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Firm Productivity, Innovation, and Financial Development

Era Dabla-Norris, Erasmus Kersting and Geneviève Verdier

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Firm Productivity, Innovation and Financial Development

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Abstract

How do firm-specific actions—in particular, innovation—affect firm productivity? And what is the role of the financial sector in facilitating higher productivity? Using a rich firm-level dataset, we find that innovation is crucial for firm performance as it directly and measurably increases productivity. Moreover, its effects on productivity are mediated through the financial sector; firms reap the maximum benefits from innovation in countries with well-developed financial sectors. This effect is particularly important for firms in high-tech sectors, which typically have higher external financing needs.

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I. INTRODUCTION

Economists still struggle to explain the large differences in output per worker across countries. The view that these differences are mostly the result of variations in investment rates has now largely been abandoned, as cross-country evidence suggests that total factor productivity (TFP) rather than capital accumulation accounts for observed per capita income differences (Hall and Jones, 1999). The largely unexplained cross-country differences in TFP led to Prescott's (1998) call for a 'theory of TFP'. In response, barriers to innovation, imitation and adoption (e.g., Parente and Prescott, 2000) and institutions (e.g., Acemoglu and Johnson, 2005) have often been offered as explanations for low TFP in poorer countries. The current global crisis and the resulting uncertainty have reinforced concerns about growth prospects in many low-income countries. After a decade of almost-universally solid growth performance, the medium-term outlook for many low-income countries appears increasingly uncertain. At the same time, the growth potential in many countries with low TFP remains dim, even beyond the eventual conclusion of this crisis.

If TFP drives growth, its determinants are the key to development prospects in low-income countries. Some country-specific direct determinants of TFP—geography, history or institutions such as the prevalent legal system—are fixed or slow-moving, and the degree to which policy can influence these conditions is limited. Others, such as innovation or the level of financial development, can respond to both foreign and domestic forces—external shocks, globalization or government policy. In this view, TFP is not primarily the result of the endowment of a country, but instead a direct result of purposeful actions by economic agents, and as such can be influenced by policy.

Innovation activity leads to technological progress in two distinct ways. Purposeful research and development can result in the invention of completely new products and processes. This kind of innovative activity moves the global technological frontier and still mainly occurs in developed countries. But innovation also consists of the adoption and adaptation of existing technology, which closes the gap between countries converging towards the global technological frontier and those on the leading edge, pushing the world frontier. Innovation shares a strong connection with the provision of financial services. Invention and adoption of technology are costly and risky activities, which require financing. It is therefore natural to study the impact of a country's financial development on TFP via the innovation channel.[2]

In this paper, we follow that agenda in two separate steps. We ask: How do firm-specific actions—in particular, innovation—affect firm productivity? And what is the role of the financial sector in facilitating higher productivity? Using firm-level data taken from the World Bank Enterprise Survey covering over 14,000 firms in 63 countries, we first establish a connection between a firm's innovative activities and its productivity. We control for country, industry and

[2] The existing literature is discussed in the next section.

firm-specific factors, including measures of the investment climate such as access to finance. The countries in our data include low, middle and high income countries, while the firms span all sizes with a focus on small and medium sized enterprises (SME). Innovation is defined broadly as the introduction of new production processes or product lines, so that it includes firms adopting existing technology. We find that, other things being equal, firms that have introduced a new process or product are more productive. In addition, we find that productive firms are large, exporters, and privately owned by foreign or private domestic interests. These results are robust to using various measures of innovation and productivity, such as output per worker and a production-function based TFP measure. Because of concerns of reverse causality, we instrument for firm-level innovation. The effect of innovation on productivity remains robust.

The second step necessary to complete the causal chain between financial development and TFP is to examine the effects of financial development on the relationship between innovation and productivity. Since innovative activity is capital intensive and tends to require outside financing, we expect innovation to be more prevalent in countries with a relatively more developed financial sector. However, we are looking for evidence that financial sector development increases the *effectiveness* of innovation activity. The main intuition behind this causal link relies on the financial system's ability to allocate capital optimally. In a country with a well developed financial sector, good innovation projects are more likely to be funded than bad ones. In other words, the financial system 'selects' the firms or projects with the highest underlying productivity.[3] This selection process means that innovation activities are more effective in countries with a high level of financial development. To test this hypothesis, we estimate the link between firm productivity and innovation while including an interaction term between a country's financial sector development and firms' innovative activity in our regression. We find that innovation has a higher effect on productivity in financially developed countries. Our results are robust to firm, industry and country-level controls and to varying measures of productivity, innovation and financial sector development. Financial-sector development is particularly important for innovative firms. In fact, the results suggest that the effect of financial development is higher for high-technology firms than for low-technology firms: the coefficient on the interaction between financial development and innovation is larger and more significant for high-tech firms.

In summary, our results suggest that innovation, broadly defined, is crucial for firm performance—it directly and measurably increases productivity—and its effect on productivity is mediated through the financial sector, i.e., it is in countries with developed financial sectors that firms reap the maximum benefits from innovation.

[3] Well-functioning capital markets and institutions also encourage the adoption of long-gestation productive technologies by reducing investors' liquidity risk. Moreover, by providing hedging and other risk sharing possibilities, well developed financial markets can promote assimilation of specialized technologies.

The paper is organized as follows. The next section briefly reviews the substantial existing literature on the links between TFP, innovation and financial sector development. Section three presents our measures of productivity, section four the data and estimation methodology. Section five presents the results, while section six concludes.

II. Total Factor Productivity, Innovation and Financial Development

The literature on this topic is understandably vast, and a complete overview is not attempted here. We instead focus on the ways in which innovation, financial development and TFP can interact, and how the empirical literature has tested the causal links between them.

