# Financial constraints and innovation: Why poor countries don't catch up*

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**Abstract**

This paper examines micro-level channels of how financial development can affect macroeconomic outcomes like the level of income. Specifically, we investigate theoretically and empirically how financial constraints affect a firm's innovation activities. Theoretical predictions are tested using unique firm survey data which provides direct measures for innovations and firm-specific financial constraints, as well as information on shocks to firms' internal funds that can serve as firm-level instruments for financial constraints. We find unambiguous evidence that financial constraints restrain the ability of domestically owned firms to innovate and hence to catch up to the technological frontiers.

**JEL classification:** O3, O16, G3

**Keywords:** innovation, productivity, financial constraint, technology frontier, BEEPS.

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# 1 Introduction

One of the central questions in economic growth and development is why disparities in income and development across countries are large and persistent, despite increasing globalization. Much of empirical and theoretical research has been developed to identify factors that prevent less developed countries from catching up with developed countries. After decades of research, however, the question continues to puzzle the profession. Most of the difference in income across countries is attributed to differences in productivity which, in words of Moses Abramovitz, is a measure of our ignorance. In this paper, we investigate one of the most prominent driving forces of productivity growth, innovation activities, and attempt to shed light on frictions that prevent companies from catching up to the technological frontier.

There is ample macroeconomic evidence suggesting that the development of a country is strongly correlated with the development of financial markets (see e.g. Banerjee and Duflo (2005) and Levine (2005) for surveys). Although microeconomic channels for this relationship are an area of active research, many aspects remain unclear. The lack of micro-level evidence is particularly striking for non-OECD countries and for dynamic aspects of productivity gains through innovation activities. Stylized facts from OECD countries point to financial frictions as one important impediment for investment as well as research and development (R&D) spending made by firms at the microeconomic level (see Hall (2002) and Hall and Lerner (2010) for surveys). Another stylized fact that appears from emerging markets and transition economies is that foreign owned firms tend to be more productive than domestically owned firms. Moreover, these productivity differences between domestically and foreign owned firms do not seem to diminish over time (Blomstrom (1988), Haddad and Harrison (1993), Aitken and Harrison (1999), Arnold and Javorcik (2009), Estrin et al. (2009)).[1] While there is certainly more than one potential explanation that can be offered for this observation, the interpretation we propose is that to the extent that domestically owned firms are more financially constrained than foreign owned firms, financial constraints may be an important factor preventing domestically owned firms from emulating the best practices and techniques.

We explore this micro-channel in a stylized theoretical framework where firms take decisions about whether or not to innovate given financial constraints. We show that a firm's decision to invest into innovative activities is sensitive to financial frictions which can prevent firms from adopting better technologies. We test predictions of our model using Business Environment and Enterprise Performance Surveys (BEEPS) which covers a broad array of sectors and countries in Eastern Europe and Commonwealth of Independent States (CIS). As we argue below, this data set has a number of advantages relative to data sets used in previous research. Most importantly,

[1] A part of the discrepancy in the levels of productivity of domestically and foreign owned firms could be due to selection effects when only most productive firms establish subsidiaries abroad or when foreign owners purchase only most productive domestically owned firms. However, even after controlling for such effects (Estrin et al. (2009)), the difference between domestically and foreign owned firms remains large and persistent.

BEEPS collects direct measures of innovation and financial constraints so that we do not have to rely on indirect proxies for the key variables in our analysis. We document that these self-reported measures are strongly correlated with more objective macroeconomic indicators of growth and financial development. In addition, BEEPS provides information on shocks to firms' cash flow and internal funds which we can use as firm-level instrumental variables for our measures of financial constraints. For example, we have information on whether or not firms have overdue payments or resort to non-conventional forms of payment like barter, which are reported as a typical response to exogenous shocks in cash flow. Furthermore, we know to what extent firms suffered losses from input delivery delays or breakage and spoilage of goods. We provide evidence from the surveys suggesting that these instruments are unlikely to be affected by innovation activities but instead are reliable measures of exogenous shocks to the firms' financial constraints. We find that with the help of these firm-specific instruments we can successfully identify the negative impact of financial constraints for firms in transition economies.

Our preferred econometric results based on instrumental variable estimates unambiguously suggest that innovative activities of firms are strongly negatively influenced by financial frictions.[2] We find that one standard deviation of our measures of financial constraints explains around 20 percent of the observed variation in product and process innovations, and hence the effects are economically highly significant. Moreover, we show that domestically owned firms innovate less and are indeed more likely to be negatively affected in their innovation activities by financial constraints than foreign firms, which helps explain why domestically owned firms do not catch up. Among the private domestically owned firms we find that smaller firms, younger firms and firms in service sectors are more negatively affected as compared to larger and older firms and firms in manufacturing sectors. We subject the sensitivity of our findings to a variety of robustness checks, controlling e.g. for labor productivity, demand shocks, or collateralization of innovation activities and find that our results are remarkably robust. Finally, we document that financial frictions measured at the firm level are strongly negatively correlated with macroeconomic measures for productivity. Thus, our analysis lends support to our argument that financial frictions constitute one potential microeconomic channel restraining macroeconomic productivity and growth by adversely affecting innovation.

These findings point to important policy issues that deserve further investigation. Reducing the cost of as well as enhancing access to external finance is likely to lead to more intensive innovation activities which, in turn, are likely to yield an enhanced development of new goods and technologies and adoption of frontier technologies and practices.[3] Otherwise, costly external

[2]In a previous version of this paper, we document also that the decision of firms to engage in exporting as another productivity enhancing activity is similarly negatively affected by financial constraints (Gorodnichenko and Schnitzer (2010)).

[3]More intensive innovation is unlikely to decrease welfare (e.g. due to duplication of efforts) in BEEPS countries since innovation in developing and transition economies is primarily about adopting technologies existing in developed countries.

funding due to poor access or excessively high interest rates may significantly hamper convergence to the technological frontier. Thus, developing financial markets that ensure access to external funding for a broad array of firms can be an important prerequisite to boost productivity at micro and macro levels.

Our analysis builds on a large literature documenting the effects of financial frictions on R&D expenditures in OECD countries (see Hall and Lerner (2010) for a review). Early papers in this literature exploited the idea that a change in available internal funds should not affect investment or R&D expenditure, if firms are not limited in their access to external funds. This hypothesis was tested by examining the sensitivity of investment and R&D spending to cash flow variables in the standard Euler-type investment regressions. The identification strategy proposed by Fazzari et al. (1988) was to classify firms on a priori characteristics like age into more and less financially constrained firms and to explore whether financially constrained firms showed a higher cash flow sensitivity in their investment behavior than firms that were classified as being less financially constrained.[4] Himmelberg and Petersen (1994) were the first to report an economically large and statistically significant relationship between R&D expenditure and internal finance for a panel of small high-tech firms. Similarly, Mulkay et al. (2001) compare the cash flow sensitivity of both R&D expenditure and capital investment for US and French firms. They find that cash flow has a much larger impact on both R&D and investment in the US than in France. They also observe no significant difference between the sensitivity of investment and R&D expenditure to measures of financial constraints. Bond et al. (2006) compare firm level panel data from the UK and Germany providing evidence that suggests that financial constraints are more relevant for British firms than for German firms.

More recently this literature has started to shift focus to direct measures of innovation rather than indirect ones such as R&D spending, as data from innovation surveys in OECD countries have become available for econometric analyses. These surveys were formalized and standardized in the Oslo Manual which defines what is meant by an innovation and specifies ways of quantitatively measuring innovation. One of the challenges that arise when using these survey data is to deal with endogeneity issues. When investigating the effects of potential obstacles to innovation it has been observed that unless such endogeneity issues are controlled for these obstacles lead to positive coefficients when in fact a negative coefficient would be expected (see Mairesse and Mohnen (2010) for a discussion of the use of innovations surveys for econometric analyses).[5] For example, Canepa and Stoneman (2008) report that firms from high industries and small firms in the U.K. were more

[4]However, the rationale of this approach was challenged by Kaplan and Zingales (2000), on the grounds that investment cash-flow sensitivities need not increase monotonically with financial constraints and that investment opportunities may not be sufficiently controlled for.

[5]Carlin et al. (2010) study to what extent the non-availability of public infrastructure poses an obstacle to business activities, using surveys like BEEPS and similar ones for developing countries. They argue that such obstacles should matter more for firms that are more productive and hence willing to do business and find that indeed more productive firms report higher costs from lack of infrastructure.

likely to report a project being abandoned or delayed due to financial constraints. Hajivassiliou and Savignac (2007) make a similar observation based on French survey data. They find that innovation and financial constraints are positively correlated in the full sample, but that the coefficient turns negative when they restrict their sample to firms they classify as likely innovators.

Our paper contributes to this literature by documenting robust evidence on the impact of financial constraints on innovation activities for non-OECD countries, on the basis of surveys similar to the innovation surveys carried out for OECD countries, but with the additional advantage of more detailed firm-specific information and hence a richer set of potential instruments than is available for OECD countries. The BEEPS surveys collects information on innovation and financial constraints in transition countries, following the recommendations of the Oslo Manual. In addition, they collect information about the structure of revenues as well as other information on shocks experienced by the firm that may affect its financial status. Thus, as outlined above, we have time-varying firm-level information that we can use to address potential endogeneity of access to external finance.

A further contribution of our paper is to document significant productivity differences between foreign owned and domestically owned private firms that are persistent over the two waves of surveys that we study. This observation is consistent with findings from other studies, like Criscuolo and Martin (2009) who show that U.S. owned plants in the U.K. are more productive than U.K. owned plants, even if the latter are restricted to U.K. multinationals. Exploiting dynamic variation in the data, they find evidence suggesting that this productivity advantage stems from U.S. firms taking over already highly productive firms in the U.K. Although our data do not permit us to properly control for possible selection of productive firms into foreign ownership ("cherry picking"), we can check the quantitative importance of such effects by assessing the gap for de novo firms which were founded after 1991 and were never in state ownership. Thus, we can effectively compare "greenfield" domestically and foreign owned firms. If we restrict our sample to these newly founded firms we find that our results are still very similar. This finding is consistent with Estrin et al. (2009) documenting that the productivity gap between domestically and foreign owned firms does not shrink considerably after controlling for selection into foreign ownership.

Ayyagari et al. (2011) is the closest work to the present paper. Similar to our results, Ayyagari et al. (2011) find a positive relationship between the use of external finance and the extent of innovation. Our paper is different from Ayyagari et al. (2011) in several key respects and we would like to emphasize the three most important ones. First, we use a direct measure of financial constraints based on reported difficulties in access to external finance rather than the actual use of external finance to finance investment which does not adequately reflect how firms intended to finance their investment and would not be informative if investments do not occur due to financial constraints. Second, we use time-varying firm-level rather than time-invariant country-level instrumental variables to address potential endogeneity of access to external finance. This is important for two

reasons: *i*) using time-invariant country-level instruments (e.g., legal origin) effectively amounts to running regressions with data aggregated to country level and thus is vulnerable to shocks affecting access to external finance at the country level; *ii*) firm-level variation dwarfs variation at the country level and hence using country-level instruments may capture only a small fraction of variation so that estimates may be imprecise and may measure the causal effect only due to country-level variation rather than quantitatively more important firm-level variation. Finally, we also provide a theoretical rationale why access to external finance may matter for innovation, even though most firms report to rely exclusively on internal finance for their innovation activities.

The paper is organized as follows. Section 2 lays out a stylized model of a firm's decision to innovate when faced with financial constraints. Section 3 describes the data and Section 4 presents the econometric specification. In Section 5 we report the main empirical findings. Section 6 concludes.

# 2 Theoretical Framework

In this section we develop a stylized model to highlight the interaction between financial constraints and innovation activities. We abstract from many details to present a clear picture of how these phenomena are interconnected. We will use this prototypical model to derive a series of falsifiable implications which we will test later in the empirical sections of the paper.

Consider an investor who has the opportunity to invest in innovation activities, at a fixed cost $F_I$, before engaging in production.[6] Since the focus of our analysis is the impact of financial constraints on the investor's innovation activities, we need to specify in some detail how innovation and production are financed. In principle, the investor can use either internal funds resulting from previous cash flows or external funding obtained from creditors to finance current expenditures. We assume that external funding is more expensive than internal due to asymmetric information problems. Specifically, to finance one unit of credit the investor has to pay $\gamma > 1$ for external financing while the opportunity cost of internal financing is normalized to 1.[7]

Consistent with the empirical evidence (e.g. Hall and Lerner (2010), Ughetto (2008)), we assume that to finance innovation at stage 1, the investor has to rely on internal funds from positive cash flows. Intuitively, innovation is an activity which is particularly prone to asymmetric information problems and that cannot be easily collateralized. This rules out using external finance for innovation.

At stage 2, production needs to be financed. The firm prefers to use internal finance for production, if possible, but needs to turn to external sources if internal funds are not sufficient.

[6] In principle, the innovation can take two forms: product innovation and process innovation. For the purpose of our analysis, however, it is not necessary to distinguish these two forms: to fix ideas, we assume that both forms of innovation increase the firm's profit potential by the same amount.

[7] The cost $\gamma$ absorbs not only the direct cost of credit from external sources but also indirect costs associated with external credit being unavailable.

We assume that a priori, sufficient internal funds for production will be available with probability $q$, while external finance needs to be used with probability $(1-q)$.

We capture financial constraints by the likelihood with which the firm needs to rely on external financing. There are two kinds of events that can increase the likelihood of the need to rely on external finance. First of all, the investor may spend internal funds on innovation activities at stage 1, which leaves less internal funds for production at stage 2. In this case, the likelihood of having sufficient internal funds is lowered by $\delta_I$. Furthermore, the investor may experience a shock to liquidity, due to late payments by customers, for instance. This lowers the likelihood of having sufficient internal funds by $\delta_L \in \{0, \overline{\delta_L}\}$. While the investor can influence the first kind of events, by choosing whether or not to innovate, we assume that he has no influence on the second kind of events.

Both cases imply that the investor has to rely on external finance with larger probability.[8] It is in these cases that the investor will feel financially constrained, because he realizes that he needs external finance which may be difficult or very costly to obtain.[9] Since innovation reduces the amount of internal funds, it increases the probability of hitting financial constraints and thus one may observe in the data that incidences of innovations and reported severity of financial constraints are positively correlated. Exogenous shocks to internal funds, on the other hand, are unaffected by innovation activities and hence this source of variation can be used later as an instrumental variable.

In summary, the sequence of events is as follows. In stage 0, the potential exogenous shock to liquidity, $\delta_L \in \{0, \overline{\delta_L}\}$, is realized. In stage 1, the investor considers whether or not to innovate. Let $\pi_i$ denote the profit if no innovation takes place where $i = 0$ if production is financed with internal funds and $i = \gamma$ if it is financed externally, with $\pi_0 > \pi_\gamma$. Similarly, for $i = \{0, \gamma\}$ let $\pi_i^I$ denote the profit if the investor has carried out an innovation with $\pi_i^I > \pi_i$. We assume that the increase in profit resulting from innovation decreases as the cost of financing increases, i.e.

**Assumption 1**

$$\frac{d(\pi_\gamma^I - \pi_\gamma)}{d\gamma} < 0 \tag{1}$$

In the appendix, we show this assumption to hold for a standard model of monopolistic competition.[10]

[8]Note that the investor may have some leeway how to deal with such a liquidity shock. He may for example consider postponing payment to his customers as well. However, this is typically considered a particularly costly way of external financing. Furthermore, it is likely to reflect negatively on his reputation as a creditor and hence likely to increase the cost of ordinary debt financing as well. Thus, it does not reduce the total need of costly external finance, and he will turn to this particular form of external finance only if forced to.

