing, while Kaplan and Zingales rely on the firm's balance sheets, income statement and other financial reports. This makes their index more like a measure of the firm's financial needs and less like an indicator of financial constraint. In other studies, the measure of financial constraint is unobserved. Instead, it is replaced by a set of proxy variables—see, for example, Whited and Wu (2006) for the investment Euler equation estimation. Since financial constraint is not measured, in the estimation of Whited and Wu, financial constraint proxies by financial variables is essentially the residual, or part of it, in the Euler equation. No information from the data informs or identifies this residual.

4 Financial Constraint and Productivity

Despite recent attention to financial constraint as a factor in capital misallocation causing loss of aggregate total factor productivity, empirical evidence on the nature of the linkage between financial constraint and productivity at the firm level is scarce.[4] This makes it challenging for a model to be credible in its prediction of the quantitative contribution of financial constraint to misallocation. The debt-to-asset ratio or debt-to-output ratio, often used in these studies as a proxy for the degree of financial constraint, are not robust indicators of financial constraint, as we showed in Section 3.

Earlier studies often derive the borrowing constraint from a model of limited enforcement of debt contracts. With this type of model, a firm's debt increases with the ease of enforcement and total factor productivity. This implies that more productive firms are less likely to be constrained by borrowing. Whether such a prediction holds in the data requires proper estimation of both productivity and the likelihood that borrowing will be constrained.

[4] See, for example, Buera, Kaboski, and Shin (2011), Midrigan and Xu (2014), and Moll (2014), among others.

We examine the relationship between productivity and financial constraint, based on the estimation of total factor productivity by taking into account measured financial constraint. The structural method of estimating total factor productivity, as in Olley and Pakes (1996) and its extensions, ignores financial constraint, and uses observed investment, intermediate inputs, and employment to proxy for unobserved productivity. In our study, these input choices are determined by both total factor productivity and financial constraint. As shown earlier, inputs and financial constraint are negatively correlated. Therefore, omitting financial constraint leads to a downward bias of coefficient estimates in the production function estimation. This in turn leads to an upward bias of productivity estimates.

We extend the Olley-Pakes method of estimating the production function to incorporate financial constraint. Estimated total factor productivity is then used as an independent variable to re-estimate the likelihood of being financially constrained. This allows us to examine the relationship between financial constraint and productivity.

4.1 Production function estimation with financial constraint

If financial constraint binds, investment and employment are likely to be lower than otherwise, conditional on the realization of a productivity shock. Abstracting from financial constraint, low investment and employment are (mistakenly) the outcome of a low productivity shock, leading to a downward bias in the estimates of the coefficients for labor and capital. The severity of the bias depends upon the extent to which the firm's ability to finance investment and employment is limited and how many firms are constrained.

If productivity has both exogenous and endogenous components, partially determined by investment (e.g., in research and development) or exports, the firm's inability to finance investment or exports leads to lower productivity. Therefore, to properly estimate productivity shocks, financial constraint needs to be taken into account.

However, whether financial constraint is binding is usually unobserved in the business-level data. Empirical models often use the firm's characteristics (e.g., age and size) and the firm's financial variables (e.g., debt-to-asset ratio and cash flow) to proxy for the likelihood of the firm being financially constrained. In our data set, the (imperfectly) measured likelihood can be used to overcome biases in the production function estimation.

Financial constraint can be specified in different ways. We focus on two of them—namely, the investment collateral constraint and the working capital loan collateral constraint. They are in reduced forms, but implied by contracts with limited enforcement. Let K_{jt} and B_{jt} be, respectively, firm j's capital stock and debt level at the beginning of period t. Let q_t be the asset price in period t, and X_{jt} be firm j's investment in period t, and let ω_{jt} be total factor productivity. The production function is $y_{jt} = F(\omega_{jt}, K_{jt}, L_{jt}, M_{jt})$, where L_{jt} and M_{jt} are, respectively, labor and intermediate inputs.

Investment collateral constraint. The constraint condition is as follows:

$$B_{jt+1} \leq \theta q_t K_{jt+1}, \tag{3}$$

under which only investment is likely to be constrained if the labor choice is static.[5] The parameter θ guides the degree of binding constraint. The investment policy function in the firm's investment problem becomes

$$X_{jt} = \mathbf{X}(K_{jt}, B_{jt}, \omega_{jt}), \tag{4}$$

or $\overline{X}_{jt}$ if the borrowing constraint binds. The optimal debt choice is $B_{jt+1} = \mathbf{B}(K_{jt}, B_{jt}, \omega_{jt})$, or $\overline{B}_{jt+1} = \theta E_t q_{t+1} K_{jt+1}$ if the firm is constrained.

The difference between investment policy functions with and without financial constraint lies in two aspects. First, current debt is a state variable in the presence of financial constraint. The debt level may affect investment because the firm needs to repay loans and interest. Second, if financial constraint binds, investment X_{jt} may no longer be monotonic in ω_{jt}, depending on the form of the cost of financing. There can exist a range of values of ω_{jt} in which the firm is constrained and investment is flat. This violates the strict monotonicity assumption of the Olley-Pakes method. Further, without solving the dynamic problem for investment, adding B_{jt} as a state variable does not tell us whether the firm is financially constrained. A binding financial constraint, particularly if in the form of fixed transaction costs, is analogous to a non-convex capital adjustment cost. The Olley-Pakes method does not intend to take into account the zero-investment moments to estimate the capital adjustment cost. Similarly, this method cannot use the zero-investment or flat investment profile to estimate whether financial constraint is binding or not. In contrast to the case of the non-convex capital adjustment cost, financial constraint can be (indirectly) measured in our data set, which can help to isolate financial constraint from productivity in shaping investment. Finally, the scalar unobservable assumption of the Olley-Pakes method can be violated, e.g., the correspondence between investment and productivity is no longer one to one if there is an unobserved heterogeneity in the firm's likelihood of being financially constrained.

If the investment-productivity monotonicity is no longer preserved in the presence of financial constraint, one cannot use the inverse of the investment policy function as a proxy for productivity. Hence, the original Olley-Pakes method is no longer valid. If the choices of labor and intermediate inputs are static, and their optimal conditions are not distorted by the investment collateral constraint, productivity estimates using the inverted static input function as proxy variables can be used, as in Levinsohn and Petrin (2003). Thus, financial constraint does not need to be taken into account in the estimation. The only differ-

[5] We omit firm age in our estimation. In our trials, when included, the coefficient estimates for firm age are small and statistically insignificant.

ence from the case of abstracting from financial constraint is that the debt and financial variables are also state variables to be used in the estimation.

However, selection bias due to endogenous firm exit is associated with financing. More financially constrained firms are more likely to exit. The second stage of estimation in the Olley-Pakes method then needs to use variables for financial constraint in estimating the probability of firm exit.[6]

Collateral constraint of working capital. Firms may need external financing to pay wage bills. For example, a firm may have to pay workers before the labor input is employed for production, as in Neumeyer and Perri (2005) and Bianchi and Mendoza (2010). Suppose that the firm is allowed to borrow in order to pay a κ fraction of the wage bill, for which the firm pays interest. Total borrowing (investment loan and working capital loan) is subject to the collateral constraint below:

$$B_{jt+1} + \kappa w_t L_{jt} \leq \theta E_t q_{t+1} K_{jt+1}.$$

The first-order optimal condition regarding the labor choice is then given by

$$F_L(\omega_{jt}, K_{jt}, L_{jt}, M_{jt}) = [1 + (R_t - 1 + \lambda_{jt}^b)\kappa] w_t, \tag{5}$$

where $\lambda_{jt}^b \geq 0$ is the Lagrangian multiplier for the collateral constraint. The optimal choice of labor is given by $L_{jt} = \mathbf{L}(K_{jt}, B_{jt}, \omega_{jt}; \kappa, \theta)$, where κ and θ represent financial frictions. The estimation strategy by Ackerberg, Caves, and Frazer (2006) (hereafter ACF) can then be used, which we describe in the next section. Note that labor choice is static and does not depend on the lagged labor input l_{jt-1}.