A. Financial Development and Economic Growth

In the macroeconomics literature, there is a well established empirical link between finance and development. Using cross-country regression techniques, researchers have found that economic growth and capital accumulation are linked to higher levels of financial market development, as measured by the size of the banking system or stock markets (see Levine, 2004, for a survey). These studies use various econometric techniques, measures of financial development and both macro- and microeconomic data. For example, Beck et al. (2000) estimate the relation between financial development, TFP and growth using cross-country and cross-industry data. Arizala et al. (2009) use panel data spanning the years from 1963 to 2003 and covering 26 manufacturing industries and find evidence of a significant, positive relationship between financial development, measured by private credit over GDP, and industry-level TFP growth.

What are the mechanisms through which finance matters for growth? Many authors have found that financial development encourages competition. Guiso et al. (2004) find that the availability of financing encourages entrepreneurship. Haber (2003) argues that restrictions on growth of financial intermediaries resulted in higher industry concentration, lower competition and productivity in Brazil and Mexico.

If access to finance is crucial for performance, small firms, which are usually cash-constrained, should grow faster in financially developed economies. A large body of literature documents the importance of financial development for firm growth and performance, particularly for small firms. Beck et al. (2005) find evidence that financial development weakens the impact of various barriers to firm growth and that small firms benefit the most from financial development. Gorodnichenko et al. (2008) find that larger firms tend to innovate more than smaller firms, while older firms are less likely to innovate. Using industry-level data, Beck et al. (2008) show that financial sector development has a disproportionately positive effect on growth of small firms.

There is evidence that the financial sector reduces the cost of capital and promotes the efficient allocation of capital. In their famous contribution, Rajan and Zingales (1998) find evidence that financially-dependent industries grow disproportionately faster in financially developed economies. In addition, Fisman and Love (2004) show that in the short-run, financial development facilitates the reallocation of capital to high-growth industries, a result echoed in Hartman et al. (2007). The importance of this capital reallocation should not be underestimated. In fact, Hsieh and Klenow (2009) attribute the success of the past decade's high performers—China and India—to the reallocation of inputs from low to high-productivity sectors.

Why would financial development be important for growth? Overall, the literature suggests that a well-functioning financial system encourages competition, reduces the cost of capital and allocates capital efficiently. Our study is related to these findings, in particular the role of finance in reducing the cost of capital and allocating resources efficiently. In financially mature economies, productive firms are more likely to engage in innovation. Therefore their innovative activities will have a higher return than the less productive firms undertaking innovation in financially underdeveloped countries. This could account for the large quantitative impact of capital reallocation observed by Hsieh and Klenow (2009).

B. Financial Development, Innovation and TFP

Increasing productivity requires a firm to either push the frontier of knowledge or to converge towards it. The literature suggests that the level of productivity and the likelihood of innovation, through invention or adoption, depend on both on the institutional environment and the availability of financing. In fact, some have suggested that we should think of finance, or financial sector development, as a theory of TFP (Eros and Cabrillana, 2008).

In what environments are firms successful in terms of innovation and productivity? Coe et al. (1997) find that good institutions and high levels of human capital encourage innovation. Firm performance is also influenced by the investment climate. Dollar et al. (2005) find that the investment climate—measured with indicators such as power outages and customs delays—accounts for a significant portion of the variation in garment-industry firm performance in Bangladesh, China, India, and Pakistan. Dollar et al. (2006) estimate that international integration—and therefore possibly the potential to adopt foreign technologies—is higher in countries with a better investment climate.

Productivity and innovation are also linked to financial development more directly. Aghion et al. (2005) argue that technological catch up is determined by thresholds in financial development. Innovation is costly and requires mature financial systems, so productivity is constrained in the absence of finance. Other studies support these findings. Gatti and Love (2008) estimate the impact of access to credit on firm productivity in Bulgaria and find a strong association between firm productivity and access to credit. Sharma (2007) finds that small firms have a higher probability of innovating in countries with high financial development. Ayyagari et al. (2007) present evidence that innovation is higher in firms that have access to finance. Finally, although globalization may boost innovation (Lane, 2009; and Gorodnichenko et al., 2008), financial development may be crucial for a country's ability to capture the technological spillovers from foreign direct investment (Alfaro et al., 2004).

Our contribution to this literature is twofold. The macroeconomic literature on growth and growth accounting has highlighted both the importance of TFP for the level of income and the role of financial development in growth. Both the theoretical and empirical literature has emphasized selected determinants of both TFP and innovation, at the firm and industry levels. As noted above, our ambition is to link productivity to innovation directly and to highlight the way in which the financial system, by allocating capital to innovative firms, affects the size of the return to innovation.

III. Explaining and estimating Firm Productivity

We start from a basic framework with total output defined as a function of total factor productivity $F(A,K,hL) = Y = AQ(K,hL)$. Our estimation is based on the following equations:

$$y = Aq(k,h) \tag{1}$$

$$A = g(\iota, X_{ijc})\exp(u_i)$$
$$\frac{\partial g}{\partial \iota} \geq 0, \frac{\partial^2 g}{\partial \iota^2} \lesseqgtr 0 \tag{2}$$

where y is firm value added per worker, A is total factor productivity, k is capital per worker, h is human capital per worker, i is innovation, X_{ijc} is a matrix of other firm (i), industry (j) or country-specific (c) explanatory variables and u_i is a random error term. We assume that productivity is a positive function of innovation but allow for the possibility that there might be increasing, constant or decreasing returns to innovation.[4] The level of total factor productivity A is difficult to estimate as it is an unobservable variable, endogenously determined with value added and input choices. Ideally, the effects of innovation and other X variables on productivity A should be estimated by directly linking TFP to observable variables. However, since TFP is not directly observable, these effects have to be inferred indirectly through output per worker.