[9]It is straightforward to extend our theoretical analysis to including the case where a negative liquidity shock $\delta_L$ has a positive impact on the cost $\gamma$ at which external finance can be attracted. This reinforces the negative impact of a negative liquidity shock on the incentive to innovate.

[10]As pointed out by one of the referees, this assumption does not cover innovation incentives that are positively affected by financial constraints, due to an immediate risk of insolvency, or the incentive to ease financial constraints by getting ahead of competitors. Even in this case, however, financial constraints still affect the capacity to finance

Ex ante, the investor's expected payoff if he does not innovate is

$$E(\pi) = (q - \delta_L)\pi_0 + (1 - q + \delta_L)\pi_\gamma \tag{2}$$

If the investor spends internal funds on innovation at stage 1, production can be financed internally at stage 2 with probability $(q - \delta_L - \delta_I)$, while with probability $(1 - q + \delta_L + \delta_I)$ external finance has to be used. In case of innovation, the ex ante expected profit is

$$E(\pi|I) = (q - \delta_L - \delta_I)\pi_0^I + (1 - q + \delta_L + \delta_I)\pi_\gamma^I - F_I, \tag{3}$$

where $F_I$ is the fixed cost of innovation activity. At stage 2, production takes place and profits are realized.

We can now determine the investor's incentive to innovate at stage 1 and how this is affected by potential financial constraints arising from negative liquidity shocks at stage 0. His incentive to innovate is given by the difference in expected profits:

$$\begin{aligned} \Delta_\pi^I &\equiv E(\pi|I) - E(\pi) \\ &= (q - \delta_L)(\pi_0^I - \pi_0) + (1 - q + \delta_L)(\pi_\gamma^I - \pi_\gamma) - \delta_I(\pi_0^I - \pi_\gamma^I) - F_I. \end{aligned} \tag{4}$$

Naturally, a firm decides to innovate if and only if $\Delta_\pi^I > 0$. To determine the impact of exogenous liquidity shocks, we take the first derivative of $\Delta_\pi^I$ with respect to $\delta_L$.

$$\frac{d\Delta_\pi^I}{d\delta_L} = -(\pi_0^I - \pi_0) + (\pi_\gamma^I - \pi_\gamma) < 0. \tag{5}$$

which follows from Assumption 1. Thus, the more severely the firm is hit by an exogenous liquidity shock, the less likely it is to innovate.

In the next step we examine how the impact of financial constraints is affected by the cost of external finance. We find that

$$\frac{d^2\Delta_\pi^I}{d\delta_L d\gamma} = \frac{d(\pi_\gamma^I - \pi_\gamma)}{d\gamma} < 0. \tag{6}$$

Thus, the larger $\gamma$, i.e. the larger the cost of external finance, the more damaging is the effect of a negative liquidity shock on the incentive to innovate. Note that although innovation is always financed internally, the cost of external finance matters for the innovation incentive. This is due to the fact that external finance may play a role for the production cost and hence for the overall profitability of the firm. Thus, the larger the cost of external finance, i.e. the smaller $(\pi_\gamma^I - \pi_\gamma)$, the more detrimental it is to rely on external finance and hence the more negative the impact of a negative liquidity shock is on the firm's innovation activities.[11]

the innovation and hence the overall conclusion that financial constraints should be expected to negatively affect innovation activities is unaffected. Hence, in our interpretation, the empirical results reflect the response of actual innovation to tighter financial constraints, not necessarily their incentives to innovate.

[11] Although our partial equilibrium analysis provides a number of useful insights, it may miss some general equilibrium effects which can amplify or attenuate factors highlighted in our analysis (see e.g. Song et al. (2010)). We leave analysis of these general equilibrium effects to future research.

We can now turn to the predictions implied by our theoretical framework. From equation (5) above, we can establish the following hypothesis.

**Hypothesis 1** *The more severe the financial constraints, as caused by the negative liquidity shock (larger $\delta_L$), the less likely it is that the firm engages in innovation activities.*

Hypothesis 1 is the central prediction of our model. Effectively it states that a drain of internal funds is likely to make other activities (e.g. production or purchases of new machines) more expensive and, therefore, firms are less likely to invest in innovation. For an empirical test of this hypothesis (Section 4), we will use exogenous shocks to a firm's liquidity as an analogue of $\delta_L$ to establish whether binding financial constraints cause less innovation.

Our strategy to test this hypothesis will be to regress firms' innovation activities on self-reported measures of financial constraints. As we will explain in more detail in Section 4, we will use exogenous shocks to a firm's liquidity as an instrument to resolve potential endogeneity issues for these financial constraints, as captured by this hypothesis.

**Hypothesis 2** *The larger are the cost of external finance (larger $\gamma$), the more negative is the impact of financial constraints on the firm's innovation activities.*

Hypothesis 2, which follows from equation (6), suggests that financial constraints are likely to be more detrimental, the more expensive it is to finance innovation externally. To test this hypothesis, one can use external (or prior) information on the degree of financial costs to classify firms into groups characterized by low and high costs (e.g., old vs. new firms, regions with different levels of development of financial markets) and then investigate whether the sensitivity of innovation to financial constraints systematically varies across groups as expected, with greater sensitivity expected for groups with higher financial costs.

# 3 Data

To test the predictions outlined in the previous section, we use data from the 2002 and 2005 Business Environment and Enterprise Performance Survey (BEEPS), a joint initiative of the European Bank for Reconstruction and Development (EBRD) and the World Bank Group.[12] These are large surveys of 6,500 firms in 2002 and 7,900 firms in 2005 in 27 transition countries.[13] An important

[12]The survey was done again in 2008, but unfortunately, some of the key variables for our empirical analysis were dropped from the questionnaire, so we restrict our data to the two waves of 2002 and 2005.

[13]In both years the surveys were administered to 15 countries from Central and Eastern Europe (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Serbia and Montenegro, Macedonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, and Slovenia), 11 countries from the former Soviet Union (Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Ukraine and Uzbekistan) and Turkey. In neither year could the survey be administered in Turkmenistan. Our estimation sample includes only about 11,500 firms due to missing observations on variables on interest.

feature of this data set is the inclusion of firms in the service sector, which is the new dynamic (yet understudied) sector in these economies. The surveys relied on the same sampling frames and used identical questionnaires in all countries. To ensure that the samples are representative of the relevant population of firms, the surveys used stratified random sampling, as explained in more detail in the Data Appendix. For example, in each country, the sectoral composition of the sample in terms of manufacturing versus services was determined by their relative contribution to GDP.[14] Firms that operate in sectors subject to government price regulation and prudential supervision, such as banking, electric power, rail transport, and water and waste water, were excluded from the sample. The sample includes very small firms with as few as two employees and firms with up to 10,000 employees. Moreover, the data include firms in the rural areas as well as large cities. Hence these data enable us to analyze diverse firms in a large number of countries. In addition, the data set contains a small panel component, where about 700 firms were surveyed in both 2002 and 2005.[15] While we use these panel data for robustness checks, our analysis relies primarily on the pooled 2002 and 2005 data since many variables of interest have a retrospective component in each survey date and because it is hard to detect robust relationships with a small panel of heterogeneous firms, especially when we use many control variables.

BEEPS asks firms to report various types of innovation activity. Specifically, it asks whether firms have undertaken any of the following initiatives in the last three years: Developed successfully a major new product line or upgraded an existing product line - hereafter *New Product*; acquired new production technology – hereafter *New Technology*. These measures of innovation follow the recommendations of the Oslo Manual (OECD (2005)) developed by the OECD and Eurostat for innovation surveys for OECD countries. It defines what is meant by an innovation, suggesting in particular the use of survey measures of innovations which are "new to the firm".

Of course, self-reported qualitative measures of innovation are by definition more prone to measurement errors and cultural biases than more objective measures like patents or R&D expenditures. Mairesse and Mohnen (2010) discuss extensively the pros and cons of using innovation surveys for econometric analysis and acknowledge the subjectivity of the measures. Nevertheless, these measures of innovation have several advantages over the commonly used measures of patents and R&D expenditures, in particular when studying innovation activities in non-OECD countries. Most importantly for our purposes, patenting and formal R&D are less likely to be observed in emerging market economies. Domestically owned firms are expected to engage more in imitation and adaptation of already created and tested technologies, rather than generating new inventions

[14]Manufacturing includes: manufacturing and agro-processing. We do not include mining, quarrying and construction into manufacturing. Services includes: Transportation, storage and communications; wholesale, retail, repairs; real estate, business services; hotels and restaurants; other community, social and personal activities; and commerce.

[15]The relatively small size of the panel should not be associated with intensive exit of firms in these countries. The size of the panel is mainly brought about by a refusal of firms to participate in the new wave of the survey (42%) and inability to reach eligible responders within firms (25%).

or expending resources on R&D (see Acemoglu et al. (2006) for more discussion). Therefore to capture the catching up process of domestic firms it is crucial to rely on measures of innovations that are "new to the firm", not "new to the world", as specified by the Oslo Manual. This is substantiated in our data where the majority (70%) of firms who answered that they acquired a new technology said that it was embodied in new machinery or equipment that was purchased or licensed from other sources. Furthermore, the measures we use capture also management innovations, which can be argued to be more important than inventions for improving a firm's competitiveness and efficiency (see e.g. Bloom et al. (2011)).

One way to check the validity our these self-reported innovation measures is to look at the correlation between the intensity of innovation activities reported in BEEPS and the growth rate of real GDP per capita. As shown in Figure 1, the strong positive correlation suggests that *New Product* and *New Technology* are meaningful indicators of innovation and our analysis can provide micro-foundations for interpreting the correlation between financial and economic development at the macroeconomic level as a causal one. In addition, cultural differences are taken care of by controlling for country and industry fixed effects.

In comparison, patents are easily and accurately measured, but have other weaknesses instead: 1) they measure inventions rather than innovations; 2) the tendency to patent varies across countries, industries and processes; and 3) firms often protect their innovations by using methods other than patents (maintaining technological complexity, industrial secrecy, and lead time over competitors). Using R&D expenditures may also be inappropriate because not all innovations are generated by R&D expenditures, R&D does not necessarily lead to innovation (it is an input rather than output), and formal R&D measures are biased against small firms (see e.g. Michie (1998), Archibugi and Sirilli (2001)). However, to complement our analysis of innovation, we construct a dummy variable equal to one if a firm reports positive R&D spending and zero otherwise. We prefer using this measure of innovation to the volume of R&D spending because the distribution of R&D spending is highly skewed with a large mass of firms reporting zero R&D expenditures. Unfortunately, few firms answer the question about R&D spending so that the sample size with non-missing responses shrinks by approximately 50%. Finally, we construct a measure of total factor productivity (TFP) which captures the *derived* effect of innovations. We compute TFP using the cost shares for labor, material and capital (computed for each firm and aggregated for a given industry in each country and year) and adjust it for capacity utilization ($CU$):

$$logTFP_{isct} = logY_{isct} - s^L_{sc} logL_{isct} - s^M_{sc} logM_{isct} - s^K_{sc} logK_{isct} - logCU_{isct} \tag{7}$$

where $i$, $s$, $c$, and $t$ index firms, industries, countries and time, $s^L_{sc}$,$s^M_{sc}$,$s^K_{sc}$ are labor, materials and capital cost shares, $Y$ is sales, $L$ is number of employees, $M$ is the value of materials and $K$ is the replacement value of capital.[16] Since only about one-half of the firms report sales revenue and

[16]The interpretation of the measured productivity given by equation (7) should be careful. As argued by Gorod-

even fewer report capital, the TFP-measure is available for less than 5,000 firms with non-missing information on TFP and other key firm characteristics.

Because we lose so many observations with the R&D dummy and TFP-based measure of innovation, we use these alternative measures only as a robustness/validity check. For example, we show in Table 1 that self-reported measures of innovation are indeed positively related to objectively measured productivity and thus they are meaningful indicators of productivity enhancing activities.

In addition to basic information about firm characteristics such as age, employment size and composition, and degree of competition, BEEPS collects information on self-reported measures of access to finance. Specifically, firms are asked to report on a 1 ("No obstacle") to 4 ("Major obstacle") scale how problematic access to financing (e.g., collateral required or financing not available from banks) is for the operation and growth of the firm's business, hereafter *Difficulty of Access to External Finance*. Similar information is collected for the cost of financing (e.g., interest rates and charges), hereafter *Cost of External Finance*.

These self-reported measures of financial constraints capture directly the problems firms face when trying to finance investments. In contrast, variables that measure the actual use of external finance to fund innovations, which are often used as a measure of financial difficulties (see e.g. Ayyagari et al. (2011)), can fail to adequately reflect how firms intended to finance their investment. One should be aware, however, that self-reported measures give rise to two potential problems. The first one is that they may be subject to endogeneity problems. In the following section we discuss in detail our IV strategy to solve this endogeneity issue. The second problem is that they are subject to potential measurement errors and may be distorted due to subjective or cultural biases. Thus, it is important to check whether these measures are correlated with alternative indicators especially at the macroeconomic level given our interest to explain cross-country differences in macroeconomic outcomes.

Figure 2 plots the average score of reported difficulties with the cost of and access to external finance against indicators of financial development (private credit to GDP ratio and the net interest rate margin). The self-reported measures are clearly positively correlated with more objective macroeconomic indicators of financial development. In addition, since our analysis aims to explain the effect of financial constraints on innovation (and more generally productivity) at the micro level, we can explore if the average size of the frictions reported at the country level is correlated with macroeconomic outcomes and thus can reconcile the macroeconomic evidence that the development of financial markets is strongly correlated with the development of a country. Figure 3 confirms that reported financial constraints at the firm level show a strong negative correlation with macro-level measures for productivity, which is consistent with previous studies based on macroeconomic data (Levine (2005), Lane (2009)). Thus, our measures of financial constraints are meaningful

nichenko (2007) and others, measured productivity captures the revenue generating ability of firms (which includes both market power and technology level) rather than the technology level of firms.

indicators of financial development at the country level and by explaining effects of variation in our measures of financial constraints we can shed new light on the sources of cross-country variation of income and productivity. Finally, in another validity check of self-reported measures, we find that self-reported measures of financial constraints are strongly positively correlated with the probability to be denied a loan and the interest rate on received loans (results not reported).