4.2 Estimation procedure

Recognizing that the assumption of productivity-investment monotonicity likely breaks down in the presence of financial constraint, we consider the case of inverting the choices of the labor input and intermediate inputs to proxy the productivity shock. This covers both forms of financial constraint discussed above. We use a two-stage estimation on the value-added production function, similar to ACF. In the first stage, we substitute the inverted demand function of intermediate inputs into the production function, and estimate the part of output variation determined by inputs. In the second stage, all the production function parameters are estimated. This estimation strategy not only solves the collinearity problem in α_l in the first stage, raised by ACF, but it is also appropriate in the case where both labor and capital inputs are dynamic choices.

[6] The short panel in our sample, and the fact that all firms survived in the 2011 sample, make selection bias a minor issue. Therefore, our estimation does not consider selection bias.

Timing assumption. Entering period t, firm j's state variables are capital K_{jt}, debt B_{jt}, and employment L_{jt-1}. The firm first observes productivity ω_{jt}. The sequence of actions is then: the firm first repays current loan B_{jt}, it then chooses future loan B_{jt+1} and makes decisions on employment L_{jt} and investment X_{jt}. Workers must be paid before labor enters production. Finally, the firm chooses the optimal intermediate input M_{jt}, and production then occurs.[7]

By the timing assumption, the intermediate input is a function of the state variables and the labor input (in lower case after taking the natural logarithm),

$$m_{jt} = M(k_{jt}, b_{jt}, l_{jt}, \omega_{jt}; \kappa, \theta).$$

Inverting this function and replacing the parameters representing financial constraint with f^c_{jt}, we obtain ω_{jt} as a function of the state variables and measured financial constraint,

$$\omega_{jt} = \mathbf{M}^{-1}(k_{jt}, b_{jt}, l_{jt}, m_{jt}, f^c_{jt}). \tag{6}$$

This allows for the possibility that a firm is financially constrained for both investment and employment. With this equation, we use the state variables and input choices to proxy productivity. But f^c_{jt} is not interpreted as an input, rather, it captures the firm-specific likelihood of being borrowing-constrained.

The first-stage estimation equation is given by

$$y_{jt} = \alpha_0 + \alpha_k k_{jt} + \alpha_l l_{jt} + \mathbf{M}^{-1}(k_{jt}, b_{jt}, l_{jt}, m_{jt}, f^c_{jt}) + \varepsilon_{jt}, \tag{7}$$

where a third-order polynomial is used for $M^{-1}(\cdot)$. No parameter is identified and estimated at this stage, but we obtain the estimate $\widehat{\Phi}_{jt}$ of the composite term,

$$\Phi_{jt} = \alpha_0 + \alpha_k k_{jt} + \alpha_l l_{jt} + \mathbf{M}^{-1}(k_{jt}, b_{jt}, l_{jt}, m_{jt}, f^c_{jt}).$$

By controlling for endogenous inputs, the first-stage estimation helps separate out the part of output determined by unanticipated shocks or the measurement error.

The productivity process is assumed to take the following form:

$$\begin{aligned} \omega_{jt} &= g(\omega_{jt-1}, x_{jt-1}, f^c_{jt-1}) + \xi_{jt} \\ &= \sum_{i=0}^{3} \gamma_i (\omega_{jt-1})^i + \gamma_4 f^c_{jt-1} + \gamma_5 x_{jt-1} + \gamma_6 f^c_{jt-1} x_{jt-1} + \xi_{jt}. \end{aligned} \tag{8}$$

[7] Note that L_{jt} is used for production in period t. For now, labor choice is static, and L_{jt-1} is not a state variable.

If $\gamma_4 = \gamma_5 = \gamma_6 = 0$, either by assumption or by estimation, then ω is exogenous. The endogenous component of productivity is determined by the choice of investment and the degree of binding financial constraint in the lagged period. Lagged investment may affect productivity transition through innovation or machines that embody new technology. The lagged likelihood of financial constraint can affect productivity through investment, captured by the interaction term.[8] We do not include the current-period estimated likelihood of being financially constrained, f_{jt}^c, because this likelihood, an endogenous outcome, is potentially determined by lagged and current productivity. For instance, in an environment with limited enforcement of loan contracts, whether or not the borrowing constraint binds depends on both the degree of contract enforcement and total factor productivity.

The second-stage estimation follows ACF to use the moment conditions of the productivity shock ξ_{jt}. Given candidate values of $\alpha = (\alpha_k, \alpha_l)$, we obtain $\xi_{jt}(\alpha)$ as a residual from the regression of equation (8), in which

$$\omega_{jt}(\alpha) = \widehat{\Phi}_{jt} - \alpha_k k_{jt} - \alpha_l l_{jt}.$$

The moment condition is formulated as

$$E\left[\xi_{jt}(\alpha) \cdot \mathbf{Z}'_{jt}\right] = 0,$$

where $\mathbf{Z}_{jt} = \begin{pmatrix} 1 & k_{jt} & l_{jt-1} \end{pmatrix}$. Using this moment condition produces smaller variance and more stable estimates, also found by ACF, than using moment condition $E\left[\xi_{jt} + \varepsilon_{jt} \cdot \mathbf{Z}'_{jt}\right] = 0$. Once α is estimated, productivity can be calculated and its process can also be estimated.

An alternative method of the second-stage estimation is to use the generalized method of moments to estimate the following equation:

$$\begin{aligned} \widehat{\phi}_{jt} \quad = \quad & \alpha_k k_{jt} + \alpha_l l_{jt} + \sum_{i=0}^{3} \gamma_i (\widehat{\phi}_{jt-1} - \alpha_k k_{jt-1} - \alpha_l l_{jt-1})^i \\ & + \gamma_4 f_{jt-1}^c + \gamma_5 x_{jt-1} + \gamma_6 f_{jt-1}^c x_{jt-1} + \xi_{jt}. \end{aligned} \tag{9}$$

Note that, because $E_t[\xi_{jt} l_{jt}] \neq 0$, instrument variables are needed to overcome the endogeneity problem of labor choice. The instrument variables are the right-hand-side variables (except labor), lagged labor, lagged labor squared, and the lagged product of capital and labor.

Two issues of estimation need to be explained. First, selection bias due to the omission of the exit decision is not considered. Although the data sample includes small and medium-sized firms, whose probability of exit is greater than large firms, the sample is short, spanning from 2009 to 2013, and all firms in the sample survived in 2011 (the survey year). The firm exit rate is fairly small. Incorporating firm exit in estimation

[8] Endogenizing productivity with lagged control variables has been used to study the contribution of R & D and exports on productivity, as in Aw, Roberts, and Xu (2011), De Loecker (2013), and Doraszelski and Jaumandreu (2013).

is left for future work. Second, our estimation pools firms from all sectors. Goods-producing firms account for a small share of the total number of firms, as most firms are in retail trade and services. Estimation by sector may create a small-sample problem, since only 22 per cent of firms are constrained in 2011. To take into account differences in productivity across sectors, we augment the first-stage estimation (equation (6)) to include the real hourly wage rate at the level of three-digit NAICS and the price of intermediate inputs (relative to aggregate GDP price) at the level of two-digit NAICS.[9]

4.3 Diagnostics

We first examine the correlation between financial constraint and productivity based on the production function estimated without taking into account financing. In estimating the second-stage equation, we use capital, lagged labor, and the square of lagged labor as instrument variables.