Taking logs of the output/TFP system above, we get

$$\log(y_i) = \log(q_i) + \log(A_i) \tag{3}$$

$$\log(A_i) = \log(g(i_i, X_{ijk})) + u_i \tag{4}$$

This system can be estimated in levels, as shown here, or by taking first differences and estimating the system in growth rates. Each option presents drawbacks (see Escribano and

[4] It is generally assumed that production functions have constant returns to scale: doubling inputs should double output. In the case of knowledge production or invention of new goods, replicating existing inputs would be equivalent to remaking the same discoveries and would leave output unchanged. It is therefore possible that there are diminishing returns to innovation. In addition, fixed costs of production could produce increasing returns to innovation.

Guasch (2005) for a detailed discussion of these issues). While estimating the system in growth rates avoids specifying a functional form for *F(A,K,hL)*, it requires a sufficiently long time-series. Moreover, it has been noted that systems in first differences suffer from a weak instrument problem (Chamberlain 1982; Griliches and Mairesse, 1995). To sidestep these problems, we estimate the system in levels.

Estimation in levels requires the specification of a functional form. Typically, a Cobb-Douglas function is chosen, e.g. $q(k) = Ak^{\alpha_k} h^{\alpha_h}$, which implies that production is log-linear in inputs, i.e.

$$\log(y_i) = \alpha_k \log(k_i) + \alpha_h \log(h_i) + \log(A_i) \quad (5)$$

$$\log(A_i) = \alpha_{innov} innovation_i + \alpha_i \log(X_i) + \alpha_j \log(X_j) + \alpha_c \log(X_c) + u_{ijc} \quad (6)$$

Estimating this system assumes that elasticities are constant across firms in the same industry and within the same country since $\alpha_{kj}^c = \alpha_k, \alpha_{hj}^c = \alpha_h$ for each country *c* and industry *j*. In addition, if the production function does not exhibit constant returns to scale and markets are not perfectly competitive, the measure of productivity will capture factors unrelated to pure technological productivity, such as the impact of monopolies, unless they are appropriately controlled for.

As noted above, the effects of innovation and other firm, industry and country characteristics have to be inferred indirectly through observed firm output. Indirect inferences could be made by estimating a single regression obtained by substituting equation (5) into equation (6):

$$\log(y_{ijc}) = \alpha_k \log(k_i) + \alpha_h \log(h_i) + \alpha_{innov} innovation_i + \alpha_i X_i + \alpha_j X_j + \alpha_c X_c + u_{ijc} \quad (7)$$

As long as input markets are competitive, estimating this equation by least squares generates unbiased estimates of the vector $\alpha = \lfloor \alpha_k, \alpha_h, \alpha_{innov}, \alpha_i, \alpha_j, \alpha_c \rfloor$. If firm-level innovation is endogenous, consistent estimates can be obtained by using instrumental variables (IV). An alternative strategy, followed here, is to aggregate the firm-level innovation variable so as to reduce the possibility of two-way causality. This strategy is discussed in the estimation section.

In a two-step estimation, Equation (3) is estimated first and a Solow residual computed as

$$\log(A_i) = \log(y_{ijc}) - \hat{\alpha}_k \log(k_i) - \hat{\alpha}_h \log(h_i) \quad (8)$$

where $\hat{\alpha}_k$ is the least squares estimate of α_k . The resulting estimate of TFP can then be regressed on innovation and other control variables in a second step. The drawback of this approach is that it requires that factor inputs be uncorrelated with innovation and other variables. We therefore choose the single-step approach and estimate versions of equation (7).

We also compute a Solow residual based on levels of output per worker. Although this also requires strong assumptions about the market environment and constancy of production function parameters, the modified (calibrated) Solow-residual approach allows us to determine the sensitivity of our results to the measure of productivity.

IV. Data and Methodology

A. Data and Summary Statistics

This section describes the different data sources and the variables used in the empirical analysis. We employ firm-level data for manufacturing firms in both developed and developing countries from the World Bank Enterprise Survey (WBES) conducted between 2005 and 2007, complemented with cross-country data on different measures of financial development. [5]

The largest sample includes 63 countries, mainly low-income and emerging market countries, and a few advanced countries (Table 1). The richest country in the sample in terms of GDP per capita is Ireland ($48,705) while the poorest is Burundi ($130). Average GDP per capita ($5263) masks large income differences in the sample of countries. The largest share of firms in the dataset are located in Latin America (37 percent), followed by Eastern Europe and Central Asia (21 percent). Sixteen industries are represented with the largest shares of firms in the food, metals and machinery and garments sectors (18 percent, 16 percent and 15 percent of the firms, respectively.)

Firms report the value of total sales and fixed assets as well as information on employees, wages and costs. We use this information to obtain estimates of productivity. The main dependent variable is output per worker measured by the log of total sales per worker in U.S. dollars. Where necessary, units are converted to US$ using PPP exchange rates from the Penn World Tables. Output per worker is not a perfect measure of productivity but it allows us to keep a larger number of observations. To control for the use of capital inputs, we use average capacity utilization or the net book value of the total assets of the firm as a measure of capital.[6] We also include the share of skilled workers in the total number of production workers to control for labor input. As an alternative dependent variable, we also show results using the Solow residual as a measure of productivity and control for capital inputs using direct measures of firm assets.

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[5] Each country survey has been standardized so that the information is comparable across countries, but we also use information directly from the country surveys when needed information has not been standardized. Within our classification of manufacturing, there are 13 industries corresponding to the NAICS 2-digit classification system.

[6] In the survey, capacity utilization is defined as the amount of output actually produced relative to the maximum amount that could be produced with the firm's existing machinery, equipment and regular shifts.