# 4 Econometric Specification

## 4.1 Baseline specification

We estimate the following baseline probit specification with the pooled data in the 2002 and 2005 BEEPS for private domestically owned firms (i.e., with no foreign or state ownership):

$$\begin{aligned} I_{isct} = \Phi\{\alpha_0 FC_{isct} &+ \beta_1 logL_{isc,t-3} + \beta_2 (logL_{isc,t-3})^2 + \beta_3 Edu_{isc,t-3} \\ &+ \beta_4 Skill_{isc,t-3} + \beta_5 Age_{isct} + \beta_6 CMN_{isct} + \beta_7 Markup_{isct} \\ &+ \beta_8 SMNE_{isct} + \beta_9 Import_{isct} + \beta_{10} CU_{isc,t-3} \\ &+ \beta_{11} OptimalEmpl_{isct} + \beta_{12} ShareTempEmpl_{isc,t-3} \\ &+ \gamma Loc_{isct} + \lambda_s + \eta_c + \psi_t + error\} \end{aligned} \tag{8}$$

where $I$ is a dummy variable equal to one if the firm reported an innovation activity (like product or process innovation), and zero otherwise; $\Phi$ denotes c.d.f. of a standard normal random variable; $i$, $s$, $c$, and $t$ index firms, industry, country, and time, respectively. For continuous measures of innovation such as TFP we estimate the linear analogue of specification (8) with the same set of regressors. Variables dated with period are taken from retrospective questions about the firm's performance three years prior to the current date. In addition to industry ($\lambda_s$), country ($\eta_c$) and year ($\psi_t$) fixed effects,[17] the following variables are included to control for a number of firm-specific factors deemed to be important in the literature (see Becheikh et al. (2006) for an extensive review):

> $FC$, the main variable of our analysis, is a measure of financial constraints faced by firms. Our theory predicts that $\alpha_0$ should be negative. To measure FC we will employ two variables, *Difficulty of Access to External Finance* and *Cost of External Finance*.
>
> $L$ (the number of employees) measures the size of the firm. The argument for including size is that large companies have more resources to innovate and can benefit from economies of scale in R&D production and marketing.

[17] We also considered interactions of year, country, and industry fixed effects and found similar results. However, since these interactions consume many degrees of freedom and in our analysis of subsamples we often have relatively few observations, we do not put these interactions in the baseline specification, but report them in the robustness checks in Table 6.

$EDU$ (the share of workers with a university education) and $SKILL$ (the share of skilled workers) capture human capital in the firm. These variables might be expected to be positively correlated with innovation if $EDU$ reflects the involvement of workers in R&D and more skilled workers ($SKILL$) are able to give feedback to the firm on how to improve a product.

*Age* of the firm is the log of the number of years since the firm began operations in the country. Two hypotheses are plausible: one suggesting that older firms developed routines that are resistant to innovation and another suggesting that older firms will accumulate the knowledge necessary to innovate. There is evidence for both hypotheses.

Variables $CNM$ and $Markup$ capture competitive pressures. $CNM$ is a dummy equal to one if the firm competes in the national markets and zero otherwise (e.g., when a firm only competes in a regional or local market). We expect $CNM$ to have a positive effect on innovation, given that the firm operates in a larger market. $Markup$ (the price to cost ratio) is used as a proxy to estimate the effect of competition faced by each firm (see e.g., Nickell (1996); Aghion et al. (2005)). $Markup$ can also proxy for profitability and, thus, more generally for demand and supply conditions. Gorodnichenko et al. (2010) show that both $Markup$ and $CNM$ are positively related to the incidence of innovations.

$SMNE$ (the share of sales to multinational enterprises) and $Import$ (the share of imported inputs) capture vertical linkages or transfer of capabilities. Presumably exposure to foreign firms and markets is likely to stimulate more innovation as foreign firms and markets are likely to have better technologies, practices and products.

Location (*Loc*) is a set of dummies for size of population where the firm is operating or headquartered. This will control for potential differences in knowledge available in larger v. smaller cities.

Capacity Utilization ($CU$) is the percentage of a firm's output relative to maximum possible output. Although capacity utilization has been found to be a strong predictor of innovations (e.g. Becheikh et al. (2006), Ayyagari et al. (2011)), the effect of $CU$ on innovation is a priori indeterminate. If firms are too busy filling demand, they may be more interested in extending their current capacity than finding new ways of producing goods and services. At the same time, if firms are at capacity they may need to innovate.

*OptimalEmpl* is the survey response to the question about optimal number of employees relative to the current employment. For example, *OptimalEmpl* equal to 10% percent means that a firm would like to grow by 10 % relative to its current size. We use *OptimalEmpl* as an additional measure of capacity utilization as $CU$ may be contaminated with measurement errors.

*ShareTempEmpl* is the share of temporary workers in the total employment in a given firm. Similar to *CU* and *OptimalEmpl*, *ShareTempEmpl* proxies for capacity utilization.

Appendix Tables A1 provides summary statistics for variables used in our analyses. More information on the construction and definition of variables is available in the Data Appendix.

## 4.2 Instrumentation Strategy

Estimating specification (8) by ordinary least squares or probit may lead to biased estimates of the key parameter $\alpha_0$. In other words, consistent with our model, firms that intend to innovate are more likely to hit a financial constraint than firms that do not even try. This observation has been made by others using innovation survey data from OECD countries. Hajivassiliou and Savignac (2007), based on French survey data, illustrate the issue by estimating the sensitivity of innovation to financial constraints for two samples of firms: the full sample, which includes all firms, and a restricted sample. In the restricted sample, they include firms that are likely innovators and exclude firms that show no innovation activity despite being not financially constrained. Hajivassiliou and Savignac (2007) find that innovation and financial constraints are positively correlated in the full sample and negatively in the restricted sample. In summary, innovating firms are more likely to hit financial constraints and therefore one may find a positive relationship between financial constraints and incidence of successful innovations.[18]

To correct for this endogeneity bias, we propose using instrumental variables which affect financial constraints but do not (directly) influence the intensity of innovative activities. Exogenous shocks to cash receipts of a firm appear to be a natural candidate since they can be interpreted as $\delta_L$ in our model. Such shocks affect the amount of internal funds as well as the attractiveness of firms to external creditors but do not influence innovations directly.[19]

Fortunately, BEEPS collects information about the structure of revenues and about exogenous shocks to the firm's cash flow as well as how the firm reacted to these shocks. Specifically, we will use three variables. The first variable is *Overdue*, which is the dummy variable equal to one if a firm has overdue payments to suppliers. There are several reasons why this variable should be a good instrument. First, Table 2 (Panel A) documents that when confronted with the hypothetical case of an unexpected loss in incoming cash flow, approximately half of all domestic private firms report that they would delay payments to their suppliers. This reaction is the most popular response to a temporary cash flow reduction. Second, it is highly unlikely that firms use non-payments to

[18]Note that the financial constraint variable *FC* refers to the last year while innovation measures are reported over last three years. Since innovation is likely to lead to financial constraints as argued in Canepa and Stoneman (2008) and Hajivassiliou and Savignac (2007), this difference in timing may bias our estimates up and thus our estimates provide a lower bound of the true causal effect.

[19]An additional source of discrepancy between regular and IV probits could be measurement errors in self-reported measures of financial constraints. Using instrumental variables could correct the attenuation bias as well.

suppliers to finance innovation as this form of external finance is considered extremely costly (e.g. Elliehausen and Wolken (1993)).[20] In fact, the usage of trade credits in general is often employed to separate groups of firms according to financing constraints (see e.g. Petersen and Rajan (1994)). As Panel B in Table 2 shows, in our surveys only a handful of firms reported that they use trade credit to any significant extent to finance investment or working capital. Only 0.7% (4%) of firms reported that 50 (10) or more percent of their new investment was financed with trade credit. 2.3% (12%) reported that 50 (10) or more percent of their working capital was financed with trade credit. The vast majority of firms (70 - 80 percent) in our sample use internal funds to finance new investment and working capital. Thus, it is highly improbable that firms voluntarily rely on overdue payments unless they face a stark shortage of liquidity. Since external creditors may be unable (e.g., due to asymmetric information) to differentiate insolvent vs. illiquid (but solvent) firms, availability of external financing is likely to fall for firms with overdue payments.[21]

The second variable is $NTP$ which is the share of payments settled by debt swaps or offsets and exchange of goods for goods (barter). As shown in Panel A of Table 2, this is another option typically chosen by firms when confronted with a temporary loss in cash flow. Overall, we find that up to three quarters of all domestic private firms chose at least one of the three options (overdue, veksels, barter) as a reaction to a potential loss of cash flow. Hence, the use of these non-traditional forms of payment settlements is likely to reflect the experience of binding financial constraints.[22] The variable we use as our second instrument is constructed as the sum of the share of non-traditional payments from customers and the share of non-traditional payments to suppliers.

The third variable *Lost sales* captures losses the firm experiences due to events that are outside the control of the firm. Because the two survey waves differ in the questions asked, we construct this variable by combining three questions from the two waves. From the 2002 survey, we take "What percent of sales was lost due to delivery delays from material input suppliers?" From the 2005 survey, we take "What percent of total sales was lost due to i) Power outages or surges from the public grid; ii) Insufficient water supply; iii) Unavailable mainline telephone service." and

[20] See e.g. Commission of Experts for Research and Innovation (EFI) (p.87) which documents the sources of financing innovation for firms sampled by the German Innovation Survey. It reports that more than 80 percent of the firms finance innovation using free cash flow, while less than 20 percent rely on bank credits. Trade credits and overdues are not an option included as one of the potential sources of finance, because they are deemed to be too expensive.

[21] One may be concerned that *Overdue* may arise from low demand for the firm's products or low productivity and thus it is not necessarily exogenous. We will show below that controlling for demand conditions (capacity utilization) and productivity does not undermine the power of our instruments.

[22] As Marin and Schnitzer (2002) and Marin and Schnitzer (2005) show for transition economies, firms resort to barter if they are considered not creditworthy. But there is an additional mechanism which can make these types of payments exacerbate financial constraints. As discussed in Gorodnichenko and Grygorenko (2008), debt swaps or offsets and exchange of goods for goods were often employed by management to channel resources away from stakeholders. Since external creditors are particularly vulnerable to these types of looting, they may be more reluctant to provide credit to firms that engage in these forms of settling payments to suppliers and payments from customers.

"What percentage of the value of products your establishment shipped over the last 12 months was lost while in transit due to breakage, spoilage or theft?" Since these incidents are i) unanticipated, ii) likely to lead to temporary reductions in available liquidity, iii) exogenous to firms, *Lost sales* should be a strong predictor of binding financial constraints and satisfy the exclusion restriction.

Observe that our baseline instruments have firm-level variation (rather than typical country-level variation), which is important for two reasons: i) using time-invariant country-level instruments (e.g., legal origin) effectively amounts to running regressions with data aggregated to country level and thus is vulnerable to shocks affecting access to external finance at the country level; ii) firm-level variation dwarfs variation at the country level and hence using country-level instruments may capture only a small fraction of variation so that estimates may be imprecise and may measure the causal effect only due to country-level variation rather than quantitatively more important firm-level variation.

We also consider alternative instrumental variables such as the speed of reforms in the financial sector. As will be shown, these alternative instrumental variables yield estimates similar to the estimates based on our baseline instrumental variables.

In our stylized theoretical model, there is a strict reaction function of innovation to financial constraints. In reality firms may have more margins of adjustment in response to liquidity shocks and therefore, when we interpret our instrumental variable estimates, it is useful to bear in mind the following thought experiment. Suppose that some firms may have flexibility in choosing the form of payment or the timing of their payments to suppliers, i.e. they may be able to partially absorb liquidity shocks along margins other than whether to finance productivity enhancing activities with internal funds. Such firms would be less affected by an exogenous liquidity shock than other firms that are not as flexible. In this case, our IV estimates of the sensitivity of these activities to financial constraints would yield less negative coefficients for financial constraints than in the case where firms do not have such flexibility. In this sense, our IV estimates provide a conservative estimate of the true causal effect on firms that have no such flexibility.

# 5 Analysis of productivity enhancing activities

## 5.1 Productivity gap

We begin our empirical analysis by documenting that foreign owned firms are more productive than domestically owned firms in BEEPS. Table 3 shows that domestically owned firms are 10 to 20 percent less productive than companies under foreign ownership and that this productivity gap appears to stay stable or even widen over time, which is consistent with previous studies (see e.g. Sabirianova Peter et al. (2005)). Likewise we observe that foreign owned firms innovate more intensively than domestically owned firms. We also find that the gap is not eliminated after we control for the initial level of firm's total factor productivity.

As indicated in the introduction, this observation is consistent with findings from other studies, like Criscuolo and Martin (2009) who show that U.S. owned plants in the U.K. are more productive than U.K. owned plants, even if the latter are restricted to U.K. multinationals. They trace this productivity difference to evidence suggesting that U.S. firms take over already highly productive firms in the U.K.. Guadalupe et al. (2010) confirm the cherry-picking argument using Spanish manufacturing data. In addition they find that firms acquired by multinationals are more likely to invest in improved firm technology and they explain this finding with an improved access to export markets. The evidence presented in Bloom and Van Reenen (2010) points to another potential cause, suggesting that such productivity differences could arise from multinationals using better management practices.

Although our data do not permit us to properly control for possible selection of productive firms into foreign ownership ("cherry picking"), we can check the quantitative importance of such effects by assessing the gap for de novo firms which were founded after 1991 and were never in state ownership. Importantly, in contrast to privatized firms, de novo private firms were unlikely to be purchased by foreign owners until recently (Meyer (2002)). Thus, we effectively compare "greenfield" domestically and foreign owned firms. Our results are very similar to the results we obtain for the baseline sample and hence the selection effects should not distort our results to any significant extent. As outlined above, this finding is consistent with Estrin et al. (2009) documenting that the productivity gap between domestically and foreign owned firms does not shrink considerably after controlling for selection into foreign ownership.[23]

The large and persistent gap in measured productivity and innovation intensity seems hard to reconcile with extensive reforms taken by BEEPS countries to accelerate growth and catching up with the technological frontier. Undoubtedly, such reforms take time to become effective, institutional rigidities need to be overcome, and some reforms may not have been so deep after all. As we conjecture above, however, some part of the gap could be explained by differential access of foreign and domestically owned firms to external credit. Indeed, Table 4 documents that foreign firms report milder financial frictions (e.g. because they can more often borrow in internal markets, in particular from a mother company) than private domestically owned companies. In the rest of the section, we investigate how productivity enhancing activities of domestically owned firms are affected by financial constraints.

[23]It is possible that foreign owned firms reported more intensive innovations because they can "import" new technologies and goods from parent companies. Although it is true that foreign owned companies report greater incidence of transfers of new technologies from parent companies, the frequency of such transfers is quite modest. In the 2005 wave of BEEPS when the relevant data were collected, less than ten percent of foreign owned firms that reported developing or acquiring a new technology indicated that the technology was transferred from parent companies. Thus a vast majority of innovations of foreign owned firms is produced locally and hence the comparison with domestically owned firms is meaningful.

## 5.2 Main findings

In this section, we present estimates of equation (8), which tests the main hypotheses described in Section 2. Our baseline specification for each measure of innovation is reported in Table 5. In addition to estimated coefficients and standard errors, we also report the elasticity of innovation with respect to financial constraints: $(\partial I/\partial FC)(\overline{FC}/\overline{I})$ where $(\partial I/\partial FC)$ is the marginal effect of financial constraint $FC$ on a measure of innovation $I$ (evaluated at mean values), and $\overline{FC}$ and $\overline{I}$ are mean values of reported severity of financial constraint and reported innovation respectively. The advantage of using elasticity is that it makes the sensitivity of innovation to financial constraints comparable across regressions since mean innovation rates vary across samples and definitions. Our baseline sample includes only private domestically owned firms.[24]

For all measures of innovation, we consistently find that a binding financial constraint is strongly negatively related to the incidence of innovations, as predicted by Hypothesis 1, according to instrumental variable estimates. At the same time, in the regular probit, we do not find any significant negative relationship between innovations and access to external finance.[25] As explained in Section 4, the endogeneity of innovation and financial constraints will bias least squares estimates upward since more innovative firms are more likely to need external funding and hence more likely to hit financial constraints. This result is in line with the previous research (e.g., de Mel et al. (2008), Banerjee and Duflo (2008)) documenting that least squares estimates are biased towards small treatment effects of financial constraints and instrumental variable estimates are much larger than least squares estimates. However, this pattern contrasts with results in Ayyagari et al. (2011) who find very similar least squares and instrumental variable estimates, using country-level instruments.