The parameter estimates of the production function are reported in Table 8. The first row shows the estimation by the ordinary least squares, the second row is the ACF estimation assuming that $\gamma_4 = 0$, and the third row is the ACF estimation with endogenous total factor productivity ($\gamma_4 \neq 0$). The estimate of the labor coefficient in ACF without financing is smaller than in ordinary least squares (OLS), because OLS estimation does not take into account the positive correlation between productivity and labor choice. This positive correlation causes an upward bias of the estimate of the labor coefficient. The coefficient estimate for capital is larger in ACF than in OLS, also as expected. By inverting the optimal intermediate input to obtain the proxy for total factor productivity, conditional on the intermediate input, total factor productivity is smaller for firms with larger capital size. Thus, the coefficient for capital is expected to be larger when moving from OLS to ACF estimation.

To diagnose the statistical relationship between productivity and financial constraint, we use estimated productivity without taking into account financing and assume that the productivity process is exogenous. Estimated productivity and measured financial constraint are negatively correlated. The correlation coefficient between estimated total factor productivity and f^c and lagged f^c are both -0.3. In Table 9, a simple regression of estimated total factor productivity on the measured probability of being constrained and its lag also shows that productivity is correlated negatively with measured financial constraint. When using assigned scores for the 2011 data sample, the median of estimated productivity (after de-meaning) among firms likely constrained and highly likely constrained is, respectively, 11 per cent and 19 per cent lower than that of unlikely constrained firms.

The negative correlation between estimated productivity and measured financial constraint suggests

[9]We use firms from sectors of NAICS 23, 31-33, 41, 44-45, 48-49, 54, 55, 56, 72 and 81. Sector-level real wage rates and relative prices of intermediate inputs are calculated using the Survey of Employment, Payrolls and Hours (SEPH) and the Industrial Producer Prices Index (IPPI).

two possibilities. First, productivity estimates are biased in this case because financial constraint is omitted. Earlier, we showed that investment and employment are both negatively correlated with measured financial constraint. If financial constraint is omitted from the estimation, low investment or low employment in the data is an outcome of low productivity, while in fact this could be due to binding financial constraint. Thus, if estimation does not take into account the negative correlation between inputs and financial constraint, estimated productivity is then biased upward, particularly for firms that are financially constrained, leading to a negative correlation between productivity and the measured financial constraint.

Second, the negative correlation between estimated productivity and measured financial constraint also suggests that the estimated productivity may affect the estimation of the probability of being financially constrained. This is possible if firms misreported their activities related to external financing. The rejection of a loan request could be a result of low productivity instead of financial frictions. Thus, we add estimated total factor productivity as an independent variable and re-estimate the probability of being financially constrained. The results are reported in Table 10. Clearly, more productive firms, conditional on needing external financing, are less likely to be financially constrained. Further, compared with the estimation in Table 6, the magnitude of the coefficient estimates for firm asset size, the cash-flow-to-asset ratio, and dividends becomes smaller when total factor productivity is taken into account. This implies that variables such as cash flow, dividends, and firm size reflect the level of the firm's productivity. If we use them to proxy for financial constraint, we may not be able to distinguish low productivity from financial constraint. However, the coefficient estimates for total factor productivity in Table 10 may no longer be statistically significant once productivity is properly estimated by incorporating the firm's financing decision and financial constraint—which is the case, as we will show later.

4.4 Production function estimation with financial constraint

The last two sets of estimates in Table 8 correspond to the estimation of the production function, taking into account external financing (debt as a state variable) and measured financial constraint. If we focus on the case of exogenous productivity, the coefficient estimates of both labor and capital are larger than estimates omitting external financing and financial constraint. This is expected, since the correlation is negative between financial constraint and choices of both labor and investment. When the ACF estimation is augmented to incorporate financial constraint, that negative correlation with labor recovers the true correlation between total factor productivity and labor, which in turn makes the coefficient estimate of labor larger. For example, a highly productive firm has low labor input (relative to other firms with the same level of total factor productivity) owing to a binding borrowing constraint. If this constraint is omitted from the estimation so that total factor productivity is the only factor determining labor input, the correlation between total factor productivity and labor input appears weak. Once the financial constraint measure is taken into account, the correlation between productivity and labor input is then corrected, leading to a coefficient estimate of labor that is larger than the estimation without financing. A similar argument applies to the coefficient estimate for capital.

Comparing the model with financing but without financial constraint and the model with financial constraint, again for the case of exogenous productivity, the coefficient estimates for labor and capital are only slightly different between the two cases. This implies that the bias of estimates is small if measured financial constraint is omitted. This is likely caused by the way we measure the likelihood of binding financial constraint. In the ACF estimation, proxy variables for total factor productivity, such as firm size and debt, were also used to estimate financial constraint. If the likelihood of being financially constrained is mostly predicted by firm size and debt, it is then not surprising that the coefficient estimates are only slightly larger when the financial constraint measure is incorporated. Ideally, this issue can be resolved if we can assign scores of financial constraint for each firm in each sample period, so that we do not need to estimate and predict the likelihood of being constrained using the firm's observables such as size and indebtedness.

Estimated total factor productivity (de-meaned, $\omega_{jt} - \overline{\omega}$) and measured financial constraint are still negatively correlated, with a correlation coefficient of -0.45, stronger than the -0.30 obtained in the case of the production function estimation without financing. In 2011, the median total factor productivity of the likely constrained firms is 9 per cent lower than that of the unconstrained firms, and the median total factor productivity of the most likely constrained firms is 19 per cent lower than that of unconstrained firms. These differentials in estimated total factor productivity are close to those of the productivity estimation without financing.

However, the negative correlation between measured financial constraint and estimated total factor productivity is now reflected more in the impact of total factor productivity on the demand for external financing, and less in the impact on the conditional probability of being financially constrained (see Table 11). This is in contrast to estimates in Table 10, where the negative correlation is seen mostly through the impact of total factor productivity on the conditional probability of being constrained.

This result appears to be intuitive. Once the bias of the production function estimation is corrected by taking into account financing and financial constraint, information on financial frictions (or part of it) is then removed from productivity estimates. Therefore, a low level of estimated productivity is no longer indicative of a high probability of being constrained.

4.5 Bias of estimated productivity

We now compare estimates of total factor productivity under different specifications. Since moments of the error term may differ across estimates, to make them comparable, total factor productivity here is calculated as $\exp(y_{it} - \widehat{\beta}_k k_{it} - \widehat{\beta}_l l_{it})$.

Table 12 reports the mean values of estimated total factor productivity. Overall, when financing and financial constraint are omitted from the production function estimation, total factor productivity is biased upward by about 4 per cent. The magnitude of this bias is similar among firms of different sizes and those with different likelihoods of being financially constrained. The bias of the median values is similar to that of the mean values. Table 12 also shows that the gap in average productivity between constrained and unconstrained firms did not change after the bias was corrected. This implies that the productivity distribution is not significantly changed when the bias is corrected.

4.6 Financial constraint and endogenous productivity

So far, total factor productivity is assumed to be exogenous in estimation. The negative correlation between total factor productivity and the measured financial constraint points to the impact of productivity on the likelihood of being constrained by financing. This causal effect can be reversed, i.e., a binding financial constraint can lead to lower productivity by limiting the firm's activities intended to boost productivity.

We estimate whether the lagged likelihood of being constrained can affect total factor productivity growth. Specifically, in estimating the production function, the productivity process is endogenous to lagged investment and the lagged probability of being financially constrained. After obtaining productivity estimates, we use ordinary least squares to estimate the productivity processes.