The survey contains questions on whether the firm has engaged in particular innovative activities (described below) and questions on resources invested into R&D. We focus on the former for two reasons. First, as discussed below, these questions cover a general type of innovative activities beyond the invention of new products. In fact, as argued by Ayyagari et al. (2007), innovation in countries located well inside the productivity frontier may consist mostly of imitation and adaptation rather than creation. Our sample largely consists of developing countries likely to operate within that frontier. Second, using R&D expenditures may also be inappropriate because not all innovations are generated by R&D expenditures, and formal R&D measures are typically biased against small firms (Gorodnichenko et al., 2008).

The survey asks several questions related to innovation. Specifically, the survey asks whether the responding firm has undertaken any of the following activities in the previous three years: *Developed a major new product line, Upgraded an existing product line, Introduced new technology that has substantially changed the way that the main product is produced, Discontinued at least one product (not production) line, Opened a new plant, Closed at least one existing plant or outlet, Agreed a new joint venture with foreign partner, Obtained a new licensing agreement, Outsourced a major production activity that was previously conducted in-house; Brought in-house a major production activity that was previously outsourced.* Each of these variables is a dummy variable that takes the value one if the answer is positive, and zero otherwise. Because many of these questions are left unanswered in the survey, we focus on the answers to the questions *developed a major new product line* (**New product**) and *introduced new technology that has substantially changed the way the main product is produced* (**New technology**). We follow Ayyagari, Demirgüc-Kunt and Maksimovic (2007) and also use combinations of these variables as measures of innovation. The measure **Core** is an aggregate index obtained by summing new product and new technology, while **Index** is an aggregate index obtained by summing the number of innovation activities in which the firm engages. Table 2 shows summary statistics for this measure and other variables and Table 3 shows the distribution of firms across industries, size and location.

In addition to data on the innovative activities undertaken by firms, enterprise managers were asked to rate the extent to which tax, regulatory, financing, and other obstacles constrained the operation of their business. Since our main interest is in the extent to which entrepreneurs perceive finance as an obstacle to growth, we use the survey question: "How problematic is financing for the operation and growth of your business?" The ratings were quantified from 0 to 4, with 0 denoting no obstacle and 4 a very severe obstacle. Overall, 4 percent of all firms in the sample report financing as a very severe obstacle, 7 percent as a major obstacle, 9 percent as a moderate obstacle, 15 percent as minor, and 65 percent as no obstacle. We also include other obstacles, including the degree to which cost of finance, access to electricity, antitcompetitive practices, licenses and regulation, and skills of available workers, are a constraint to doing business.

The survey also includes information on firm size, age, and ownership, all of which are used as firm-level controls in our study. The survey defines firms of different sizes, small, medium and large firms, on the basis of the number of employees. We construct two dummy variables for large and small and interpret our results in relation to medium sized firms. Over 45 percent of the sample is made up of small firms, while only 20 percent of sample firms are large, with more than 100 employees. We also include dummy variables for ownership (government and foreign-owned) and for exporting firms. In the sample, 2 percent of firms in the sample are government-owned, 11 percent are foreign-owned, and over 24 percent of them are exporters. Firms are on average 19 years old, but a few are close to 200 years old.

To assess the relationship between financial development, innovation, and productivity, we use different country-level proxies of financial development. The main measure is the ratio of private credit to GDP from Beck et al. (2000), where private credit is defined as total credit from deposit-taking institutions to the private sector. This measure captures the development of financial intermediaries. As shown in Table 1, there is considerable variation in private credit to GDP ratio across countries in the sample; ranging from a low of 3 percent in Guinea-Bissau to a high of 143 percent in Ireland.

Three alternative measures of a country's financial development are also considered: stock market capitalization, financial openness, and a composite measure of access to financial services. These measures examine the different channels by which financial development affects productivity. Stock market capitalization, obtained from the Financial Structure Database (Beck et al., 2007), is defined as the ratio of total stock market capitalization to GDP. Financial openness is taken from the dataset by Lane and Milesi-Ferretti (2006) and is measured as the ratio of the sum of a country's total cross-border assets and liabilities to its GDP. Finally, the composite measure of access to financial services from Beck et al. (2008) takes into account data on geographic and demographic bank branch penetration, among other factors.

Panel A of Table 4 presents the correlations between output per worker and the different innovation indicators and other firm-level variables. Panel B presents the correlations between the country-level variables. All aspects of firm innovation are highly correlated at the 1 percent level and are positively associated with output per worker.

B. Baseline Specification

Our basic regression is as follows:

$$\log(y_{ijc}) = cst + \alpha_{innov} innovation_i + \alpha_i Firm_i + \alpha_j Industry_j + \alpha_c Country_c + u_{ijc} \quad (9)$$

The dependent variable is output per worker measured by log total sales per worker in PPP-adjusted U.S. dollars. In the robustness section, we construct an alternative measure of total factor productivity and control for capital inputs using direct measures of firm assets. *Innovation* is either **New Product** or **New Technology**, or one of the two aggregate indicators (**Core** or **Index**). In the basic regressions, $Industry_j$ and $Country_c$ are industry and country dummies whereas $Firm_i$ is a matrix of firm characteristics (age, size, exporter status, foreign-owned, government-owned) and factor inputs (share of skilled workers to total workers, and capacity utilization or capital per worker). Equation (9) is used as the baseline and we build on it to examine the impact of various controls, such as business climate constraints, financial development on productivity.

Studies using micro-level data to make inferences about productivity have been criticized on the grounds that firms often use increases in productivity to grow in size until output per worker has decreased to equal the real wage again (Kortum, 2008). Our framework is not subject to this criticism for several reasons. Due to the absence of a time dimension, we do not run the danger of interpreting a fall in output per worker as a firm becoming less productive, when in fact it is expanding. Instead, we observe a cross-section of firms at one point in time and identify those that have recently innovated. Moreover, we show that these firms are systematically different in terms of output per worker and TFP, controlling for a host of firm-specific factors such as firm size, age and ownership structure.