Once the endogeneity bias is corrected, we find a strong negative causal effect of financial constraints on innovation. Specifically, the bottom panel of Table 5 shows that the elasticity of innovations with respect to financial constraints implied by estimates in the top panel of Table 5 is in -0.89 to -1.57 range for developing a new good or adopting a new technology, approximately -1.88 for the R&D spending, and -0.27 for TFP. These are economically significant magnitudes. For example, a one-standard deviation increase in the severity of financial constraints lowers the

[24]We exclude state- and foreign-owned firms from our baseline regression because these firms have different incentives to innovate. Indeed, we overwhelmingly reject equality of coefficients on controls for private domestic or foreign/state firms on regressors in our baseline specification. We use this difference in our sample splits when we compare our baseline results with private firms to that of state- and foreign-owned firms to check the plausibility of our results.

[25]We find similar results for linear probability models. Here and henceforth we use Cook's distance to identify outliers, i.e., non-typical observations that considerably move point estimates. Because the specification is not linear, the procedure is implemented as follows: i) drop one observation at at time; ii) re-estimate a given specification and record the estimate for the parameter of interest; iii) repeat steps i) and ii) for all observations in the sample; iv) identify observations (outliers) that move the point estimate by more than four standard deviations of the estimate for the parameter of interest (this cutoff is widely recommended in the literature); v) estimate the specification on the sample that excludes outliers.

probability of a successful innovation by 16 percentage points for developing a new good, 22 percentage points for adopting a new technology, 26 percentage points for positive R&D spending, and 21 percentage points for TFP.[26]

Note that our instrumental variables are strong predictors of the endogenous variable: i) the F-statistics for the first stage fit is well above 10, a value commonly suggested as a sign of variables to be good instruments; ii) we cannot reject the null that instruments are correctly excluded when we test overidentifying restrictions following the procedure designed in Blundell and Smith (1989).[27] We report first stage estimates in Appendix Table A3. Consistent with predictions of economic theory, positive *Overdue*, *NTP* and *Lost sales* significantly raise the severity of financial constraints.[28] Since *Lost sales* is likely outside of firm's control, the over-identifying restrictions test suggests that *Overdue* and *NTP* are also not likely to be endogenous. If *Overdue* and *NTP* were endogenous, the over-identifying restrictions test would reject the null given how strong the first stage fit is.

There are a number of interesting findings with respect to the control variables in Table 5. First, larger firms are more to likely to report innovations than smaller firms, which is consistent with the finding in the vast majority of studies on innovation (see e.g., Becheikh et al. (2006)) and the Schumpeter (1943) hypothesis. The size effect is concave for both types of innovations. Second, the effect of human capital varies by how it is measured. Having a higher share of skilled workers is not correlated with the probability of developing a new product and acquiring new technology. On the other hand, all types of innovation and the share of workers with a university education are positively correlated. Third, older (more mature) firms are not as likely to innovate with respect to product and technology as new firms. Fourth, firms that compete/operate in national markets are more likely to innovate in any of the three areas than firms that only compete/operate in a local or regional market. This may reflect both the capability of the firms operating in the larger national market, as well as the characteristics of the national as opposed to local environment. Fifth, lower competition, proxied by markup, is positively correlated with innovations, which is consistent with the results in Carlin et al. (2006) and Gorodnichenko et al. (2010) who use a similar econometric framework. Sixth, consistent with Gorodnichenko et al. (2010), linkages to foreign firms ($SMNE$ and $Import$) are positively associated with the success of innovation. Seventh, we find that selling to a MNE loses its significant impact on the likelihood of process innovation once financial constraints are properly instrumented.[29] Finally, more intensive capacity utilization is

[26]Because our data are repeated cross-sections, we are not able to establish whether these effects are transitory or permanent. These findings are consistent with the results reported in Ayyagari et al. (2011).

[27]One has to bear in mind that for overidentifying restrictions tests to be meaningful at least one of the instrumental variables must be valid. Given the properties of our instrumental variables we discussed above and extensive sensitivity and robustness checks we discuss below, we believe that this requirement is likely to be satisfied.

[28]Interestingly, after conditioning on industry/country dummies, observable characteristics of firms other than those related to liquidity and capacity utilization (and as we discuss later initial levels of debt and productivity) are not strong predictors of reported financial constraints.

[29]This contradicts the suggestion of Guadalupe et al. (2010) that access to foreign market explains the higher

associated with less intensive innovative activities although labor and capacity constraints appear to have differential effects.

## 5.3 Robustness checks

Financial constraints have many dimensions. Typically, financial constraints are measured along (i) whether firms have access to external credit and (ii) the price firms have to pay for external credit if they have access to it. We have focused on whether firms have access to credit. In Table 6, we examine if our results also extend to the price of credit which we measure with the *cost of external credit* variable. This variable is a self-reported measure of the cost of financing which runs on 1 ("No obstacle") to 4 ("Major obstacle") scale. We find that results are largely the same as for the access to credit and thus we do not report controls to preserve space.

Since BEEPS collected information on the importance of innovations, we can also assess whether financial constraints affect the intensity of innovations. In particular, we estimate equation (8) with a measure of innovation importance for firm's survival reported on scale from 1 ("Not important") to 5 ("extremely important") as the dependent variable, called "intensive margin" in Table 6. The effect is strongly negative for *New good* and approximately zero for *New technology*, which is likely to be determined by the small sample size for the latter as the information for the importance of *New technology* innovations was collected only in the 2002 wave of BEEPS.

We find similar results when our baseline specification is estimated only on the sample of firms reporting that they would delay payments to suppliers or would engage in non-conventional forms of payments in response to a hypothetical, unanticipated, temporary 10% reduction in cash flow. Thus, our results are robust to restricting our sample to firms for whom we have direct evidence from the survey that they consider overdue payments and non-conventional forms of payments when confronted with an unanticipated loss in cash flow.

To check for possible selection effects into foreign ownership, we explore the sensitivity of estimates to restricting the sample only to de novo firms and again find similar results. Likewise our results do not change substantively when we recode the ordinal self-reported measure of financial constraints into dummy variables equal to one if firms indicate severe constraints and zero otherwise (results are not reported).

Our theory predicts that innovations are increasingly sensitive in their ability to be collateralized, as higher collateralization lowers the cost of external finance. To test this prediction, we use information (contained in the 2005 wave of BEEPS) about how new technology was implemented. Specifically, we construct two measures of new technology: i) machine-based when firms report that their new technology was mainly embodied in new equipment; ii) non-machine-based when new technology was primarily a result of research efforts. Consistent with our theory, we find that non-machine-based new technology is more sensitive to financial constraints than machine-based

innovation activities of firms after being acquired by foreign owners.

acquisition of new technology.

We also experiment with qualitatively different instrumental variables. Specifically, we can examine how our estimates change when we use EBRD's indices of reforms in banking and financial sectors as an additional set of instruments. These reforms are likely to improve access to external credit and lower its cost. Indeed, Figure 4 shows that the self-reported measures of financial constraints are strongly negatively correlated with the EBRD's indices of reforms in the financial and banking sectors. Note that unlike instrumental variables used in previous research (e.g. legal origin), these indices are time varying and hence we can exploit within-country variation which may be a more credible source of identification. Overall, estimates based on this alternative set of instrumental variables are similar to our baseline estimates.[30]

It is possible that our results might be driven by omitted variables (e.g. level of productivity, managerial ability, initial conditions) correlated with innovation, financial constraints and our instrumental variables.[31] Note that capacity utilization addresses these concerns to some extent because, as argued in Abel and Eberly (1998), capacity utilization can serve as a sufficient statistic for the state of demand and technology conditions. We control for capacity utilization with the self-reported measures of the intensity of utilization, share of temporary workers in total employment, and the size of employment relative to the optimal size. In addition, we control for i) markup which could be interpreted as a measure of profitability and thus could also control for some variation in demand and supply conditions; ii) share of temporary workers in total employment; iii) optimal employment relative to current employment. To further explore the sensitivity of our estimates to these potentially omitted factors, we estimate a series of specifications augmented with variables proxying for these omitted factors. In particular, the augmented regressions include the level of labor productivity and level of debt as a fraction of total assets three years before the current year in the survey wave,[32] level of education of the general manager,[33] manager's time spent with government officials, and index of limiting factors.[34] The last two controls can be interpreted as

[30]Although the strength of the first stage fit with these alternative instruments is sufficiently strong (F-statistic is in the range between 17 and 19 for *New good* and *New technology*), the firm-level instrumental variables clearly dominate country-level instruments in terms of first-stage predictive power (F-statistics are about 90) for variables measuring financial constraints.

[31]It is not possible to a priori sign the bias stemming from these potentially omitted factors. On the one hand, these factors are likely to be negatively correlated with the instruments, financial constraints and positively with the innovation so that IV overstates the treatment effect of financial constraints. On the other hand, these factors are likely to push firms into more innovation and hence these firms are more likely to hit financial constraints so that IV understates the treatment effect of financial constraints.

[32]This information is taken from retrospective questions. In this exercise we prefer labor productivity to total factor productivity because with labor productivity we have more observations than with total factor productivity. Results are similar when we use total factor productivity although the precision of TFP-based estimates is smaller. Information on the level of debt was collected only in the 2002 wave of BEEPS. We do not include these additional regressors in the baseline specification because these variables have many missing values which would substantially reduce the sample size available for estimation.

[33]This information was collected only in the 2002 wave of BEEPS.

[34]The index of limiting factors is computed as the average score of how problematic different factors (access to infrastructure, regulation burden, crime, property rights, etc) are. See Data Appendix for more details.

proxying for quality of infrastructure and institutions. With these additional controls, we find estimates of the causal effect of financial constraints on innovation similar to our baseline set of estimates and therefore these omitted factors are not likely to strongly bias our estimates. Note that following the evidence laid out in Carlin et al. (2010), one could interpret the index of limiting factors as another proxy for the productivity of the firm. As Carlin et al. (2010) show, firms are more likely to report a high score on this index the higher is their productivity and hence the more likely they are to be negatively affected by a lack of infrastructure. In the light of this interpretation, it is interesting to observe that the coefficients for financial constraints are even more negative when we control for these limiting factors. This pattern is inconsistent with the view that our results are driven by omitted variables (e.g., quality of institutions) which are negatively correlated with innovation and positively with financial constraints and our instrumental variables.

Another way to capture the productivity of firms would be to control for the distance to country-industry frontier. The 2002 wave of BEEPS provides information on the relative technology of firms. Specifically, firms were asked to rate their technology relative to competitors. In addition to a larger sample size, the advantage of this direct measure is that firms can assess their technology relative to perceived competitors (i.e., the theoretically relevant benchmark) rather than some firm picked by an econometrician in a broadly defined industry. In other words, we can utilize private information that would not be available to the econometrician who observes only TFP and 2-3 digit industry code of a firm. We find that results are very similar even after controlling for the distance to the frontier.

Since the econometrician may have information on firm's health less complete than lenders, we also try to control for indicators suggestive of how well a firm is doing. Specifically, we include as an additional regressor a dummy variable equal to one if a firm reported being a defendant in courts which captures firm's issues to some extent. Consistent with the results above, we find that this additional regressor does not change our results for the sensitivity of innovation to financial constraints. We also find that the sensitivity of innovation to financial constraints increases when we include all controls shown in the bottom panel of Table 6.

While we cannot rule out that these additional controls as well as controls in the baseline specification (8) fully remove possible variation in demand/supply conditions across firms, the list of controls is sufficiently rich so that one may expect that first-order concerns about these kinds of omitted variables are addressed to a reasonable degree. Firms may be heterogenous in other ways that we cannot control for with the variables considered above. We have a small panel component in the data and thus we can control for time-invariant characteristics of firms by including firm fixed effects. Although the estimated sensitivity of innovations to financial constraints is broadly in line with the baseline estimates, the estimates based on the panel regressions with firm fixed effects are imprecise and smaller than the baseline estimates. This is an expected result given the much smaller sample size (only about 700 firms were surveyed both in the 2002 and 2005

waves) and the amount of noise contained in the survey data such as BEEPS. As discussed in Griliches and Hausman (1986), including fixed effects can dramatically exacerbate the adverse effects of measurement errors so that estimates can be strongly biased toward zero and be much less precise. These issues are likely to be further complicated by the non-linearities in estimation. As an alternative to control for firm heterogeneity, we estimate equation (8) with the interactions of country*year and industry*year fixed effects. With this alternative, we find results very similar to the baseline set of results.[35]

## 5.4 Analysis of subsamples

To investigate possible heterogeneity of causal effects of financial constraints on innovation across types of firms, we re-estimate specification (8) for a series of subsamples. In these subsamples, we focus only on the incidence of acquiring a new technology and developing a new good. For two other measures of innovation (TFP and positive R&D spending) we have too few observations for certain cells which makes statistical analysis imprecise and sensitive to a handful of observations. Table 7 reports our results for various sub-samples which differentiate firms by ownership, sector, age, size, and region.

First, we re-estimate specification (8) for state owned and foreign owned firms. Both types of firms are less likely to experience financial constraints since they can borrow funds internally either from an appropriate level of government (directly or indirectly using loan guarantees from the government) or from a mother company. Thus, they are less likely to be forced to rely on costly external finance, even in case of negative liquidity shocks, and hence we should expect a weaker (if any) effect of financial constraints on innovation.[36] This conjecture is by and large supported by our results: only state owned firms exhibit some sensitivity to financial constraints; in all other cases, we find no significant sensitivity. Thus, we can identify financial constraints as one important reason for why domestically owned firms innovate less than foreign firms do, why domestically owned firms are less productive than foreign firms and why they do not catch up over time.

Second, by and large the strength of the causal effect is similar for firms in services and manufacturing. This result is important because most of previous work on the effects of financial

[35]We also considered including the full set of interactions of fixed effects, i.e., industry*country*year. This alternative has a larger sample size than in panel regressions but it also creates about 1,400 fixed effects so that the number of degrees of freedom is smaller by approximately a fifth of the sample we have in the baseline specifications. Because of the smaller effective sample size and the multitude of fixed effects which are likely to aggravate the adverse effects of measurement errors, we find somewhat smaller sensitivity to financial constraints than in the baseline specifications although the difference between the estimates is smaller than in the case of panel regressions. In light of these results, including firm fixed effects or full interactions of industry/country/year fixed effects appears to wash out a great deal of informative variation and, thus, our baseline specification (8) which controls for country/year/industry fixed effects (but not for the interactions of these fixed effects) seems to emerge as an empirically reasonable middle ground to control for heterogeneity of firms.

[36]For example, Harrison and McMillan (2003) report for firms in Côte d'Ivoire that domestically owned firms are more credit constrained in their investment than foreign firms.

constraints on firms' behavior was done for firms in manufacturing.

Third, we also find that new firms are more sensitive to financial constraints than old firms, which is consistent with Ayyagari et al. (2011). This finding is consistent with the idea that new firms may have shorter credit history which makes access to external financing harder and that they have had less opportunities to accumulate internal funds and hence need to rely more on external finance. In the literature on cash-flow sensitivities of investment, age has often been used as a firm characteristic to classify more and less financially constrained firms (Fazzari et al. (1988)). Our finding is also consistent with previous studies reporting that R&D spending of mature firms is much less sensitive to cash flow and external equity than that of young firms (e.g., Brown et al. (2009)).[37]

Fourth, the strength of the response strongly varies with the firm size. Small firms (2 to 10 employees) have an elasticity of innovation with respect to financial constraints two to three times larger than the elasticity of large firms (100 and more employees). This result is consistent with many previous studies documenting that small firms are more likely to experience lack of external funds and severe informational frictions than large firms (see e.g. Harhoff (1998), Canepa and Stoneman (2008), Ughetto (2008), and Ayyagari et al. (2011)).