To diagnose whether measured financial constraint affects productivity, we estimate the production function with external financing (debt) but assume no financial constraint, so that in the first stage of the ACF estimation, we use $\omega_{jt} = \mathbf{M}^{-1}(k_{jt}, b_{jt}, l_{jt}, m_{jt})$ to proxy for productivity. In the second stage, productivity is endogenous. Estimates reported in Table 13 show that a higher likelihood of being financially constrained leads to lower productivity.

However, when the production function is estimated with financing and financial constraint (that is, $\omega_{jt} = \mathbf{M}^{-1}(k_{jt}, b_{jt}, l_{jt}, m_{jt}, f^c_{jt})$ is used in the first stage of ACF), various estimates of γ_4 are all positive and mostly statistically insignificant (as shown in Table 14). This suggests that, once the estimation bias from omitting financial constraint is corrected, the measured likelihood of being constrained no longer has a separate effect on productivity processes.

In an extended estimation, we interact measured financial constraint with estimated productivity. Table 15 shows that firms with higher lagged productivity and a higher likelihood of being constrained are less productive, resulting in lower productivity growth.

In summary, we find no significant estimate of the effect of financial constraint on productivity if the productivity estimation corrects the bias due to the omission of financial constraint.

5 Productivity, Financial constraint and Firm growth

If financial constraint is believed to lead to misallocation, hence the loss of aggregate productivity, one should expect that, at the firm level, financial constraint affects the firm growth, in terms of both investment and employment growth. Firms that are more likely constrained by the external financing may experience a slower growth, causing misallocation and productivity loss. We examine the impact of financial constraint and productivity on firm growth.

First, we focus on real effects of the estimated degree of financial constraint. Decisions on investment and employment are determined by the underlying productivity shocks, factor adjustment costs, and the degree of financial constraint. The importance of measure of financial constraint in our model should be able to be separated from other variables, such as cash flow that is indicative of both the level of productivity and the degree of financial constraint.

We estimate the reduced-form equations for investment and employment growth, implied by the firm's Euler equation, by augmenting them to include financial variables. The data sample spans from 2008 to 2013, while the measure of financial constraint is only for 2011. We therefore use the estimated model of financial constraint to predict the probability of a firm being financially constrained for the years before and after 2011. These predicted probabilities are unconditional on the demand for external financing, because this demand is observed also only for 2011.

The estimation of the investment-to-capital ratio in a linear equation, for which results are not reported here, shows that the parameter estimates are statistically insignificant. One possible reason for this may arise from the substantial heterogeneity of investment by small and medium-sized firms. Using definitions of inaction and lumpiness of investment from Cooper and Haltiwanger (2006), we find that 31 per cent of the firm/year sample displays an investment-to-capital ratio of within 1 per cent in absolute value. The fraction of zero investment is 46 per cent among firms in the first lowest quintile of asset size, in contrast to only 17 per cent in the last largest quintile. On the other end, about 33 per cent of the sample displays an investment-to-capital ratio larger than 20 per cent. The linear regression (to mean) may likely become insignificant, given inaction and lumpiness. In addition, measurement errors of investment and capital stock are a potentially more severe problem among these small firms used in our sample, compared with larger firms used in earlier studies.

Given the investment spikes, we estimate the extensive margin, and the probability of positive investment. Table 16 reports the coefficient estimates of a logit model under five specifications. The data sample spans from 2008 to 2013, and contains firms from most business sectors in the two-digit NAICS. Age and sector dummy variables are included in all specifications, while estimates are omitted from the table. The fully specified estimation is reported in column (5). Investment is sensitive to both cash flow and financial constraint. More likely constrained firms with a low cash flow are less likely to invest a positive amount. In addition, the likelihood of positive investment increases if the current debt-to-asset ratio becomes higher. Estimates in column (1) represent a model specification similar to investment regressions in earlier studies. Investment, as usual, is sensitive to cash flow; firms with a higher cash flow are more likely to invest. The total debt-to-asset ratio is insignificant and its coefficient has an opposite sign if this ratio is believed to reflect the degree of financial constraint. In column (2), where only the measured unconditional probability of being financially constrained is included, we observe that the more likely the firm is to be constrained, the less likely its investment is positive.

Employment growth is also sensitive to measured financial constraint. Table 17 reports results of linear regressions of the employment growth rate on financial variables and measured financial constraint. The coefficient estimates are consistent with our prior—financial constraint limits firm growth. In addition, employment growth is higher for firms with a higher cash flow. These findings are largely comparable to the regression of the extensive margin of investment.

Adding the estimated productivity to the firm growth regression does not affect the above results. Focus on the employment growth, Table 18 reports the results from the linear regression, where the dependent variable is the percentage change in employment. Clearly, when taking into account TFP estimates, the degree of financial constraint continues to have negative impacts on employment growth. This and the above evidence are consistent with previous literature, for example, Angelini and Generale (2008) and Cabral and Mata (2003). Coefficient estimates are negative for total factor productivity but statistically insignificant for lagged total factor productivity, similar to results based on sector-level data by Basu, Kimball, and Fernald (2006).[10] Finally, the extensive margin of investment is negatively affected by the measured degree of financial constraint, and positively affected by total factor productivity, both estimates are statistically significant.

6 Conclusions

In this paper, we constructed a measure of the likelihood of a firm being financially constrained, using data on small and medium-sized firms. This measure appears to reflect the financial frictions facing borrowing firms. The advantage of our measure is that it separates the need for external financing from the likelihood of being constrained by borrowing, which is missing from previous studies. We found that a firm's asset size and cash flow are robust indicators of financial constraint, while the debt-to-asset ratio is not. This result raises a caveat for models using the debt-to-asset ratio to calibrate the parameters of financial frictions.

[10] Not reported here, coefficient estimates for the change in total factor productivity are negative and statistically significant. A potential explanation for the negative effect of total factor productivity on employment growth is nominal rigidity in output prices.

We also show that the coefficient estimates for capital and labor in the production function are downward biased if debt and measured financial constraint are omitted, because of negative correlations between measured financial constraint and inputs. This downward bias in the parameter estimates leads to an upward bias in the productivity estimation.

Without correcting the bias, estimated productivity is negatively correlated with measured financial constraint. This is reflected in the statistically significant coefficient estimate pointing to a negative effect of productivity on the conditional probability of being constrained. Once productivity is properly estimated, such a correlation, although still negative, no longer suggests that productivity affects the conditional probability of being constrained. Rather, it is reflected in the impact of productivity on the need for financing.

Our results have important implications for models quantifying the importance of financial frictions in causing misallocation and loss of productivity. Notably, our results suggest that productivity and financial frictions should be jointly calibrated by targeting moments that are informative and accurate regarding the likelihood of binding financial constraint.

To what extent a firm is financially constrained is ultimately an endogenous outcome, given the demand for financing, which in turn is determined by the demand for investment and employment, as well as underlying productivity shocks. To estimate both the likelihood of being financially constrained and productivity processes in one framework requires the estimation of a fully specified dynamic model of investment and financing, incorporating a theory of financial constraint. This is left to future research.

References

Abel, A. B., and J. C. Eberly (2011): "How Q and Cash Flow Affect Investment without Frictions: An Analytic Explanation," *Review of Economic Studies*, 78(4), 1179–1200.

Ackerberg, D., C. L. Benkard, S. Berry, and A. Pakes (2007): "Econometric Tools for Analyzing Market Outcomes," in *Handbook of Econometrics*, ed. by J. Heckman, and E. Leamer, vol. 6 of *Handbook of Econometrics*, chap. 63. Elsevier.

Ackerberg, D., K. Caves, and G. Frazer (2006): "Structural Identification of Production Functions," MPRA Paper 38349, University Library of Munich, Germany.