C. Results

Baseline regressions

Table 5 reports results from regressing firm productivity on various measures of innovation and firm characteristics. Columns 1 and 2 present results for New technology and New product as the relevant innovation measures, respectively, while columns 3 and 4 report results for the aggregate indicators of innovation. All columns report coefficient estimates with industry and country dummies to control for unobserved heterogeneity across industries and countries. Standard errors presented allow for clustering by country.

The results in Table 5 indicate that firms that innovate tend to be more productive. This is true whether innovation is defined as the introduction of a new product, new technology, or indices of various innovative activities. Overall, we find that innovation has an economically and statistically significant effect on output per worker. The estimated coefficient on **New Technology** suggests that a firm that adopts a new technology or develops a new product line is 7 percent more productive relative to a firm that does not engage in these innovative activities.[7]

Older firms, exporters, and foreign-owned firms tend to be more productive. Larger firms are more productive as compared to small and medium-sized firms. We also find that firms with higher capacity utilization tend to be more productive. It is possible that capacity utilization is not a good control for capital intensity. To assess this possibility, we measure capital as the net book value of the total assets of the firm. As shown in the last two columns (Columns 5 and 6) of Table 5 for **New Technology** and **Core**, the resulting sample is much smaller, less than 9300

[7] The economic impact of innovation at the sample mean is estimated by multiplying its coefficient by the sample mean of the variable.

observations, but the coefficient on innovation remains significant. Moreover, the point estimates on the innovation coefficient are larger in this specification.

Impact of business climate

We extend the baseline regressions reported in Table 5 to include various self-reported constraints to firm performance. In Table 6, we initially introduce financial, regulatory, and other investment climate constraints one at a time (Columns 1-7), and finally all together (Column 8). All regressions include country and industry dummies and **Core** is used as the relevant innovation measure.[8]

Specifications (1) and (8) in Table 6 show how financing constraints, as proxied by firm's perceptions of access to finance, affect productivity. Access to finance has a negative and significant coefficient suggesting that firms that report higher financing obstacles tend to be less productive. In fact, self-reported financing constraints are more important than other obstacles to firm performance such as access to electricity, antitcompetitive practices, licenses and regulation, and availability skills of available workers (Columns 2-8). None of these obstacles are significant when entered individually or considered together. Both innovation and access to finance remain significant in all specifications.

Controlling for endogeneity

There are two main econometric issues associated with the estimating the link between innovation and output per worker: (i) problems due to measurement error inherent in using micro-data; and (ii) the fact that innovation and productivity are likely to be jointly determined. For instance, while innovation produces more productive firms it is likely that productive firms are more likely to innovate (which in our context would imply a positive bias to the coefficient on the innovation variables estimated above). To address these issues we use the average level of innovation (**Avg_innovation**) by firms in a similar-sized location within a country as a measure of innovation.[9]

So far, innovation has been treated as an exogenous variable. Despite efforts to control for most factors that may influence firm performance, any failure to properly account for other sources of cross-firm differences may result in biased estimates. To address this problem, we measure innovation as the average of firm-level indicators over a geographical location, in particular the city where the firm is located. The location-size averages should also serve to mitigate the effects

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[8] The results are unchanged if alternative measures of innovation are used and are available from the authors upon request.

[9] Using grouped averages as instruments has been found to mitigate the measurement error in micro-data (Krueger and Angrist, 2001). Our approach mirrors that of Dollar et al (2005). See also Fissman and Svensson (2007) for a discussion of the benefits of using grouped averages to deal with endogeneity issues in using firm-level data.

of measurement error, since these errors are generally idiosyncratic to the firm, and hence uncorrelated with the average innovation values.

Equation (9) is reestimated by replacing firm-level innovation by average innovation. The results are presented in Table 7. The coefficient on innovation remains significant, suggesting that firms that innovate tend to be more productive. We obtain larger point estimates than in previous regressions, consistent with smaller measurement errors in using grouped averages.

Innovation and financial development

How does the impact of innovation on firm performance depend on the institutional environment? In particular, how is it mediated by financial sector development? This dataset allows us to answer this question by interacting a measure of financial development with innovation activities. The hypothesis is that the effect of innovation is mediated through finance; financial underdevelopment is particularly detrimental for innovative firms.

To capture the mediation effect of financial development for innovation, the following equation is estimated:

$$\begin{aligned}\log\left(y_{ijc}\right) &= cst + \alpha_{fin} Avg - innovation_i \times Fin\_dev_c \\ &+\alpha_i Firm_i + \alpha_j Industry_j + \alpha_c City - Country_c + u_{ijc}\end{aligned} \qquad (10)$$

where *City-Country*$_j$ refers to city-location dummy variables.[10] This equation focuses on the interaction between financial development and average innovation. All other firm, country and city-specific characteristics are captured by the dummy variables.

The results are reported in Table 8. Following the literature, we first use the ratio of private credit to GDP as a measure of financial development (column 1). The coefficient on the interaction term is positive and significant, which supports our view that the effect of innovation on productivity is mediated through the financial sector. Firms in financially developed countries reap greater benefits from innovation. Although the measure of financial sector development used is fairly standard in the literature, we present results with alternative measures for robustness. Columns (2–4) also shows the results of estimation with additional measures of financial sector development, stock market capitalization, financial openness and a composite measure of access to financial services. The coefficient on the interaction terms between innovation and these alternative measures of financial development remains positive and significant, suggesting that the main conclusions of the paper are robust to different measures of financial development.