Fifth, the sensitivity can also vary with the level of development of financial markets. Generally, more developed financial markets are more likely to overcome asymmetric information and other impediments for access to external credit. To examine this hypothesis, we split countries into four regions commonly used in the analysis of Eastern European and CIS countries: Central European and Baltic countries which became new EU members; South-East European (SEE) countries (mainly Balkans); Western CIS (WCIS) countries (Belarus, Russia, Ukraine); Eastern CIS (ECIS) countries (Caucasus and Central Asia). The ranking of financial market development as an indicator of accessability of external finance typically runs from new EU members (most developed) to SEE to WCIS to ECIS (least developed).[38] Therefore, according to Hypothesis 2, we should expect that the sensitivity to financial constraints should be the lowest in new EU member countries and the highest in the Eastern CIS countries. Our results are consistent with this prediction. We find a relatively monotonous increase in sensitivity as we move from more to less financially developed economies.

Finally, we estimate the effect of financial constraints using sub-samples as in Hajivassiliou and Savignac (2007), i.e., we exclude firms that report no financial constraints and no innovations. For these subsamples, the effect is highly negative and similar to what we find in our IV regressions.

[37]Another interesting question to explore would be whether there are any significant differences in the nature of investment between old and new firms. Acemolgu and Vu Cao (2010) argue that incumbents are more likely to do incremental innovations, whereas new entrants are more likely to do radical innovations. Unfortunately, our data do not allow us to trace this distinction.

[38]Our ranking of the countries is also consistent with the ranking of venture capital deals across countries, as documented by e.g. VentureXpert. Specifically, new EU member countries have the largest number of venture capital deals while ECIS countries have the lowest.

# 6 Concluding remarks

We started our analysis with the stylized fact that in developing and transition economies, foreign owned firms are more productive than domestically owned firms and that this productivity gap is not decreasing over time. The evidence from BEEPS is consistent with this observation. As documented in Section 5.1, domestically owned firms in our sample are significantly and robustly less productive than companies under foreign ownership and foreign owned firms innovate more intensively than domestically owned firms. In other words, domestically owned firms fall behind the technological frontier often represented by foreign owned firms.

We conjectured that this gap in productivity and innovation may be due to more severe financial constraints faced by domestically owned firms. Our findings are consistent with this conjecture: domestically owned firms are strongly hampered in their innovation activities by difficult and costly access to external finance while foreign firms exhibit much weaker (if any) sensitivity to financial constraints in our data. Thus, our results provide micro-foundations consistent with a causal interpretation of the positive correlation between development of financial markets and the level of income at the macroeconomic level.

Our analysis paints a detailed picture for which firms financial frictions are most detrimental. Most notably these are small or young firms. This evidence suggests that transition and emerging market economies could benefit from emulating policies that support innovations of firms most sensitive to financial frictions (e.g., Small Business Innovation Research grants in the U.S.A.).

More broadly, our cross-country analysis of firms' behavior at the micro level suggests that the severity of financial frictions faced by firms is decreasing in the level of development of financial markets. Deeper reforms in banking and financial sectors are likely to alleviate the adverse effects of financial frictions (recall Figure 4) and, consequently, to stimulate the growth of the economies in our sample. At the same time, one should bear in mind the disciplinary benefits of external finance that come from careful screening and monitoring. Thus, a sensible strategy should be geared towards making finance available discriminatingly, which may include an enhanced screening process, improved information systems, and well maintained, clear property records to facilitate collateralization. Examples of the nature of the required policy measures are highlighted in the Transition Report (2010). For Uzbekistan, priorities for structural reform are improving credit and risk management skills of commercial banks, as well as removing non-core functions such as tax collection to ensure that credit is only allocated on a fully commercial basis. Tajikistan could benefit from the establishment of the transferability of land-user rights to allow them to be used as collateral. For the Kyrgyz Republic the Transition Report calls for strengthening the independence of the National Bank to ensure that banking regulation is applied in accordance with the law.

Foreign multinationals may ease local credit constraints by bringing foreign capital into the economy which is consistent with the negative correlation between foreign presence and self-reported financial constraints. However, to the extent that foreign firms borrow locally, they

can also crowd out domestic borrowers and exacerbate financial constraints faced by domestically owned firms (see Marin and Schnitzer (2011) and Harrison and McMillan (2003) for further discussion and evidence). Deeper understanding of globalization trade-offs as well as establishing exact mechanisms of how foreign presence affects financial frictions in developing economies is an important task for future studies.

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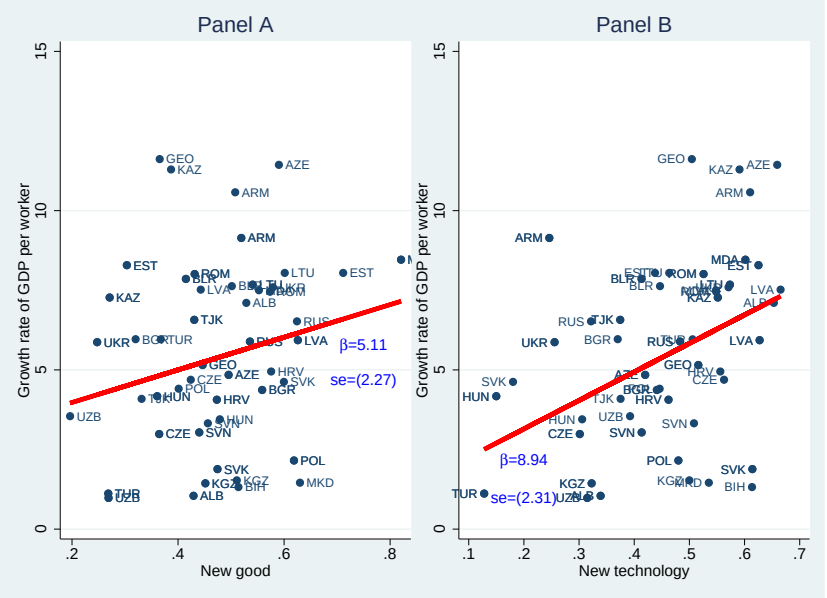
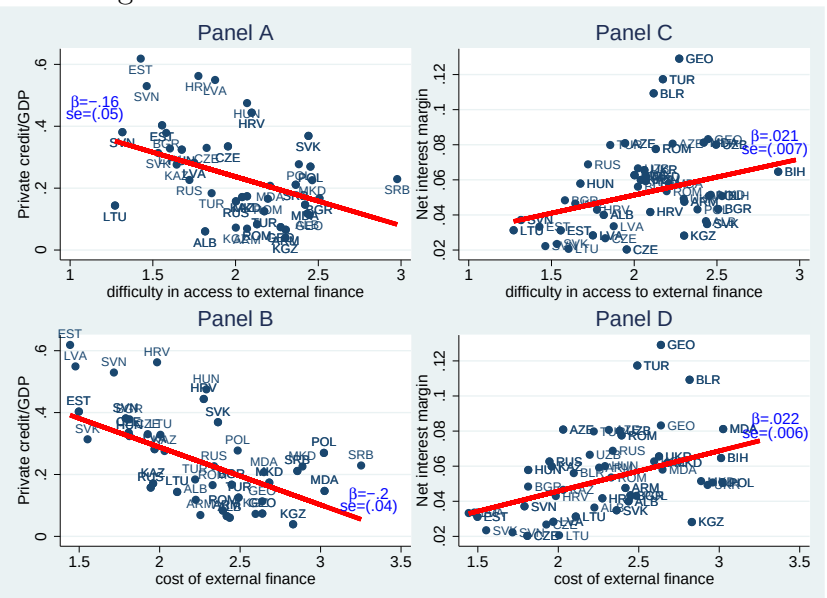
Figure 1: Innovation and economic growth.



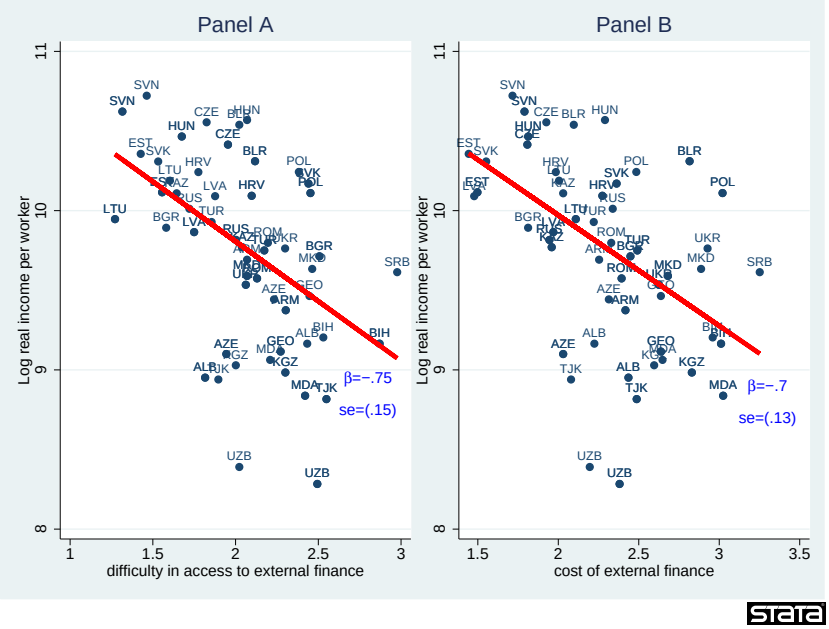

***Notes***: The figure presents the growth rate of real GDP per worker against the average value (weighted by employment size) of intensity of New good and New technology reported in BEEPS. Growth rates of real GDP per worker data are from the Penn World Tables (version 6.3). The solid red line is the fitted line from the Huber robust regression with $\beta$ and $se$ showing the estimated slope and the associated standard error. In all panels, the slope is significantly different from zero at 1 percent.

Figure 2: Measurement of financial constraints.



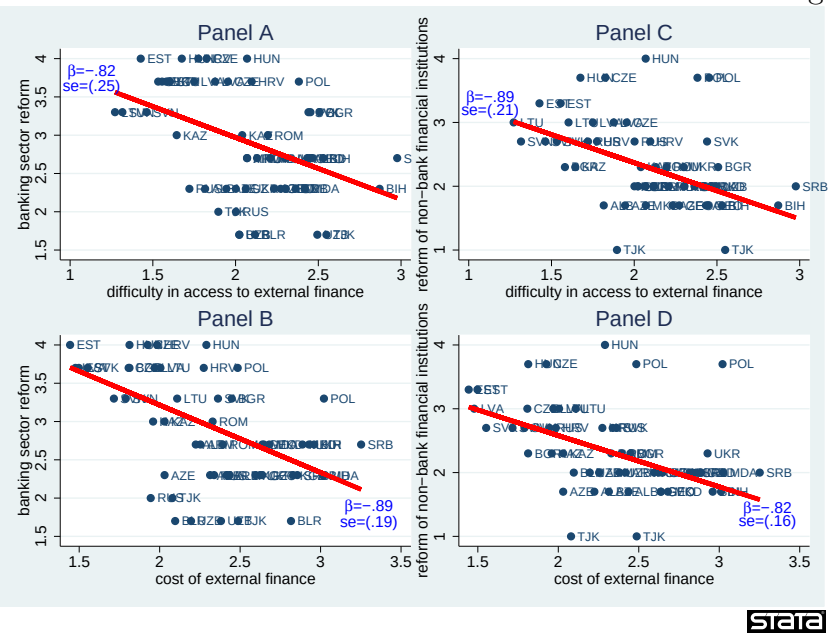

***Notes***: The figure presents macroeconomic indicators of financial development against the average value (weighted by employment size) of reported severity of access to external finance and cost of access to external finance across all types of firms in a given country and year (2002 and 2005). The ratio of private credit to GDP and the net interest margin (which is the accounting value of bank's net interest revenue as a share of its interest-bearing (total earning) assets) are taken from the World Bank's Database on Financial Development and Structure. The solid red line is the fitted line from the Huber robust regression with $\beta$ and $se$ showing the estimated slope and the associated standard error. In all panels, the slope is significantly different from zero at 1 percent.

Figure 3: Financial constraints and macroeconomic outcomes.




***Notes***: The figure presents macroeconomic outcomes against the average value (weighted by employment size) of reported severity of access to external finance and cost of access to external finance across all types of firms in a given country and year (2002 and 2005). Log real income per worker data are from the Penn World Tables. The solid red line is the fitted line from the Huber robust regression with $\beta$ and $se$ showing the estimated slope and the associated standard error. In all panels, the slope is significantly different from zero at 1 percent.

Figure 4: Financial constraints and reforms in financial and banking sectors.




***Notes***: The figure presents macroeconomic outcomes against the average value (weighted by employment size) of reported severity of access to external finance and cost of access to external finance across all types of firms in a given country and year (2002 and 2005). Indices of reforms in financial and banking sectors are from the European Bank for Reconstruction and Development (EBRD). The solid red line is the fitted line from the Huber robust regression with $\beta$ and $se$ showing the estimated slope and the associated standard error. In all panels, the slope is significantly different from zero at 1 percent.

Table 1. The link between productivity and innovations.

| | Productivity | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| | | | **Panel A**: TFP | | |
| New technology | 0.038** | | | 0.032* | 0.032 |
| | (0.019) | | | (0.019) | (0.024) |
| New good | | 0.036* | | 0.033 | 0.018 |
| | | (0.020) | | (0.020) | (0.024) |
| Positive R&D spending | | | 0.145*** | | 0.119*** |
| | | | (0.028) | | (0.031) |
| Observations | 6,861 | 6,922 | 4,733 | 6,829 | 4,677 |
| $R^2$ | 0.397 | 0.388 | 0.433 | 0.408 | 0.455 |
| | | | **Panel B**: Labor productivity, $\ln(Y/L)$ | | |
| New technology | 0.067*** | | | 0.050** | 0.050** |
| | (0.022) | | | (0.022) | (0.024) |
| New good | | 0.070*** | | 0.063*** | 0.049** |
| | | (0.019) | | (0.019) | (0.024) |
| Positive R&D spending | | | 0.306*** | | 0.283*** |
| | | | (0.038) | | (0.039) |
| Observations | 11,816 | 11,882 | 7,335 | 11,810 | 7,272 |
| $R^2$ | 0.606 | 0.604 | 0.680 | 0.606 | 0.682 |

***Notes***: *TFP* measures log total factor productivity computed as log sales minus log capital, log employment, and log material input weighted by cost shares of each input and adjusted for capacity utilization (see equation (7)). Cost shares are allowed to vary by industry and country. *New technology* is the dummy variable equal to one if the firm reports successful development and/or adaption of new technology and zero otherwise. *New good* is the dummy variable equal to one if the firm reports successful introduction of a new good or service and zero otherwise. *Positive R&D spending* is the dummy variable equal to one if the firm reports positive research and development spending and zero otherwise. Dummy variables for interactions between year, country, and industry are included but not reported. Robust standard errors clustered by country and year are in parentheses. ***, **, * denote significance at 0.01, 0.05, and 0.10 levels.