Alti, A. (2003): "How Sensitive Is Investment to Cash Flow When Financing Is Frictionless?," *Journal of Finance*, 58(2), 707–722.

Angelini, P., and A. Generale (2008): "On the Evolution of Firm Size Distributions," *American Economic Review*, 98(1), 426–38.

Aw, B. Y., M. J. Roberts, and D. Y. Xu (2011): "R&D Investment, Exporting, and Productivity Dynamics," *American Economic Review*, 101(4), 1312–44.

Basu, S., M. S. Kimball, and J. G. Fernald (2006): "Are Technology Improvements Contractionary?," *American Economic Review*, 96(5), 1418–1448.

Bianchi, J., and E. G. Mendoza (2010): "Overborrowing, Financial Crises and 'Macro-prudential' Taxes," NBER Working Papers 16091, National Bureau of Economic Research Inc.

Buera, F. J., J. P. Kaboski, and Y. Shin (2011): "Finance and Development: A Tale of Two Sectors," *American Economic Review*, 101(5), 1964–2002.

Cabral, L. M. B., and J. Mata (2003): "On the Evolution of the Firm Size Distribution: Facts and Theory," *American Economic Review*, 93(4), 1075–1090.

Caggese, A. (2007): "Financing Constraints, Irreversibility, and Investment Dynamics," *Journal of Monetary Economics*, 54(7), 2102–2130.

Cooper, R. W., and J. Ejarque (2003): "Financial Frictions and Investment: Requiem in Q," *Review of Economic Dynamics*, 6(4), 710–728.

Cooper, R. W., and J. Haltiwanger (2006): "On the Nature of Capital Adjustment Costs," *Review of Economic Studies*, 73(3), 611–33.

De Loecker, J. (2013): "Detecting Learning by Exporting," *American Economic Journal: Microeconomics*, 5(3), 1–21.

Doraszelski, U., and J. Jaumandreu (2013): "R&D and Productivity: Estimating Endogenous Productivity," *Review of Economic Studies*, 80(4), 1338–1383.

Fazzari, S. M., R. G. Hubbard, and B. C. Peterson (1988): "Financing Constraints and Corporate Investment," *Brookings Papers on Economic Activity*, 19(1), 141–206.

Ferrando, A., and A. Ruggieri (2015): "Financial Constraints and Productivity: Evidence from Euro Area Companies," Working Paper Series 1823, European Central Bank.

Gilchrist, S., and C. P. Himmelberg (1995): "Evidence on the Role of Cash Flow for Investment," *Journal of Monetary Economics*, 36(3), 541–572.

Hennessy, C. A., and T. M. Whited (2007): "How Costly Is External Financing? Evidence from a Structural Estimation," *Journal of Finance*, 62(4), 1705–1745.

Kaplan, S. N., and L. Zingales (1997): "Do Investment-Cash Flow Sensitivities Provide Useful Measures of Financing Constraints?," *The Quarterly Journal of Economics*, 112(1), 169–215.

Levine, O., and M. Warusawitharana (2014): "Finance and Productivity Growth: Firm-level Evidence," Finance and Economics Discussion Series 2014-17, Board of Governors of the Federal Reserve System (U.S.).

Levinsohn, J., and A. Petrin (2003): "Estimating Production Functions Using Inputs to Control for Unobservables," *Review of Economic Studies*, 70(2), 317–341.

Luca, G. D., and V. Perotti (2011): "Estimation of Ordered Response Models with Sample Selection," *Stata Journal*, 11(2), 213–239.

Midrigan, V., and D. Y. Xu (2014): "Finance and Misallocation: Evidence from Plant-Level Data," *American Economic Review*, 104(2), 422–58.

Moll, B. (2014): "Productivity Losses from Financial Frictions: Can Self-Financing Undo Capital Misallocation?," *American Economic Review*, 104(10), 3186–3221.

Neumeyer, P. A., and F. Perri (2005): "Business Cycles in Emerging Economies: the Role of Interest Rates," *Journal of Monetary Economics*, 52(2), 345–380.

Olley, G. S., and A. Pakes (1996): "The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica*, 64(6), 1263–97.

Rispoli, L., D. Leung, and J. R. Baldwin (2013): "Canadian Labour Productivity Differences Across Firm Size Classes, 2002 to 2008," *The Canadian Productivity Review* 2013032e, Statistics Canada,.

Whited, T. M., and G. Wu (2006): "Financial Constraints Risk," *Review of Financial Studies*, 19(2), 531–559.

Appendix A Data Description

Overall, small and medium-sized enterprises (SMEs) (firms with fewer than 500 employees) account for more than 50 per cent of business sector output, and 70 per cent of hours worked (2008 data (Rispoli, Leung, and Baldwin, 2013)).

We use data from the Survey on Financing and Growth of Small and Medium Enterprises (SFSME) merged with administrative data. The SFSME is a repeated cross-section database of Canadian firms with fewer than 500 employees and with gross revenue below $50 million. Businesses from some specific industries are excluded, e.g., those in finance and insurance, utilities, and health services. It provides detailed information on a firm's demand for financing, reported demand for external financing, reasons the loan request is rejected, how the firm uses the loan, the borrowing rate and rate type, fees for obtaining credit, collateral and whether the loan is guaranteed by the government. The data also provide information on leasing, equity financing, and government financing. Data are available for the years 2004, 2007, and 2011. The administrative data provide information on firms in the SFSME regarding financial statements and income statements.

In this paper, we use data from the 2011 survey, although we also report financing activities from the 2007 survey.

A.1 SMEs: Some basic facts

Most small businesses are in industries related to construction, retail trade, professional services, accommodation, and other services. Manufacturing firms account for 7 per cent of the sample. About 76 per cent of businesses have fewer than 10 employees. Table 1 shows the average size and age of SMEs. More than 70 per cent of businesses were created from scratch by the owner, and the rest were acquired from others.

Table 1: SME size and age with the current owner

Year	Mean employment	Median employment	Mean age	Median age	% from scratch
2007	9	3	14	10	75%
2011	9	4	15	12	71%

In 2007, the median age of the business owners is 50, and the mean age is 51. In 2011, the median and mean age of business owners are both 52. With the exception that there are fewer business owners who are high school drop-outs, the education achievement in 2011 is roughly equally distributed over the business owners.

A.2 Summary statistics on financing, 2011

There are five financing instruments: loans, equity, leasing, government loans or grants, and trade credit. We categorize them into loan, equity and "the rest". In 2011, 36 per cent of firms requested at least one type of external financing, about 71 per cent of these applied for loans (46 per cent for loans only), and 27 per cent of businesses who requested financing used "the rest" only. As in 2007, only a very small percentage of firms issued equity in 2011. In non-loan financing, trade credit is used the most.

For those who did not request external financing in 2011, 88 per cent of firms reported that external financing was not needed, about 6 per cent reported that the request for financing would be turned down or that applying for financing was too difficult (or time-consuming) or the cost of financing was too high.

Table 2: Percentage of SMEs requesting external financing

Year	Any external financing	Type of requested financing			
		loan at least	equity at least	loan and equity only	the rest only
2011	36	46	1	2	27

In 2011, 25 per cent of all firms requested loans (they could also have requested other financing such as trade credit). The mean size of total loan values is slightly higher than $180,000, and the median of total loans is $50,000. In total, about 8 per cent of all firms requested trade credit, and 3.7 per cent of all firms requested some form of government financing.[11]

In 2011, the majority of external financing was intended to finance the purchase of land and buildings, vehicles, information technology, equipment, and working capital. About 51 per cent of firms that requested external financing said this would be used to finance working capital (not necessarily only working capital).