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[10] The city-country pair wise dummy captures unobservable heterogeneity across a city location within a given country. This allows us to introduce the interaction term between financial development and Average innovation without controlling for the Average innovation variable separately.

What is the mechanism through which firms in financially developed countries reap greater benefits from innovation? To address this question, we estimate regressions for two sub-samples of high- and low-tech industries. The underlying idea is that financial development should lead to relatively larger effects of innovation on productivity in high-tech industries, which typically have a larger need for financing and capital. Following Parisi et al. (2006), low-tech firms are defined as those operating in food, beverages, garments, leather, textiles, wood and furniture, non-metallic and plastic materials, paper, other manufacture, and agro-industry. High-tech firms are those operating in metal and machinery, electronics, chemicals and pharmaceutics, auto components, and other transport equipment.

Table 9 shows the results for different industries. The baseline result establishing the link between innovative activity and productivity continues to be positive and significant when focusing on these sub-samples (columns 1-2). Columns 3 and 4 present the results for the interaction term between average innovation and financial sector development for the high-tech and low-tech firms separately. For firms in high-tech industries (column 3), the interaction term between measures of financial sector development and innovative activity remains positive and statistically significant. This result weakens somewhat when focusing on firms in low-tech industries (column 4). This suggests that a well-developed financial sector is particularly important for firms in high-tech sectors.

Measuring productivity

The approach so far has focused on the single-equation approach of inferring the effect of innovation and financial development on firm TFP from output per worker. As noted above, an alternative is to estimate TFP directly from output per worker and use this constructed measure for estimation. In particular, we can construct a Solow residual and regress it on firm, industry and country characteristics.

Consider again Equation (1) and suppose that the total output of firm *i* is a Cobb-Douglas production function: $Y_i = AK_i^{\alpha_K} L_i^{\alpha_L}$. Taking logs and rearranging, we have

$$\log(A_i) = \log(Y_i) - \alpha_K \log(K_i) - \alpha_L \log(L_i) \quad (11)$$

We can measure α_K and α_L as the shares of capital and labor costs in total costs as $c_s^k = \frac{r \times capital}{r \times capital + w \times labor}$ and $c_s^l = \frac{w \times labor}{r \times capital + w \times labor}$. The cost of capital, *r*, is assumed to be 10 percent of the capital stock measured as the net book value of total assets reported by the firm and $w \times labor$ is measured by total labor compensation (see appendix for details)[11].

[11] Following, Escribano and Guasch (2005), we use a value of 10 percent for the cost of capital which is based on their estimation of a production function for three Latin American countries.

Formally, this residual can be computed as
$tfp\_cs\_kl = \ln(output) - c_s^K * \ln(capital) - c_s^L * \ln(labor)$.
The resulting measure has a correlation of 0.96 with our innovation measure.

Table 10 shows the results of estimating Equation (10) using this measure of firm productivity. Given data limitations, the sample size is reduced to around 9000. The importance of innovation for productivity however, is still significant. As before, we find that the effects of innovation are mediated through financial development. The estimated coefficient on **New Technology** suggests that a firm that adopts a new technology or develops a new product line has a 8 percent higher productivity relative to a firm that does not engage in innovation. Moreover, the result on the importance of financial development for innovation is robust to the use of this measure of productivity. Table 11 shows the results when innovation is measured by **Avg_innovation** and interacted with financial development. As before, coefficients are significant for all measures of financial development.

D. Robustness

To determine whether the results are driven by special cases, we run a number of robustness checks, estimating our baseline regressions for different subsets of countries, industries and variables.

The baseline regression is estimated after removing firms in the three countries with the largest number of observations: Bangladesh, India and Mexico. The resulting sample consists of 60 countries and between 8000 and 11000 observations (column 1 of Table 12). As in the larger sample, the interaction between financial development and innovation remains statistically and economically significant (column 3). The robustness tests also included estimating regressions using various country samples— samples of low and middle income countries (GDP per capita lower or greater than $1000) and a sample excluding high-income countries—as well as different subsets of industries. The results (not reported here, but available on request) are robust to these different country and industry groupings.

Finally, we consider the effects of competition. A large literature exists on the effects of competition on innovation and productivity. For example, Aghion et al. (2005a) argue that competition can have different effects on the willingness to innovate. High-efficiency firms may respond positively to competition by innovating more while low-efficiency firms may be discouraged by competition. The empirical evidence in Aghion et. al. (2005a) points to a possible inverted U-shaped relationship between innovation and competition whereas in Aghion et al. (2005b), the authors find that increased competition in India (liberalized entry) led to higher firm productivity. In contrast, Gorodnichenko, Svejnar and Terrell (2008) find large negative effects of competition on innovation and no evidence of a U-shaped relationship. To control for these effects, we add a variable measuring the degree of competition. [12]

The results are shown in Columns 2 and 4 of Tables 12. The sample size drops significantly and the results suggest that competition has no direct effect on firm productivity. It may be that competition does not affect productivity directly but only through innovation. The coefficient on innovation, however, remains significant.

V. Conclusion

Using a firm-level, cross-industry and cross-country dataset, we find evidence that innovation—defined broadly to include the introduction of new products, improvements in production processes and adoption of existing technologies—has an important effect on firm performance. This result holds whether one examines the link between output per worker or one regresses the standard measure of TFP on the innovation dummies. Furthermore, we find that this effect is mediated through financial markets. That is, the positive impact of innovation on productivity is significantly larger in countries with well-developed financial markets.

Policymakers and economists generally agree that well-functioning financial institutions and markets contribute to economic growth. In this paper, we find that a key channel by which financial development could influence growth is by facilitating technological innovations and low-cost production methods that boost productivity. This has important implications for growth and for medium-term prospects in low-income countries. Given the broad definition of innovation in our data, our results suggest that policies that encourage the adoption or imitation of existing technology in order to increase TFP will be important. This suggests a continued agenda for financial sector policy reform and strengthening in low-income countries.