Table 2. Response to cash flow shocks and sources of financing.

Panel A. Response to an unanticipated, temporary cash flow shock.

| Response | Number of firms reporting response | |
|---|---|---|
| | All firms | Domestic private |
| Liquidate short term financial assets | 1,725 | 1,202 |
| Obtain credit from banks | 2,741 | 1,899 |
| Obtain credit from suppliers | 2,441 | 1,758 |
| Delay payment to suppliers/utilities | 2,906 | 2,045 |
| Issue bills of exchange (e.g. veksels) | 544 | 382 |
| Exchange goods for goods | 1,627 | 1,232 |
| Delay payments to budget (taxes) and extra-budgetary funds | 1,304 | 917 |
| Delay payments to workers (wages) | 1,988 | 1,430 |
| Obtain credit from the government | 305 | 159 |
| Obtain a subsidy from the government | 273 | 112 |

Panel B. Share of firms reporting at least X percent of new investment or working capital financed with trade credit from suppliers.

| Percent of financing | New investment | Working capital |
|---|---|---|
| 10 percent | 0.043 | 0.120 |
| 25 percent | 0.021 | 0.061 |
| 50 percent | 0.007 | 0.023 |
| 75 percent | 0.005 | 0.011 |
| 90 percent | 0.003 | 0.005 |

***Notes***. *Panel A*: The question is: "Now I would like to ask you a hypothetical question: Suppose that the incoming cash flow to your firm for the next quarter is 10% lower than you had expected. This cash flow is not permanently lost, but merely unexpectedly delayed. However, your working capital needs and level of production remain the same. Please look at this list and select at most 4 sources from which you would finance this gap. For each of the source selected, please indicate its importance." The question was only in the 2002 wave of BEEPS. Firms can choose multiple responses. The total number of firms with a non-missing response is 6,023 for all firms and 4,234 for domestic private firms. *Panel B*: The question is "What proportion of your firm's working capital and new fixed investment has been financed from each of the following sources, over the past 12 months?" The table shows the fractions of firms reporting that at least a given percentage of new investment or working capital was financed with trade credit from suppliers (option "Trade credit from suppliers" in the question). Both 2002 and 2005 waves of BEEPS had this question.

Table 3. Differences in productivity between foreign and domestic private firms.

| Dependent Variable | All years | 2002 | 2005 | De novo firms, all years | Control for productivity at $t-3$, all years |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Total factor productivity | 0.115*** | 0.096** | 0.135*** | 0.106*** | 0.061*** |
| | (0.024) | (0.042) | (0.028) | (0.031) | (0.024) |
| Observations | 6,266 | 2,236 | 4,030 | 3,845 | 6,010 |
| $R^2$ | 0.158 | 0.213 | 0.21 | 0.136 | 0.229 |
| Labor productivity | 0.258*** | 0.245*** | 0.266*** | 0.232*** | 0.104*** |
| | (0.022) | (0.038) | (0.027) | (0.028) | (0.012) |
| Observations | 10,587 | 4,205 | 6,382 | 6,681 | 10,111 |
| $R^2$ | 0.582 | 0.501 | 0.621 | 0.557 | 0.884 |
| New good | 0.072*** | 0.073*** | 0.064*** | 0.069*** | 0.073*** |
| | (0.012) | (0.016) | (0.017) | (0.015) | (0.015) |
| Observations | 14,513 | 5,701 | 8,812 | 9,430 | 10,091 |
| $R^2$ | 0.073 | 0.1 | 0.073 | 0.07 | 0.077 |
| New technology | 0.036*** | 0.022 | 0.046*** | 0.039*** | 0.030** |
| | (0.011) | (0.014) | (0.016) | (0.013) | (0.014) |
| Observations | 14,395 | 5,703 | 8,688 | 9,342 | 9,992 |
| $R^2$ | 0.087 | 0.093 | 0.095 | 0.089 | 0.1 |
| Positive R&D spending | 0.110*** | 0.047*** | 0.147*** | 0.088*** | 0.109*** |
| | (0.014) | (0.014) | (0.020) | (0.015) | (0.015) |
| Observations | 7,032 | 2,055 | 4,977 | 4,401 | 6,315 |
| $R^2$ | 0.538 | 0.561 | 0.153 | 0.579 | 0.507 |

***Notes***: Each panel reports the estimated OLS coefficient on the foreign ownership dummy variable for the equation with the dependent variable shown in the left column. A firm is considered foreign owned if foreigners have 50 or more percent ownership. Only private firms are included in the sample. Fixed effects for year, country, and industry are included but not reported. *Total factor productivity* is computed as in equation (7). *Labor productivity* is computed as log of sales to employment ratio. In column (5), productivity is measured as labor productivity. *New technology* is the dummy variable equal to one if the firm reports successful development and/or adaption of new technology and zero otherwise. *New good* is the dummy variable equal to one if the firm reports successful introduction of a new good or service and zero otherwise. *Positive R&D spending* is the dummy variable equal to one if the firm reports positive research and development spending and zero otherwise. *De novo firms* are firms founded after 1991. Robust standard errors clustered by country and year are in parentheses. ***, **, * denote significance at 0.01, 0.05, and 0.10 levels.

Table 4. Differences in financial constraints between foreign and domestic private firms.

| Dependent Variable | All years | 2002 | 2005 | De novo firms, all years | Control for productivity at $t-3$, all years |
|---|---|---|---|---|---|
| | (1) | (2) | 3 | (4) | (5) |
| Difficulty of access | -0.296*** | -0.256*** | -0.320*** | -0.302*** | -0.296*** |
| to external finance | (0.026) | (0.040) | (0.035) | (0.032) | (0.033) |
| Observations | 13,855 | 5,433 | 8,422 | 8,985 | 9,674 |
| $R^2$ | 0.069 | 0.069 | 0.094 | 0.073 | 0.076 |
| Cost of external finance | -0.243*** | -0.165*** | -0.303*** | -0.202*** | -0.235*** |
| | (0.026) | (0.036) | (0.036) | (0.032) | (0.034) |
| Observations | 13,966 | 5,498 | 8,468 | 9,026 | 9,759 |
| $R^2$ | 0.089 | 0.098 | 0.11 | 0.085 | 0.097 |

***Notes***: Each panel reports the estimated OLS coefficient on the foreign ownership dummy variable for the equation with the dependent variable shown in the left column. A firm is considered foreign owned if foreigners have 50 or more percent ownership. Only private firms are included in the sample. Fixed effects for year, country, and industry are included but not reported. In column (5), productivity is measured as labor productivity. *De novo firms* are firms founded after 1991. Robust standard errors cluster by country and year are in parentheses. ***, **, * denote significance at 0.01, 0.05, and 0.10 levels.

Table 5. Baseline results.

| | New good | | New technology | | Positive R&D spending | | TFP | |
|---|---|---|---|---|---|---|---|---|
| | IV probit | Probit | IV probit | Probit | IV probit | Probit | IV | OLS |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Difficulty of access | -0.369*** | 0.017 | -0.561*** | -0.009 | -0.814*** | 0.026 | -0.177*** | 0.005 |
| to external finance | (0.099) | (0.013) | (0.075) | (0.015) | (0.045) | (0.025) | (0.067) | (0.008) |
| Share of sales to MNE | 0.146** | 0.191** | 0.093 | 0.171* | 0.1 | 0.297* | 0.065 | 0.071 |
| | (0.071) | (0.078) | (0.090) | (0.088) | (0.106) | (0.165) | (0.049) | (0.044) |
| Share of imported | 0.275*** | 0.246*** | 0.289*** | 0.267*** | 0.275*** | 0.306*** | 0.007 | -0.009 |
| inputs | (0.041) | (0.042) | (0.034) | (0.038) | (0.064) | (0.079) | (0.033) | (0.027) |
| ln(Labor) | 0.260*** | 0.299*** | 0.260*** | 0.350*** | 0.136* | 0.408*** | 0.106*** | 0.112*** |
| | (0.043) | (0.042) | (0.047) | (0.044) | (0.072) | (0.116) | (0.029) | (0.029) |
| $\ln(\text{Labor})^2$ | -0.024*** | -0.025*** | -0.022*** | -0.026*** | 0 | 0.002 | -0.008* | -0.007* |
| | (0.006) | (0.006) | (0.005) | (0.005) | (0.009) | (0.016) | (0.004) | (0.004) |
| Share of skilled labor | 0.04 | 0.037 | 0.009 | 0.002 | -0.069 | -0.203** | -0.001 | 0.008 |
| | (0.053) | (0.044) | (0.060) | (0.064) | (0.106) | (0.099) | (0.038) | (0.033) |
| Share of labor with | 0.148** | 0.191*** | 0.115** | 0.190*** | 0.003 | 0.155 | 0.072 | 0.087** |
| university degree | (0.061) | (0.065) | (0.055) | (0.058) | (0.082) | (0.166) | (0.047) | (0.035) |
| Markup | 0.238* | 0.266** | 0.428*** | 0.518*** | 0.406** | 0.851*** | 0.062 | 0.027 |
| | (0.125) | (0.117) | (0.096) | (0.101) | (0.180) | (0.246) | (0.073) | (0.072) |
| Log(age) | -0.081*** | -0.083*** | -0.063*** | -0.072*** | -0.058** | -0.101** | -0.017 | -0.019 |
| | (0.020) | (0.023) | (0.021) | (0.025) | (0.024) | (0.044) | (0.017) | (0.013) |
| Compete in national | 0.137*** | 0.148*** | 0.197*** | 0.244*** | 0.140*** | 0.478*** | 0.003 | 0.004 |
| markets | (0.033) | (0.035) | (0.048) | (0.039) | (0.053) | (0.057) | (0.023) | (0.028) |
| Size of optimal labor | 0.239*** | 0.196*** | 0.165*** | 0.100** | 0.157** | -0.039 | -0.012 | -0.034 |
| | (0.046) | (0.045) | (0.051) | (0.049) | (0.069) | (0.108) | (0.028) | (0.021) |
| Share of temporary workers | 0.128 | 0.045 | 0.051 | -0.103 | 0.208 | -0.025 | -0.367*** | -0.439*** |
| | (0.103) | (0.106) | (0.096) | (0.109) | (0.146) | (0.315) | (0.067) | (0.066) |
| Capacity utilization | -0.297*** | -0.206*** | -0.361*** | -0.251*** | -0.388*** | -0.350*** | -1.364*** | -1.321*** |
| | (0.069) | (0.065) | (0.057) | (0.070) | (0.101) | (0.116) | (0.053) | (0.067) |
| Elasticity with respect | -0.890*** | 0.042 | -1.567*** | -0.022 | -2.428*** | 0.056 | -0.257*** | 0.006 |
| to access to finance | (0.248) | (0.027) | (0.310) | (0.036) | (0.282) | (0.066) | (0.093) | (0.011) |
| Observations | 10,291 | 10,290 | 10,198 | 10,195 | 5,129 | 5,100 | 4,613 | 4,593 |
| Over-id p-val | 0.737 | | 0.347 | | 0.257 | | 0.194 | |
| 1st stage F-stat | 87.0 | | 87.3 | | 46.0 | | 17.5 | |

***Notes***: The table reports estimates of equation (8). *Elasticity* is the marginal effect divided by the mean value of the dependent variable and multiplied by the mean value of the difficulty in access to external finance. *Over-id p-val* is the p-value for the overidentifying restrictions test. *1st stage F-stat* is the value of the F statistic for the hypothesis that instrumental variables have jointly zero coefficients in the first stage regression. Fixed effects for year, country, industry and location are included but not reported. Interactions of fixed effects are not included. Only private domestically owned firms are included in the estimation sample. First stage results are reported in Appendix Table A3. Robust standard errors clustered by country and year are in parentheses. ***, **, * denote significance at 0.01, 0.05, and 0.10 levels.

Table 6. IV probits estimates: Robustness checks.

| | New good | | | New technology | | |
|---|---|---|---|---|---|---|
| | Coefficient | Elasticity | Obs. | Coefficient | Elasticity | Obs. |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Interactions of fixed effects | | | | | | |
| country*year | -0.357*** | -0.859*** | 10,291 | -0.543*** | -1.508*** | 10,198 |
| | (0.098) | (0.248) | | (0.080) | (0.310) | |
| industry*year | -0.370*** | -0.892*** | 10291 | -0.554*** | -1.545*** | 10,198 |
| | (0.074) | (0.248) | | (0.064) | (0.310) | |
| Panel sample | -0.692*** | -1.817** | 1,185 | -0.949*** | -3.246*** | 1,173 |
| | (0.286) | (0.823) | | (0.088) | (0.449) | |
| Intensive margin | -0.200*** | -0.486*** | 3,816 | -0.059 | -0.144 | 1,019 |
| | (0.058) | (0.141) | | (0.151) | (0.369) | |
| De novo firms | -0.471*** | -1.153*** | 6,446 | -0.722*** | -2.203*** | 6,376 |
| founded after 1991 | (0.143) | (0.363) | | (0.072) | (0.278) | |
| Firms reporting ovedue/barter if hit | -0.415*** | -1.050*** | 2,353 | -0.538*** | -1.615*** | 2,348 |
| with a hypothetical cash shock | (0.120) | (0.314) | | (0.129) | (0.446) | |
| New technology | | | | | | |
| Machine-based | | | | -0.769*** | -2.763*** | 6,504 |
| | | | | (0.065) | (0.357) | |
| Non Machine-based | | | | -0.838*** | -8.482*** | 6,494 |
| | | | | (0.049) | (1.319) | |
| EBRD indices as IVs | -0.375*** | -0.893*** | 9,586 | -0.608*** | -1.699*** | 9,496 |
| | (0.104) | (0.252) | | (0.072) | (0.229) | |
| Cost of external finance | -0.434*** | -1.162*** | 10,354 | -0.641*** | -2.017*** | 10,267 |
| | (0.106) | (0.292) | | (0.075) | (0.282) | |
| Control for: | | | | | | |
| Initial productivity, $ln(\frac{Y_{t-3}}{L_{t-3}})$ | -0.331*** | -0.802*** | 7,461 | -0.551*** | -1.540*** | 7,379 |
| | (0.131) | (0.324) | | (0.110) | (0.352) | |
| Initial debt, $(\frac{D_{t-3}}{TA_{t-3}})$ | -0.442*** | -1.133*** | 3,674 | -0.568*** | -1.725*** | 3,677 |
| | (0.122) | (0.327) | | (0.085) | (0.307) | |
| Index of limiting factors | -0.536*** | -1.303*** | 10,291 | -0.767*** | -2.223*** | 10,198 |
| | (0.133) | (0.335) | | (0.076) | (0.274) | |
| Education of chief manager | -0.386*** | -0.982*** | 3,647 | -0.511*** | -1.524*** | 3,651 |
| | (0.118) | (0.309) | | (0.088) | (0.302) | |
| Being a defendant in courts | -0.386*** | -0.935*** | 9,957 | -0.547*** | -1.519*** | 9,876 |
| | (0.107) | (0.267) | | (0.096) | (0.301) | |
| Distance to the frontier | -0.300** | -0.751** | 3,481 | -0.431*** | -1.248*** | 3,483 |
| | (0.140) | (0.356) | | (0.092) | (0.296) | |
| Manager's time spent with officials | -0.474*** | -1.153*** | 9,700 | -0.610*** | -1.713*** | 9,632 |
| | (0.089) | (0.225) | | (0.077) | (0.252) | |
| Include all controls | -0.692*** | -1.817** | 2,370 | -0.949*** | -3.246*** | 2,346 |
| | (0.286) | (0.823) | | (0.088) | (0.449) | |

***Notes***: The table reports estimates of the coefficient on the *difficulty in access to external credit* in equation (8) except the last row in the first panel where estimates are reported for the *cost of external finance*. Initial productivity $ln(Y_{t-3}/L_{t-3})$ and initial debt $(D_{t-3}/TA_{t-3})$ are from retrospective questions. *De novo firms* are firms founded after 1991. *Education of chief manager* is a set of three dummies for education attainment. *Index of limiting factors* is computed as the average score of how problematic different factors (access to infrastructure, regulation

burden, crime, property rights, etc). *Distance to frontier* is a self-reported measure of firm's technology relative to competitors. *Being a defendant in courts* is a dummy variable equal to one if a firm reports being a defendant in courts. *Manager's time spent with officials* is the percent of time managers spend with government officials. *Intensive margin* is a self-reported importance (with scores ranging from 1 ("not important") to 5 ("extremely important")) of an innovation for a firm's survival. Row *Firms reporting ovedue/barter if hit with a hypothetical cash shock* estimates the specification only on the sample of firms reporting that they would stop paying suppliers or would engage in non-conventional forms of payments if hit with a hypothetical, temporary, unanticipated 10% reduction in cash flow. Indices of reforms in financial and banking sectors are from the European Bank for Reconstruction and Development (EBRD). These indices are included in addition to the baseline set of instruments. See Data Appendix for more details on the variables. *Include all controls* presents results for the specification where all controls included in the bottom panel are included on the RHS. Results for the panel sample of firms are based on the linear probability model. The number of observations for the panel sample shows the number of firms. Fixed effects for year, country, industry and location are included but not reported. Except the first two rows, interactions of fixed effects are not included. Robust standard errors clustered by country and year are in parentheses. ***, **, * denote significance at 0.01, 0.05, and 0.10 levels.