Table 3: Percentage of loan requests by outcome in 2011

Year	full amount	partial amount	turned down	under review	withdrawn
2011	85	5.0	7.6	-	-

Among those firms that requested loans in 2011, more than 50 per cent requested business lines of credit (new or increased limit), 40 per cent applied for a business credit card, 35 per cent applied for a term loan, and only 16 per cent applied for a non-residential mortgage (new or refinancing). Note that these do not sum to 100, as firms may apply for more than one type of loan.

The approval rate for loan applications is high—85 per cent of requests were approved for the full amount in 2011, and only 5 per cent of requests were authorized for a partial amount. About 7.6 per cent of loan requests were rejected. For those rejected loan requests, the main reasons given for rejection were a poor or lack of credit history and the project was considered too risky. Rejected loans did not appear to be concentrated in one particular type of loan.

About 48 per cent of loans used business assets as collateral, 26 per cent used personal assets as collateral, and 35 per cent did not use any collateral. Note that some loans were refinancing or additions to existing loans, so a firm may report that no collateral was needed for the new part of an existing loan.

Appendix B Score Assigning

We use the 2011 survey data to measure financial constraint because in the 2007 survey no information is available on why firms did not request external financing. We assign scores according to the following criteria. Note: a firm is more likely to be constrained the larger the assigned score is.

[11] Government financing includes direct loans, loan guarantees, grants, subsidies, and non-repayable contributions and equity from government or government lending institutions.

1. Not applying for external financing because: (i) thought the request would be turned down, (ii) applying for financing is too difficult or time-consuming, or (iii) the cost of financing is too high.

2. The provider of external financing is the government and/or friends.

3. Loan requests were refused, or approved for a partial amount.

4. Other financing (including leases, equity, trade credit, and government financing) requests were refused or only partially approved.

5. The firm pays a high interest rate relative to other loans of the same type.

To start, we assign the same score to all firms. Then we subtract a score from the initially assigned score depending on how the firm's answers satisfy the above criteria. We assign the highest scores to those that did not request external financing and reported that it is too costly to do so. Firms that requested external financing but do not satisfy any of the above criteria are assigned with the lowest score. In between are firms that satisfy some of the above criteria—for example, loans were partly approved or the firm resorted to the government for loans or loan guarantees. Finally, firms that did not request external financing do not have a score.

The indication of being constrained defined here likely represents a lower bound of the degree of constraint. Firms that made financing requests and obtained full authorization can still be financially constrained. These firms may have knowledge of the underlying financial frictions and, hence, could have taken into account such knowledge and requested an amount that the bank would approve with full authorization. Any higher amount would have been rejected.

In 2011, close to 43 per cent of firms needed external financing, including 7.8 per cent of firms that needed financing but did not apply for it. Table 4 reports the percentage of firms by degree of financial constraint. Firms with the highest scores are most likely constrained. Firms reporting no need for external financing have no value for the degree of financial constraint.

Table 4: Share of firms by likelihood of being financially constrained, 2011

No value	Unlikely	Likely	Most likely
57.0	20.4	13.7	8.9

Appendix C Data Variable Definition

The measured degree of financial constraint is based on the SFSME survey. Most other variables are from the longitudinal administrative data, General Index of Financial Information (GIFI), which is submitted to Canada Revenue Agency when business file a T2 Corporation Income Tax Return or a T5013 Partnership Information Return.

Current Debt: current liabilities, including mainly accounts payable, taxes payable, short-term debt, current deferred income, and current portion of long-term liabilities.

Long-term Debt: includes long-term debt, long-term deferred income,, and future income taxes.

Current Asset: includes cash and deposits, accounts receivable, inventories, short-term investments (e.g. term deposits),

Total Asset: equals current asset plus capital assets (i.e., machinery, equipment, furniture, and buildings) plus long-term financial assets (.e.g, shares, lending).

Cash Flow: equals income before tax but after extraordinary items, plus capital depreciation.

Value Added: equals total sales minus cost of intermediate inputs, the latter equals cost of sales minus wages and crown charges.

Hours worked: is calculated as the annual total payrolls divided average hourly wage by region and at the 3-digit NAICS level. Hourly wage is drawn from Survey of Employment, Payrolls and Hours (SEPH) by Statistics Canada.

Investment: is calculated as year-to-year changes in tangible capital assets.

Capital stock: Book value of after-depreciation capital. Alternative capital measure using the perpetual method was also used for robust checks.

When needed, real variables are obtained using the current-price values divided by corresponding implicit prices at the 2-digit NAICS level. These implicit prices are drawn from the multi-factor productivity data sets at Statistics Canada.

Appendix D Tables

Table 5: Summary statistics by likelihood of being financially constrained, 2011

	Unlikely	Likely	Most likely	No value
Investment / Capital	0.59	0.48	0.43	0.44
CF / Asset	0.22	0.18	0.15	0.24
Current debt / Asset	0.52	0.60	0.69	0.50
Long-term debt / Asset	0.30	0.33	0.32	0.27
Current asset / Asset	0.58	0.60	0.60	0.63
Firm age	14.64	13.33	13.01	15.85
Employment	15.39	11.55	7.16	9.22
Log (capital)	11.51	10.96	10.25	10.50
Log (asset)	13.03	12.60	11.89	12.41
Sales growth	4.31%	3.28%	0.33%	0.61%
Dividend>0	0.25	0.17	0.15	0.23

Table 6: Ordered probit estimation of financial constraint, 2011

	Full model		(2)	(3)
	FC	NeedFin	FC	FC
Current debt / Asset	0.174***	0.264***	0.07	0.192***
	(0.057)	(0.038)	(0.049)	(0.039)
Long-term debt / Asset	0.003	0.153***	-0.067	0.063
	(0.040)	(0.053)	(0.058)	(0.046)
Current asset / Asset	0.007	-0.200**	0.084	-0.068
	(0.117)	(0.091)	(0.139)	(0.069)
ln(asset)	-0.201***	0.134**	-0.271***	-0.086
	(0.012)	(0.060)	(0.057)	(0.058)
Sales growth	-0.006	0.102	-0.04	0.044
	(0.047)	(0.075)	(0.072)	(0.033)
Cash flow / Asset	-0.211***	-0.128***	-0.193***	-0.201***
	(0.056)	(0.033)	(0.069)	(0.047)
$1_{\{\text{Dividend}>0\}}$	-0.192***	-0.01	-0.200***	-0.152**
	(0.069)	(0.048)	(0.072)	(0.067)
$\{3 < \text{Age} \leq 5\}$	-0.629	0.715	-0.767	-0.1
	(1.262)	(1.354)	(1.455)	(1.485)
$\{5 < \text{Age} \leq 10\}$	-1.284	-0.08	-1.172	-0.642
	(0.881)	(1.009)	(1.012)	(1.102)
$\{10 < \text{Age} \leq 15\}$	-1.134**	0.237	-1.077	-0.529
	(0.533)	(0.956)	(1.101)	(0.685)
$\{15 < \text{Age} \leq 20\}$	-1.107	0.131	-0.997	-0.705
	(0.690)	(1.006)	(0.766)	(1.046)
$\{20 < \text{Age}\}$	-2.554***	-0.359	-2.284**	-1.935**
	(0.461)	(0.863)	(1.130)	(0.765)
$\{3 < \text{Age} \leq 5\}$*ln(asset)	0.06	-0.062	0.075	0.014
	(0.097)	(0.107)	(0.113)	(0.116)
$\{5 < \text{Age} \leq 10\}$*ln(asset)	0.107	0.01	0.099	0.059
	(0.068)	(0.076)	(0.082)	(0.083)
$\{10 < \text{Age} \leq 15\}$*ln(asset)	0.091**	-0.02	0.087	0.046
	(0.040)	(0.075)	(0.086)	(0.054)
$\{15 < \text{Age} \leq 20\}$*ln(asset)	0.086	-0.021	0.081	0.053
	(0.054)	(0.081)	(0.062)	(0.082)
$\{20 < \text{Age}\}$*ln(asset)	0.188***	0.002	0.176**	0.136**
	(0.033)	(0.070)	(0.086)	(0.059)
Cut 1	-2.015		-3.444***	-0.321
	(0.000)		(0.722)	(0.739)
Cut 2	-1.207***		-2.518***	0.297
	(0.059)		(0.716)	(0.737)
Observations	7,258	7,258	3,747	7,397