[12] Firms are asked: If you were to raise your prices of your main product line or main line of services 10 percent above their current level in the domestic market, which of the following would best describe the result assuming that your competitors maintained their current prices: (1) Our customers would continue to buy from us in the same quantity as now; (2) Our customers would continue to buy from us, but at slightly lower quantities; (3) Our customers would continue to buy from us, but at much lower quantities; (4) Our customers would stop buying from us.

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Table 1. Sample of Countries

Country	GDP per capita (in USD)	Private Credit/ GDP	Number of firms
Angola	2848	0.06	207
Argentina	5458	0.11	608
Armenia	1477	0.07	202
Burundi	120	0.18	102
Bangladesh	415	0.33	1200
Bulgaria	4120	0.43	511
Bosnia and Herzegovina	2751	0.39	40
Belarus	3097	0.09	37
Bolivia	1167	0.35	304
Botswana	7021	0.2	110
Chile	8903	0.62	587
Cameroon	979	0.09	69
Colombia	2911	0.22	602
Cape Verde	2425	0.41	24
Costa Rica	4667	0.32	295
Czech Republic	12191	0.33	55
Ecuador	3058	0.22	315
Spain	26077	1.3	105
Egypt	1137	0.51	944
Estonia	10343	0.46	33
Georgia	1484	0.11	27
Guinea-Bissau	190	0.03	50
Greece	22290	0.78	76
Guatemala	2327	0.25	295
Honduras	1462	0.42	240
Hungary	10944	0.48	273
India	717	0.37	1814
Ireland	48705	1.43	155
Jamaica	3532	0.23	40
Jordan	2519	0.88	333
Kazakhstan	3786	0.28	245
Kyrgyzstan	479	0.07	46
Korea	16444	0.89	182
Lebanon	6147	1.88	87
Lithuania	7536	0.29	39
Latvia	6955	0.48	26
Moldova	883	0.22	118
Madagascar	309	0.09	216
Mexico	8060	0.17	957
Macedonia	2860	0.24	27
Mauritania	938	0.24	79
Mauritius	4972	0.73	136
Malawi	222	0.06	145
Namibia	3389	0.57	99

Table 1. Sample of Countries (continued)

Country	GDP per capita (in USD)	Private Credit/ GDP	Number of firms
Niger	265	0.06	7
Nicaragua	896	0.24	324
Panama	5217	0.74	184
Peru	3366	0.17	342
Poland	7965	0.26	391
Portugal	17587	1.41	113
Paraguay	1657	0.16	296
Romania	4453	0.17	334
Russia	5326	0.23	87
Rwanda	312	0.11	59
Serbia and Montenegro	3526	0.27	52
El Salvador	2661	0.42	416
Slovakia	8854	0.32	29
Slovenia	17559	0.51	53
Swaziland	2431	0.18	64
Tajikistan	364	0.16	55
Turkey	7110	0.24	93
Tanzania	372	0.11	270
Uganda	318	0.06	304
Ukraine	1842	0.15	135
Uruguay	6036	0.25	285
Uzbekistan	547	.	58
Vietnam	638	0.59	237
Dem. Republic of Congo	147	0.02	149
Total: 63 countries			16,392 firms

Notes: See Data Appendix for variable definitions and sources.

Table 2. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Characteristics of Firms					
Age	14640	19.00	18.00	1	190
Firm sales per worker (in '000 USD)	14640	57.43	552.77	0.003	25985.5
Size (number of employees)	14640	112.00	384.00	1	18000
Government ownership	14640	0.02	0.14	0	1
Foreign ownership	14640	0.11	0.31	0	1
Exporter	14640	0.24	0.43	0	1
Access to finance	14385	0.68	1.08	0	4
New technology	14640	0.47	0.50	0	1
New product	14625	0.51	0.50	0	1
Share of skilled production workers	14640	63.98	34.42	0	100
Macroeconomic Variables					
GDP per capita (USD)	63	5512	7799	120	48705
Private Credit (percent of GDP)	63	0.35	0.31	0.02	1.43
Stock market capitalization (percent of GDP)	47	0.27	0.23	0.001	1.07
Financial openness	59	1.84	2.37	0.39	18.8

Table 3. Distribution of Firms

Industry	Number of firms	Share of firms (%)
Distribution of firms across industries		
Textiles	1180	8.1
Leather	351	2.4
Garments	2301	15.7
Food	2672	18.3
Beverages	588	4.0
Metals and machinery	2300	15.7
Electronics	357	2.4
Chemicals and pharmaceutics	1499	10.2
Wood and furniture	677	4.6
Non-metallic and plastic materials	733	5.0
Paper	251	1.7
Other manufacturing	1543	10.5
Auto and auto components	188	1.3
Total	14640	100.0
Size distribution of firms		
Small (below 20 employees)	6634	45.3
Medium (20-100 employees)	4945	33.8
Large (more than 100 employees)	3061	20.9
Total	14640	100.0
Location distribution of firms		
Capital City	6795	46.4
Other city with population >1 Million	2803	19.2
City with population 250,000 - 1,000,000	2026	13.8
City with population 50,000-250,000	1473	10.1
City with population of less than 50,000	1543	10.5
Total	14640	100