Table 7. IV probits estimates: Analysis of subsamples.

| | | New good | | | New technology | | |
|---|---|---|---|---|---|---|---|
| | | Estimate | Elasticity | Obs. | Estimate | Elasticity | Obs. |
| | | (1) | (2) | (3) | (4) | (5) | (6) |
| Sector | Manufacturing | -0.392*** | -0.783*** | 3,517 | -0.475*** | -1.063*** | 3,490 |
| | | (0.148) | (0.297) | | (0.150) | (0.340) | |
| | Services | -0.297** | -0.785* | 5,483 | -0.339** | -1.051* | 5,436 |
| | | (0.153) | (0.420) | | (0.165) | (0.579) | |
| Firm age | New | -0.444*** | -1.081*** | 8,014 | -0.671*** | -1.969*** | 7,937 |
| | | (0.100) | (0.251) | | (0.073) | (0.259) | |
| | Old | -0.182 | -0.431 | 2,277 | -0.209 | -0.526 | 2,263 |
| | | (0.204) | (0.486) | | (0.168) | (0.429) | |
| Firm size | 2-10 | -0.373*** | -1.048*** | 4,739 | -0.627*** | -2.354*** | 4,701 |
| | | (0.108) | (0.318) | | (0.121) | (0.649) | |
| | 11-49 | -0.489*** | -1.113*** | 3,253 | -0.404* | -1.011* | 3,225 |
| | | (0.171) | (0.399) | | (0.215) | (0.560) | |
| | 50-99 | -0.384 | -0.777 | 961 | -0.26 | -0.561 | 953 |
| | | (0.262) | (0.532) | | (0.639) | (1.391) | |
| | 100+ | -0.272 | -0.515 | 1,323 | -0.398*** | -0.788** | 1,320 |
| | | (0.185) | (0.352) | | (0.171) | (0.339) | |
| Region | New EU members | 0.24 | 0.599 | 3,127 | -0.17 | -0.482 | 3,102 |
| | | (0.161) | (0.407) | | (0.225) | (0.655) | |
| | South-East Europe | -0.402*** | -0.857*** | 2,072 | -0.519*** | -1.330*** | 2,055 |
| | | (0.164) | (0.349) | | (0.189) | (0.507) | |
| | Western CIS | -0.796*** | -1.776*** | 2,041 | -0.855*** | -2.482*** | 2,032 |
| | | (0.167) | (0.375) | | (0.072) | (0.260) | |
| | Eastern CIS | -0.774*** | -2.152*** | 2,306 | -0.716*** | -1.827*** | 2,307 |
| | | (0.083) | (0.290) | | (0.139) | (0.416) | |
| Ownership | State | -0.183 | -0.441 | 1,402 | -0.431*** | -1.082*** | 1,392 |
| | | (0.168) | (0.411) | | (0.150) | (0.402) | |
| | Foreign | -0.011 | -0.02 | 1,743 | 0.063 | 0.131 | 1,734 |
| | | (0.226) | (0.394) | | (0.263) | (0.553) | |
| Hajivassiliou and Savignac (2007) sample | | -0.385*** | -0.888*** | 8,355 | -0.417*** | -1.107*** | 8,111 |
| | | (0.024) | (0.056) | | (0.030) | (0.081) | |

***Notes***: In *state* (*foreign*) ownership only state (foreign) owned firms are included in the estimation sample. In all other subsamples, the estimation samples include only private domestically owned firms. Robust standard errors clustered by country and year are in parentheses. ***, **, * denote significance at 0.01, 0.05, and 0.10 levels. See notes to Table 5 for more details.

# Appendix Tables

Appendix table A1. Descriptive statistics.

| | Mean | St.Dev. | Obs. |
|---|---|---|---|
| Innovation Variables | | | |
| New Product | 0.374 | 0.484 | 16,278 |
| New Technology | 0.307 | 0.461 | 16,148 |
| Positive R&D spending | 0.368 | 0.482 | 7,867 |
| Total factor productivity | 1.669 | 0.710 | 10,186 |
| Measures of financial constraints | | | |
| Difficulty of access to external finance | 2.279 | 1.145 | 15,514 |
| Cost of external finance | 2.512 | 1.134 | 15,628 |
| Vertical Transfer of Capability | | | |
| Share of sales to multinationals (MNEs) | 0.079 | 0.214 | 15,736 |
| Share of imported inputs | 0.298 | 0.378 | 15,716 |
| Controls | | | |
| ln(Labor) | 3.158 | 1.628 | 24,533 |
| $\ln(\text{Labor})^2$ | 12.625 | 12.279 | 24,518 |
| Share of skilled workers | 0.483 | 0.314 | 23,703 |
| Share of workers with university education | 0.284 | 0.300 | 23,555 |
| Log(age) | 2.346 | 0.781 | 16,314 |
| Compete in national markets | 0.467 | 0.499 | 24,534 |
| Markup | 0.212 | 0.141 | 14,116 |
| Capacity utilization | 0.794 | 0.209 | 15,873 |
| Size of optimal labor | 1.072 | 0.298 | 15,980 |
| Share of temporary workers | 0.075 | 0.159 | 16,075 |
| Location | | | |
| Capital | 0.316 | 0.465 | 24,534 |
| Other,over 1million | 0.061 | 0.239 | 24,534 |
| Other, 250,000-1,000,000 | 0.160 | 0.367 | 24,534 |
| Other, 50,000-250,000 | 0.225 | 0.417 | 24,534 |
| Under 50,000 | 0.238 | 0.426 | 24,534 |
| Instrumental variables | | | |
| Overdue dummy | 0.162 | 0.369 | 15,987 |
| Share of non-conventional forms of payments | 0.058 | 0.232 | 24,534 |
| Lost sales | 0.018 | 0.057 | 16,021 |
| EBRD's reform in the banking sector | 2.866 | 0.707 | 22,949 |
| EBRD's reform of non-bank financial institutions | 2.518 | 0.729 | 22,949 |
| Additional controls | | | |
| Labor productivity, $ln(Y_{t-3}/L_{t-3})$ | 2.600 | 1.326 | 11,353 |
| Initial debt, $(\frac{D_{t-3}}{TA_{t-3}})$ | 3.920 | 12.620 | 14,879 |
| Being a defendant in courts | 1.980 | 0.590 | 16,321 |
| Index of limiting factors | 0.141 | 0.348 | 15,653 |

Appendix table A2. Unconditional probabilities of innovation.

| | New technology | New good | R&D expenditure |
|---|---|---|---|
| | (1) | (2) | (3) |
| Sector | | | |
| Manufacturing | 0.489 | 0.490 | 0.354 |
| Services | 0.295 | 0.300 | 0.233 |
| Firm age | | | |
| New | 0.364 | 0.367 | 0.281 |
| Old | 0.375 | 0.379 | 0.381 |
| Firm Size | | | |
| 2-10 | 0.296 | 0.304 | 0.156 |
| 11-50 | 0.400 | 0.400 | 0.331 |
| 51-100 | 0.452 | 0.452 | 0.408 |
| 100+ | 0.460 | 0.462 | 0.657 |
| Ownership | | | |
| Private domestic | 0.367 | 0.367 | 0.308 |
| State | 0.325 | 0.328 | 0.557 |
| Foreign | 0.456 | 0.456 | 0.569 |
| Region | | | |
| New EU members | 0.348 | 0.352 | 0.287 |
| South-East Europe | 0.460 | 0.461 | 0.287 |
| Western CIS | 0.420 | 0.420 | 0.440 |
| Eastern CIS | 0.302 | 0.306 | 0.251 |

Appendix table A3. First stage regression.

| | New good | New technology | Positive R&D spending | TFP | Interactions of fixed effects country*year | | industry*year | |
|---|---|---|---|---|---|---|---|---|
| | | | | | New good | New technology | New good | New technology |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Overdue dummy | 0.296*** | 0.292*** | 0.301*** | 0.325*** | 0.288*** | 0.284*** | 0.295*** | 0.293*** |
| | (0.033) | (0.032) | (0.042) | (0.047) | (0.032) | (0.031) | (0.030) | (0.028) |
| Share of non-convetional forms of payments | 0.152*** | 0.132*** | 0.116*** | 0.128** | 0.174*** | 0.161*** | 0.154*** | 0.132*** |
| | (0.042) | (0.050) | (0.044) | (0.056) | (0.048) | (0.053) | (0.043) | (0.038) |
| Lost sales | 0.514** | 0.554** | -0.043 | 0.075 | 0.493* | 0.622** | 0.439** | 0.577*** |
| | (0.257) | (0.254) | (0.275) | (0.276) | (0.259) | (0.260) | (0.175) | (0.151) |
| Share of sales to MNE | -0.075 | -0.078 | -0.04 | -0.015 | -0.044 | -0.05 | -0.079 | -0.082 |
| | (0.065) | (0.065) | (0.083) | (0.095) | (0.061) | (0.062) | (0.073) | (0.072) |
| Share of imported inputs | 0.131*** | 0.133*** | 0.137*** | 0.137** | 0.137*** | 0.139*** | 0.129*** | 0.131*** |
| | (0.038) | (0.038) | (0.053) | (0.055) | (0.038) | (0.037) | (0.039) | (0.039) |
| ln(Labor) | -0.041 | -0.04 | -0.021 | -0.049 | -0.038 | -0.036 | -0.042 | -0.04 |
| | (0.039) | (0.039) | (0.048) | (0.057) | (0.038) | (0.039) | (0.028) | (0.027) |
| $\ln(\text{Labor})^2$ | -0.003 | -0.003 | -0.005 | -0.003 | -0.003 | -0.003 | -0.003 | -0.003 |
| | (0.005) | (0.005) | (0.007) | (0.007) | (0.005) | (0.005) | (0.004) | (0.003) |
| Share of skilled labor | 0.023 | 0.016 | 0.012 | -0.11 | 0.025 | 0.018 | 0.02 | 0.013 |
| | (0.063) | (0.063) | (0.112) | (0.094) | (0.064) | (0.064) | (0.032) | (0.032) |
| Share of labor with university degree | -0.05 | -0.05 | -0.022 | -0.084 | -0.04 | -0.04 | -0.05 | -0.051 |
| | (0.046) | (0.047) | (0.088) | (0.088) | (0.047) | (0.048) | (0.046) | (0.046) |
| Markup | -0.009 | 0.008 | 0.092 | 0.049 | -0.022 | -0.004 | -0.017 | 0 |
| | (0.108) | (0.111) | (0.171) | (0.173) | (0.110) | (0.113) | (0.073) | (0.074) |
| Log(age) | -0.021 | -0.02 | -0.029 | -0.006 | -0.018 | -0.017 | -0.02 | -0.019 |
| | (0.019) | (0.020) | (0.026) | (0.029) | (0.019) | (0.020) | (0.021) | (0.021) |
| Compete in national markets | 0.006 | 0.003 | -0.049 | -0.006 | -0.01 | -0.014 | 0.001 | -0.002 |
| | (0.040) | (0.040) | (0.049) | (0.051) | (0.041) | (0.041) | (0.025) | (0.025) |
| Size of optimal labor | 0.163*** | 0.159*** | 0.223*** | 0.095 | 0.155*** | 0.151*** | 0.164*** | 0.159*** |
| | (0.040) | (0.042) | (0.045) | (0.058) | (0.040) | (0.041) | (0.048) | (0.048) |
| Share of temporary workers | 0.210** | 0.221*** | 0.203* | 0.228** | 0.204** | 0.212** | 0.213*** | 0.223*** |
| | (0.084) | (0.085) | (0.115) | (0.108) | (0.085) | (0.086) | (0.070) | (0.069) |
| Capacity utilization | -0.245*** | -0.252*** | -0.254*** | -0.260*** | -0.230*** | -0.237*** | -0.246*** | -0.253*** |
| | (0.060) | (0.060) | (0.085) | (0.074) | (0.061) | (0.061) | (0.061) | (0.064) |
| Observations | 10,291 | 10,198 | 5,129 | 4,618 | 10,291 | 10,198 | 10,291 | 10,198 |

***Notes***: The table reports the first stage estimation results for estimates reported in Tables 5 and 6. *Overdue dummy* is the dummy variable equal to one if a firm has overdue payments to suppliers. *NTP* is the share of payments from customers and to suppliers settled by debt swaps or offsets and exchange of goods for goods (barter). *TFP* measures log total factor productivity computed as log sales minus log capital, log employment, and log material input weighted by cost shares of each input and adjusted for capacity utilization (see equation (7)). Cost shares are allowed to vary by industry and country. Fixed effects for year, country, industry and location are included but not reported. Except for columns (5)-(8), interactions of fixed effects are not included. Robust standard errors clustered by country and year are in parentheses. ***, **, * denote significance at 0.01, 0.05, and 0.10 levels.