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 7: Marginal effects on probability of being financially constrained, 2011

	Likely		Most likely	
	dy/dx	Standard error	dy/dx	Standard error
ln(asset)	-0.015	0.004	-0.017	0.006
Business age>20	-0.029	0.019	-0.040	0.017
Current debt / asset	0.029	0.010	0.030	0.008
Cash flow / asset	-0.036	0.009	-0.036	0.011

Table 8: Production function estimation under different specifications

	$\widehat{\alpha_l}$	Std.Err.	$\widehat{\alpha_k}$	Std.Err.	RHS vars. in ω process
OLS	0.715	0.008	0.049	0.004	
No financing decisions					
ACF, exog	0.652	0.166	0.054	0.013	
ACF, endo	0.631	0.091	0.052	0.009	X_{jt-1}
With external financing, but without financial constraint					
ACF, exog	0.665	0.195	0.057	0.011	
ACF, endo	0.639	0.206	0.056	0.011	$\widehat{f^c}_{jt-1}$
ACF, endo	0.623	0.203	0.056	0.011	$\widehat{f^c}_{jt-1}, X_{jt-1}, \widehat{f^c}_{jt-1} * X_{jt-1}$
With financial constraint					
ACF, exog	0.664	0.101	0.059	0.011	
ACF, endo	0.683	0.370	0.061	0.020	$\widehat{f^c}_{jt-1}$
ACF, endo	0.674	0.280	0.061	0.013	$\widehat{f^c}_{jt-1}, X_{jt-1}$
ACF, endo	0.672	0.268	0.061	0.012	$\widehat{f^c}_{jt-1}, X_{jt-1}, \widehat{f^c}_{jt-1} \cdot X_{jt-1}$
ACF, endo	0.643	0.244	0.057	0.013	$\widehat{f^c}_{jt-1}, X_{jt-1}, \widehat{f^c}_{jt-1} \cdot X_{jt-1}, \widehat{f^c}_{jt-1} \cdot \omega_{jt-1}$

Table 9: OLS regression of productivity estimates ($\hat{\omega}$) on measured FC

	Coefficient	Robust Std.Err.
lagged FC	-0.737	0.113
FC	-0.721	0.115
Constant	0.278	0.061

Note: Total factor productivity is estimated without financing.

Table 10: Ordered probit estimation of financial constraint, 2011: role of TFP
TFP is exogenous, estimated in the model without financing.

	(1)		(2)	
	FC	NeedFin	FC	NeedFin
Current debt / Asset	0.195***	0.274***	0.181**	0.289***
	(0.066)	(0.053)	(0.074)	(0.063)
Long-term debt / Asset	0.001	0.148***	0.055	0.158**
	(0.056)	(0.051)	(0.069)	(0.071)
Current asset / Asset	0.0646	-0.197**	0.008	-0.236**
	(0.108)	(0.083)	(0.101)	(0.092)
ln(asset)	-0.086***	0.209***	-0.078***	0.205***
	(0.011)	(0.074)	(0.012)	(0.075)
Sales growth	-0.038	0.238***	-0.042	0.202**
	(0.107)	(0.055)	(0.092)	(0.084)
Cash flow / Asset	-0.146***	-0.102*	-0.187***	-0.080
	(0.055)	(0.061)	(0.036)	(0.076)
$1_{\{Dividend>0\}}$	-0.177***	-0.029	-0.114**	-0.010
	(0.068)	(0.044)	(0.056)	(0.040)
TFP	-0.269***	-0.080		
	(0.091)	(0.097)		
Lagged TFP			-0.308***	-0.120
			(0.093)	(0.090)
$\{3 < Age \leq 5\}$	1.457	1.740	0.103	0.961
	(1.318)	(1.460)	(1.146)	(1.420)
$\{5 < Age \leq 10\}$	-0.015	1.050	0.344	1.098
	(0.771)	(1.162)	(0.798)	(1.188)
$\{10 < Age \leq 15\}$	-0.004	1.188	-0.070	0.924
	(0.562)	(1.083)	(0.507)	(1.072)
$\{15 < Age \leq 20\}$	-0.314	0.747	-0.113	0.466
	(0.589)	(0.968)	(0.575)	(1.012)
$\{20 < Age\}$	-1.642***	0.618	-1.667***	0.441
	(0.496)	(0.944)	(0.635)	(1.017)
$\{3 < Age \leq 5\}$*ln(asset)	-0.094	-0.133	0.007	-0.075
	(0.106)	(0.117)	(0.093)	(0.114)
$\{5 < Age \leq 10\}$*ln(asset)	0.020	-0.065	-0.009	-0.068
	(0.061)	(0.089)	(0.062)	(0.090)
$\{10 < Age \leq 15\}$*ln(asset)	0.016	-0.082	0.021	-0.062
	(0.040)	(0.083)	(0.035)	(0.083)
$\{15 < Age \leq 20\}$*ln(asset)	0.038	-0.059	0.024	-0.038
	(0.046)	(0.075)	(0.044)	(0.079)
$\{20 < Age\}$*ln(asset)	0.129***	-0.062	0.131***	-0.049
	(0.035)	(0.077)	(0.045)	(0.082)
# of Obs.	6,459	6,459	6,112	6,112

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 11: Ordered probit of financial constraint, 2011: role of TFP
TFP is exogenous, estimated by taking into account measured FC as in Table 6.

	(1)		(2)	
	FC	NeedFin	FC	NeedFin
Current debt / Asset	0.190***	0.263***	0.194***	0.274***
	(0.074)	(0.051)	(0.065)	(0.051)
Long-term debt / Asset	0.026	0.158***	0.015	0.174***
	(0.047)	(0.054)	(0.055)	(0.051)
Current asset / Asset	0.045	-0.184**	0.038	-0.188**
	(0.113)	(0.086)	(0.115)	(0.080)
ln(asset)	-0.139***	0.180**	-0.106***	0.242***
	(0.013)	(0.070)	(0.011)	(0.075)
Sales growth	0.018	0.214***	-0.053	0.203***
	(0.091)	(0.053)	(0.099)	(0.062)
Cash flow / Asset	-0.184***	-0.083*	-0.159***	-0.089
	(0.053)	(0.046)	(0.052)	(0.060)
$1_{\{Dividend>0\}}$	-0.190***	-0.018	-0.172**	-0.020
	(0.066)	(0.037)	(0.069)	(0.042)
TFP	-0.033	-0.145**		
	(0.087)	(0.072)		
Lagged TFP			-0.072	-0.186***
			(0.090)	(0.063)
$\{3 < Age \leq 5\}$	0.236	0.648	1.407	1.790
	(1.862)	(1.360)	(1.362)	(1.423)
$\{5 < Age \leq 10\}$	-0.518	0.194	0.024	1.239
	(0.870)	(1.013)	(0.801)	(1.121)
$\{10 < Age \leq 15\}$	-0.362	0.381	0.036	1.330
	(0.638)	(0.991)	(0.598)	(1.044)
$\{15 < Age \leq 20\}$	-0.765	0.001	-0.217	0.954
	(0.559)	(0.822)	(0.554)	(0.961)
$\{20 < Age\}$	-1.958***	0.052	-1.442***	0.945
	(0.437)	(0.953)	(0.445)	(0.963)
$\{3 < Age \leq 5\}$*ln(asset)	-0.007	-0.059	-0.092	-0.137
	(0.144)	(0.108)	(0.109)	(0.114)
$\{5 < Age \leq 10\}$*ln(asset)	0.047	-0.013	0.015	-0.080
	(0.069)	(0.078)	(0.063)	(0.086)
$\{10 < Age \leq 15\}$*ln(asset)	0.031	-0.034	0.011	-0.094
	(0.050)	(0.076)	(0.043)	(0.080)
$\{15 < Age \leq 20\}$*ln(asset)	0.059	-0.016	0.029	-0.075
	(0.046)	(0.066)	(0.045)	(0.074)
$\{20 < Age\}$*ln(asset)	0.141***	-0.032	0.112***	-0.087
	(0.033)	(0.076)	(0.032)	(0.078)
# of Obs.	6,459	6,459	6,112	6,112