Appendix table A4. Innovation and financial constraints.

| | Reported degree of a financial constraint | | | | |
|---|---|---|---|---|---|
| | No obstacle | Minor obstacle | Moderate obstacle | Major obstacle | Total |
| | (1) | (2) | (3) | (4) | (5) |
| | Panel A: Difficulty of access to external finance | | | | |
| New good | | | | | |
| No | 0.23 | 0.13 | 0.15 | 0.12 | 0.62 |
| Yes | 0.13 | 0.08 | 0.09 | 0.08 | 0.38 |
| Total | 0.36 | 0.20 | 0.24 | 0.20 | 1.00 |
| New technology | | | | | |
| No | 0.25 | 0.14 | 0.16 | 0.14 | 0.69 |
| Yes | 0.11 | 0.07 | 0.08 | 0.06 | 0.31 |
| Total | 0.36 | 0.20 | 0.24 | 0.20 | 1.00 |
| Positive R&D spending | | | | | |
| No | 0.22 | 0.12 | 0.16 | 0.12 | 0.63 |
| Yes | 0.13 | 0.08 | 0.09 | 0.07 | 0.37 |
| Total | 0.35 | 0.20 | 0.25 | 0.19 | 1.00 |
| | Panel B: Cost of external finance | | | | |
| New good | | | | | |
| No | 0.18 | 0.13 | 0.17 | 0.14 | 0.62 |
| Yes | 0.09 | 0.08 | 0.10 | 0.11 | 0.38 |
| Total | 0.27 | 0.21 | 0.27 | 0.25 | 1.00 |
| New technology | | | | | |
| No | 0.19 | 0.14 | 0.19 | 0.17 | 0.69 |
| Yes | 0.08 | 0.07 | 0.09 | 0.08 | 0.31 |
| Total | 0.27 | 0.21 | 0.27 | 0.25 | 1.00 |
| Positive R&D spending | | | | | |
| No | 0.16 | 0.12 | 0.18 | 0.17 | 0.63 |
| Yes | 0.09 | 0.09 | 0.10 | 0.09 | 0.37 |
| Total | 0.26 | 0.21 | 0.28 | 0.26 | 1.00 |

***Notes***: The table reports tabulations of responses to questions about the degree of financial constraints and the incidence of innovations.

# Data Appendix

In this Appendix, we describe the purpose, design and response rate of the Business Environment and Enterprise Performance Survey (BEEPS) based on two reports compiled by MEMRB Custom Research Worldwide (2002) and Synovate (2005) for the EBRD: "The Business Environment and Enterprise Performance Survey - 2002: A brief report on observations, experiences and methodology from the survey" and "The Business Environment and Enterprise Performance Survey (BEEPS) 2005: A brief report on observations, experiences and methodology from the survey."

BEEPS is an ongoing enterprise that is carried out by the European Bank for Reconstruction and Development and the World Bank. Its purpose is to provide information about the impact of government policies and public services on the environment for investment and business development in Central and Eastern Europe and the Commonwealth of Independent States. The survey was implemented by MEMRB Custom Research Worldwide (MCRW) and later by Synovate. Fieldwork personnel were trained locally in each country in day long workshops. Refresher training courses were given based on feedback from pilot surveys (10 (5) in each country in 2002 (2005)). Screening interviews were done over the phone, the interviews as such were done face-to-face. 20 (30) percent of the cases were checked again by call-backs to verify and clarify responses in the 2002 (2005) survey. For Russia and the Asian republics, 100 percent of all interviews were checked with call-backs.

The target number of firms to be interviewed was 6,500 for the 2002 survey and 9,500 for the 2005 survey. To ensure that the samples are representative of the relevant population of firms, the surveys used stratified random sampling. In each country, the sectoral composition of the total sample in terms of manufacturing versus services was determined by their relative contribution to GDP, subject to a minimum of 15 percent for each category. At least 10 percent of the total sample should be in the small (2-49 employees), 10 percent in the medium (50 - 249 employees) and 10 percent in the large (250-9,999 employees) size categories. At least 10 percent of the firms should have foreign control and 10 percent state control. At least 10 percent of the firms were to be in the category "small/countryside." If satisfying these quotas in all dimensions was not achievable, more than the target number of interviews were conducted. The design was specified according to the total population of enterprises, the ownership ratio, the size of firms, their geographic location and their sub-sectors. For certain parameters, where statistical information was not available, enterprise populations and distributions were estimated from other accessible demographic and socio-economic data (e.g. employment). If adjustments of the sample design had to be done, they were done systematically at the MCRW's Head Office for all the countries, to ensure consistency across countries.

For the 2002 survey in total 18,052 firms were contacted. The interview completion rate was 36.93 %. 38.34 % of the firms contacted were not interested or unable to be interviewed. 24.73 % of the firms contacted were not eligible (e.g. because they belonged to firm categories for which the quota was already met). Of the firms interviewed in 2002, 73.05% consented in being contacted again for the 2005 survey.

To maintain comparability with the 2002 survey data, the 2005 sample of each country was based on the *achieved* sample distribution of the 2002 survey. Priority was given to the firms that had agreed in the 2002 survey to be contacted again. Once the panel list of firms was exhausted, non-panel firms were contacted with the aim to meet the overall distribution of the total sample.

Altogether, around 30 percent of the firms that had agreed to be contacted again could actually be interviewed for the 2005 survey. This relatively small number is not due to exit of firms, but rather caused by a refusal of firms to be interviewed again (42 %) or because they could not be reached (25 % of the firms).

At each firm the interviews were done with "the person who normally represents the company for official purposes, that is who normally deals with banks or government agencies/institutions". In small firms, interviewing just one person was usually enough to complete the questionnaire. In larger firms, often the principal respondent consulted with other experts in the firm to acquire all the relevant information.

The variables are constructed as follows.

**Age** is the log of firm's age. The age is computed as the year of the survey minus the year when the firm was established. The minimum age is two years. The year when a firm is established is based on the following question: "In what year did your firm begin operations in this country?"

**Being a defendant in courts** is a dummy variable equal to one if a firm reports a positive magnitude for the following question: " How many cases in civil or commercial arbitration courts have involved your firm either as a defendant in the last 36 months?"

**Capacity utilization (CU)** is the level of utilization of facilities/man power relative to the maximum output possible using its facilities/man power 36 month ago. This variable is based on the following question: "In your judgement, what is your firm's current output in comparison with the maximum output possible using its facilities/man power at the time? If you are using the facilities/man power to the full, answer 100%; if output was 60% of capacity, answer 60%. What was the capacity utilization 36 months ago?"

**CNM** captures whether a firm competes in national markets. This is a dummy variable equal to one if a firm responds 'Yes' to "Does your firm compete in the national market (i.e. whole country) for its main product line or service or does it serve primarily the local market (i.e. region, city, or neighborhood)?"

**Cost of External Finance** is based on the following question: "Can you tell me how problematic is cost of financing (e.g., interest rates and charges) for the operation and growth of your business?" The answer can take values "No obstacle", "Minor obstacle", "Moderate obstacle", and "Major obstacle".

**Difficulty of Access to External Finance** is based on the following question: "Can you tell me how problematic is access to financing (e.g., collateral required or financing not available from banks) for the operation and growth of your business?" The answer can take values "No obstacle", "Minor obstacle", "Moderate obstacle", and "Major obstacle".

**Distance to the frontier** is based on the following question: "Thinking of your main product line or main line of services and comparing your production process with that of your closest competitor, which of the following best summarizes your position:" with the options ranging on scale from one to three and categorized into "My firm's technology is less advanced than that of its main competitor", "My firm's technology is about the same as that of its main competitor", and "My firm's technology is more advanced than that of its main competitor". In regressions, we create a dummy variable for each category. This question was present only in the 2002 wave of BEEPS.

**EDU** is the share of workers with higher education, 3 years ago. This variable is based on the following question: "What share of the workforce at your firm had some university education 36 months ago?"

**Education of chief manager** is a set of dummy variables aimed to capture the education attainment of firm's chief manager. This variable is based on the following question: "What is the highest level of education of the general manager?" The possible answers are "Did not complete secondary school", "Secondary school", "Vocational training", "Some university training", "Completed university degree", "Completed higher university degree (eg. masters, doctorate)". This question was asked only in the 2002 wave of BEEPS.

**Import** is the share of inputs that are imported. The variable is based on the question that asks a firm to report the share of a firm's material inputs and supplies that are imported directly or indirectly through a distributor.

**Index of limiting factors** is the average response (which can range from 1 to 4: "No obstacle", "Minor obstacle", "Moderate obstacle", and "Major obstacle") across the following questions: "Can you tell me how problematic are these different factors for the operation and growth of your business:"

- "Telecommunications"
- "Electricity"
- "Transportation"
- "Access to land"
- "Tax rates"
- "Tax administration"
- "Customs and trade regulations"
- "Business licensing and permits"
- "Labour regulations"
- "Skills and education of available workers"
- "Economic policy uncertainty"
- "Macroeconomic instability (inflation, exchange rate)"
- "Functioning of the judiciary"
- "Corruption"
- "Street crime/theft/disorder"

- "Organised crime/Mafia"
- "Anti-competitive practices of other producers"
- "Contract violations of by customers and suppliers"
- "Title or leasing of land"

**Industry** information in BEEPS is available in NACE at the four-digit level. However, we aggregated industries as a number of disaggregated industries were sparsely populated. Specifically, NACE industries codes are combined as follows: 10-14; 37-41; 15-16; 17-19; 20-22; 23-26; 27-28; 29-36; 45; 50; 51; 52; 55; 60; 61-64; 65-70; 71-73; 74-91; 92; 93; 95; 99.

**Initial debt,** $(\frac{D_{t-3}}{TA_{t-3}})$ is the ratio of the debt to total assets three years ago. This variable is based on the following question: "At the end of 1998/1999, what was the level (expressed as a per cent) of debt in relation to your total assets?"

**Intensive margin** is based on the following question: "How important is $X$ for firm's survival?" reported on a scale from 1 ("Not important") to 5 ("extremely important") where $X$ is a type of an innovation (e.g., introduction of new technology).

**Labor (L)** is the number of permanent and temporary employees 36 month ago. This variable is based on the following two questions:

- "How many permanent, full-time employees did your firm have 36 months ago?"
- "How many part-time or temporary employees did your firm have 36 months ago?"

**LOC** is a set of location dummies. Types of locations are based on population and whether a location is capital: Capital; Other city over 1 million; Other 250,000-1,000,000; Other 50,000-250,000; Under 50,000.

**Lost sales** is based on several questions. For the 2002 wave of BEEPS, we use the following question: "What percent of sales in 2001 was lost due to delivery delays from your material input suppliers?" This question was collected only in the 2002 wave of BEEPS. For the 2005 wave of BEEPS we use the following questions: "What percent of total sales was lost due to i) Power outages or surges from the public grid; ii) Insufficient water supply; iii) Unavailable mainline telephone service." and "What percentage of the value of products your establishment shipped over the last 12 months was lost while in transit due to breakage, spoilage or theft?" We take the sum of lost sales reported in response to these two questions. These questions were collected only in the 2005 wave of BEEPS. All losses are expressed as a percent of sales.

**Manager's time spent with officials** is the share of time senior managers spend dealing with government officials. This variable is based on the following question: "What percent of senior management's time over the last 12 months was spent in dealing with public officials about the application and interpretation of laws and regulations and to get or to maintain access to public services?"

**Markup** is the ratio of the price to the marginal cost. This variable is based on the following question: "Considering your main product line or main line of services in the domestic market, by what margin does your sales price exceed your operating costs (i.e., the cost of material inputs plus wage costs but not overhead and depreciation)?"

**New good** shows when a firm reports development of a new product or upgrade existing product. This is a dummy variable equal to one if a firm responds 'yes' to any of the two questions: Has your company undertaken any of the following initiatives over the last 36 months?

- Developed successfully a major new product line
- Upgraded an existing product line

**New technology** shows when a firm reports that a new technology is implemented. This is a dummy variable equal to one if a firm's answer is affirmative to the following question: Has your firm acquired new production technology over the last 36 months?

**OptimalEmpl** is the survey response to the question about optimal number of employees relative to the current employment. This variable is based on the following question: "If you could change the number of regular full-time workers your firm currently employs without any restrictions (i.e. without seeking permission, making severance payments etc.), what would be your optimal level of employment as a percent of your existing workforce? (e.g., 90% implies you would reduce your workforce by 10%, 110% means you want to expand by 10%)".

**Productivity** is computed as in equation (7) for TFP or as log sales per employee for labor productivity ($log(Y/L)$). The number of employees is the sum of permanent and temporary employees. Productivity dated by period $t-3$ is constructed using questions on current sales and employment as well as the growth of sales and employment over the last three years.

**RDdummy** indicates whether a firm reports positive spending on research and development. This variable is based on the following question: "Could you please tell me how much did your firm spend in 2004 (2001) on Research and development (including wages and salaries of R&D personnel, R&D materials, R&D related education and R&D training costs)?"

**ShareTempEmpl** is the share of temporary workers in the total employment in a given firm. This variable is based on the following two questions:

- "How many permanent, full-time employees did your firm have 36 months ago?"
- "How many part-time or temporary employees did your firm have 36 months ago?"

**SKILL** is the share of skilled workers, 3 years ago. This variable is based on the following question: "What share of your current permanent, full-time workers were skilled workers 36 months ago?"

**SMNE** is the share of sales to multinational enterprises (MNEs). The variable is based on the question that asks a firm to report the share of sales to multinationals located in your country (not including your parent company, if applicable).

# Mathematical Appendix

Consider the following example of a firm that is competing in a monopolistic competition environment à la Dixit/Stiglitz. Consumers have a preference for variety and hence there are total expenditures $Y$ on a diversified bundle of goods. Solving the utility maximization problem of a representative consumer, we can derive the demand function for the firm as

$$x = \frac{Yp^{-\sigma}}{P^{1-\sigma}}, \tag{9}$$

where $p$ is the price charged by the firm, $P$ is the price index of all varieties' prices, and $\sigma$ is the elasticity of substitution.

Firms produce at a constant marginal cost $c$. If the firm innovates, it reduces this marginal cost to $\alpha c < c$, with $\alpha < 1$. If production is financed with external funds, the cost of each unit is increased by a factor of $\gamma$, with $\gamma > 1$. Profits are given by

$$\pi_0 = px - cx \tag{10}$$

if internal funds are used and no innovation is carried out. Firms set prices to maximize their profits. Consider the first order condition

$$\frac{d\pi_0}{dp} = x + (p - c)\frac{dx}{dp} = 0 \tag{11}$$

From (9) we can derive

$$\frac{dx}{dp} = -\sigma\frac{Yp^{-\sigma-1}}{P^{1-\sigma}} \tag{12}$$

using the fact that the price index does not change if a single firm changes its price, due to the continuum of firms.

Plugging (12) and (9) into (11), we can solve for the optimal price

$$p = c\frac{\sigma}{\sigma - 1} \tag{13}$$

Now, using (13) and (9), we can determine the profit as

$$\pi_0 = \frac{Y}{\sigma}\left(\frac{p}{P}\right)^{1-\sigma} \tag{14}$$

Consider next the case where external finance is used. The only difference with respect to $\pi_0$ is that now the constant marginal cost is multiplied by $\gamma$ and so is the optimal price set by the firm. Hence

$$\pi_\gamma = \gamma^{(1-\sigma)}\pi_0 \tag{15}$$

Similarly, we can determine $\pi_0^I = \alpha^{(1-\sigma)}\pi_0$ and $\pi_\gamma^I = (\alpha\gamma)^{(1-\sigma)}\pi_0$. Thus, assumption 1 is confirmed by

$$\frac{d(\pi_\gamma^I - \pi_\gamma)}{d\gamma} = (1 - \sigma)\gamma^{(-\sigma)}(\alpha^{1-\sigma} - 1)\pi_0 < 0 \tag{16}$$

Note that $\frac{d\Delta_\pi}{d\delta_L} = -(1 - \gamma^{1-\sigma})(\alpha^{1-\sigma} - 1)\frac{Y}{\sigma}\left(\frac{p}{P}\right)^{1-\sigma} < 0$ when $\gamma > 1$, $\alpha < 1$ and $\sigma > 1$.