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 12: Comparison of productivity estimates, 2011

	OLS	ACF		
		No financing	With financing, no FC	With FC
Overall	5.86	6.37	6.25	6.14
		By asset size quintile		
1 (small)	5.56	6.02	5.91	5.81
2	5.68	6.15	6.04	5.94
3	5.83	6.31	6.21	6.10
4	5.96	6.51	6.37	6.25
5 (large)	6.28	6.85	6.73	6.60
		By measured FC		
Unlikely	5.96	6.49	6.36	6.24
Likely	5.90	6.41	6.29	6.18
Most likely	5.72	6.21	6.10	5.99
No value	5.84	6.34	6.22	6.11

Table 13: Estimation of endogenous productivity

	Coefficient	Robust Std.Err.
ω_{jt-1}	-1.326	1.174
ω^2_{jt-1}	0.374	0.167
ω^3_{jt-1}	-0.020	0.008
$\widehat{f^c}_{jt-1}$	-0.139	0.036
x_{jt-1}	0.0001	0.0004
$x_{jt-1} \cdot \widehat{f^c}_{jt-1}$	0.001	0.002
Constant	4.996	2.743
# of obs.	25,966	
F test:	$F(6,15) = 1305.53$	
R-square:	0.802	

Note: This is estimated with OLS, after obtaining TFP estimates using our ACF procedure, where the productivity process is the same as shown in this table. In ACF estimation, measured financial constraint is not used as a proxy for TFP.

Table 14: Estimation of endogenous productivity

	Coefficient	Robust Std.Err.
ω_{jt-1}	-2.515	1.494
ω^2_{jt-1}	0.567	0.239
ω^3_{jt-1}	-0.031	0.013
$\widehat{f^c_{jt-1}}$	0.065	0.040
x_{jt-1}	-0.0001	0.0004
$x_{jt-1} \cdot \widehat{f^c_{jt-1}}$	0.001	0.002
Constant	7.388	3.159
# of obs.	19,099	
F test:	$F(6,15) = 1166.61$	
R-square:	0.746	

Note: This is estimated using OLS, after obtaining TFP using our ACF procedure, where the productivity process is the same as shown in this table. In ACF estimation, measured financial constraint is used as a proxy for TFP.

Table 15: Estimation of endogenous productivity

	Coefficient	Robust Std.Err.
ω_{jt-1}	-2.058	1.510
ω^2_{jt-1}	0.511	0.234
ω^3_{jt-1}	-0.028	0.012
x_{jt-1}	-0.0002	0.0004
$\widehat{f^c}_{jt-1}$	2.122	0.640
$x_{jt-1} \cdot \widehat{f^c}_{jt-1}$	0.002	0.002
$\omega_{jt-1} \cdot \widehat{f^c}_{jt-1}$	-0.331	0.105
Constant	5.996	3.311
# of obs.	19,099	
F test:	$F(7,15) = 1889.96$	

Note: This is estimated using OLS, after obtaining TFP using our ACF procedure, where the productivity process is the same as shown in this table. In ACF estimation, measured financial constraint is used as a proxy for TFP.

Table 16: Investment regression, extensive margin, 2009 to 2013

	(1)	(2)	(3)	(4)	(5)
X_{jt-1}/K_{jt-1}	-0.0005*	-0.0004	-0.0005*	-0.0005**	-0.0005**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CF_{jt}/A_{jt}	0.199**		0.195**	0.059	0.020
	(0.083)		(0.097)	(0.070)	(0.036)
B_{jt}/A_{jt}	0.006		0.007	0.009	
	(0.024)		(0.023)	(0.023)	
ln(asset)	0.173***		0.170***	0.174***	0.163***
	(0.018)		(0.025)	(0.023)	(0.022)
Prob(FC)		-1.429***	-0.068	-0.077	-0.537**
		(0.178)	(0.308)	(0.245)	(0.240)
Prob(FC)*CF_{jt}/A_{jt}				0.737***	0.728***
				(0.162)	(0.139)
B^s_{jt}/A_{jt}					0.071***
					(0.025)
Constant	-1.864***	0.788***	-1.811***	-1.866***	-1.607***
	(0.246)	(0.062)	(0.421)	(0.370)	(0.348)
Observations	33,634	33,951	33,634	33,634	33,611

Robust standard errors in parentheses
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 17: Employment growth and financial constraint, 2009 to 2013

	(1)	(2)	(3)	(4)	(5)
CF_{jt}/A_{jt}	0.007***		0.006***	0.006***	0.006***
	(0.001)		(0.001)	(0.001)	(0.001)
B_{jt}/A_{jt}	-0.023***		-0.022***	-0.023***	
	(0.005)		(0.005)	(0.005)	
ln(asset)	-0.005*		-0.010***	-0.006	-0.0002
	(0.003)		(0.003)	(0.004)	(0.003)
Prob(FC)		-2.185***	-0.153***	-0.062	0.062
		(0.142)	(0.043)	(0.064)	(0.055)
Prob(FC)*CF_{jt}/A_{jt}				0.119**	0.154***
				(0.048)	(0.038)
B^s_{jt}/A_{jt}					-0.034***
					(0.006)
Constant	0.183***	1.056***	0.296***	0.202**	0.092
	(0.049)	(0.025)	(0.055)	(0.081)	(0.062)
Observations	41,917	58,540	41,917	41,917	41,896
R-squared	0.014	0.204	0.014	0.015	0.015

Robust standard errors in parentheses
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 18: Impact of FC and TFP on employment growth

	(1)	(2)	3)	(4)
CF_{jt}/A_{jt}	0.009	0.007		
	(0.009)	(0.018)		
B^s_{jt}/A_{jt}	-0.016***	-0.010**		
	(0.004)	(0.004)		
ln(asset)	-0.0004	-0.003		
	(0.004)	(0.003)		
Prob(FC)	-0.072	-0.067	-0.155**	-0.100*
	(0.065)	(0.060)	(0.064)	(0.050)
TFP	-0.024		-0.028**	
	(0.016)		(0.012)	
Prob(FC)*CF_{jt}/A_{jt}	0.116**	0.094*		
	(0.046)	(0.053)		
Lagged TFP		0.021		0.014
		(0.012)		(0.009)
Constant	0.055	0.062	0.076***	0.040**
	(0.060)	(0.039)	(0.024)	(0.015)
Observations	32992	25827	33227	26011
R-squared	0.009	0.007	0.005	0.004

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Firm age and industry are controlled for, but not reported. TFP is estimated in the model with financial constraint, assuming that the TFP process is exogenous.