Table 4. Correlation Matrix

Panel A: Firm Level variables

	New product	New technology	Capacity utilization	Age	Small	Large	Exporter	Government	Foreign	Business constriant: Access to finance	Business constraint: Cost of finance	Output per worker
New product	1											
New technology	0.3488	1										
Capacity utilization	0.1118	0.049	1									
Age	0.0058	0.0154	-0.0525	1								
Small	-0.167	-0.1478	-0.0616	-0.164	1							
Large	0.1565	0.1425	0.0847	0.2315	-0.4588	1						
Exporter	0.172	0.1469	0.0977	0.1033	-0.3481	0.37	1					
Government	0.0356	0.0015	-0.0349	0.1484	-0.1321	0.215	0.0674	1				
Foreign	0.081	0.0672	0.0521	-0.0103	-0.2231	0.2773	0.2716	0.0077	1			
Business constriant: Access to finance	0.0581	-0.0107	-0.0188	-0.0364	0.0083	-0.0414	0.0118	0.0401	-0.0143	1		
Business constraint: Cost of finance	0.0955	0.0108	-0.0113	0.0117	-0.0337	-0.0026	0.0367	0.0359	0.0178	0.7581	1	
Output per worker	0.1544	0.0968	0.193	0.1249	-0.0768	0.0985	0.2085	-0.0048	0.1534	0.038	0.0514	1

Panel B: Country Level variables

	GDP per capita (USD)	Private Credit (percent of GDP)	Stock market capitalization (percent of GDP)	Financial openness
GDP per capita (USD)	1			
Private Credit (percent of GDP)	0.6037	1		
Stock market capitalization (percent of GDP)	0.102	0.5376	1	
Financial openness	0.8074	0.5488	0.0933	1

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Table 5. Baseline Regression

The dependent variable is firm-level output per worker. *Innovation* is a measure of firm-level innovation. It is measured by *New product* (a dummy variable that takes the value 1 if the firm has developped a major new product line), *New technology* (a dummy variable that takes the value 1 if the firm has introduced new technology that has substantially changed the way the main product is produced), a sum of *New product* and *New technology* or a sum of all the innovation dummy variables in the survey. *Firm* are firm-level controls including capacity utilization, firm age, size, proportion of skilled workers, as well as dummies equal to 1 if the firm is owned by the government, if it is foreign-owned, and if it is an exporter. *Industry* are industry dummies, *City Size* are location dummies, and *Country* are country dummies. Robust standard errors are in parentheses; significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.

Dependent variable	Innovation measure				Controlling for capital per worker	
log of output per worker	New technology	New product	Core	Index	New technology	Core
	(1)	(2)	(3)	(4)	(5)	(6)
Innovation	0.156	0.112	0.093	0.066	0.162	0.110
	(0.019)***	(0.019)***	(0.011)***	(0.009)***	(0.024)***	(0.014)***
Capacity utilization	0.378	0.384	0.379	0.382		
	(0.049)***	(0.049)***	(0.049)***	(0.049)***		
Age	0.093	0.092	0.093	0.092	0.067	0.067
	(0.012)***	(0.012)***	(0.012)***	(0.012)***	(0.015)***	(0.015)***
Small	-0.179	-0.186	-0.177	-0.179	-0.193	-0.188
	(0.021)***	(0.022)***	(0.022)***	(0.021)***	(0.027)***	(0.027)***
Large	0.024	0.029	0.022	0.023	0.024	0.019
	(0.028)	(0.028)	(0.028)	(0.028)	(0.034)	(0.034)
Exporter	0.311	0.316	0.310	0.308	0.374	0.372
	(0.025)***	(0.025)***	(0.025)***	(0.025)***	(0.032)***	(0.032)***
Government	0.003	0.005	0.008	0.006	0.231	0.233
	(0.070)	(0.070)	(0.070)	(0.070)	(0.192)	(0.191)
Foreign	0.369	0.366	0.367	0.367	0.336	0.333
	(0.034)***	(0.035)***	(0.035)***	(0.035)***	(0.043)***	(0.044)***
Skilled	-0.0001	-0.0001	-0.0001	-0.0001	0.0000	0.0000
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0004)	(0.0004)
Capital per worker					0.227	0.231
					(0.010)***	(0.010)***
Constant	1.616	1.642	1.597	1.627	1.765	1.733
	(0.089)***	(0.090)***	(0.090)***	(0.089)***	(0.096)***	(0.097)***
Industry dummies	YES	YES	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES	YES	YES
City Size dummies	YES	YES	YES	YES	YES	YES
No. of Countries	63	63	63	63	34	34
Observations	14640	14625	14625	14640	9213	9202
R^2	0.42	0.42	0.42	0.42	0.41	0.42

Table 6. Business Climate

Business constraint variables take the value 1 if the firm identifies an issue (access to finance, cost of finance, electricity, anticompetitive/informal practices, crime, theft, disorder, licensing and operating permits, skills of available workers) as a problem for the operation and growth of business. Industry are industry dummies, *City Size* are location dummies, and Country are country dummies. Robust standard errors are in parentheses; significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.

Dependent variable log of output per worker	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Innovation	0.157	0.154	0.157	0.159	0.160	0.158	0.152	0.153
	(0.019)***	(0.030)***	(0.019)***	(0.019)***	(0.019)***	(0.019)***	(0.019)***	(0.020)***
Business constraint: Access to finance	-0.035							-0.046
	(0.010)***							(0.011)***
Business constraint: cost of finance		-0.020						
		(0.012)*						
Business constraint: electricity			-0.006					-0.003
			(0.011)					(0.012)
Business constraint: anti-competitive/informal practices							-0.001	0.005
							(0.010)	(0.011)
Business constraint: crime, theft, disorder						-0.015		-0.012
						(0.011)		(0.013)
Business constraint: licensing and operating permits					0.001			0.012
					(0.011)			(0.013)
Business constraint: skills of available workers				0.009				0.014
				(0.011)				(0.012)
Capacity utilization	0.346	0.484	0.372	0.375	0.375	0.365	0.362	0.354
	(0.049)***	(0.087)***	(0.049)***	(0.049)***	(0.049)***	(0.049)***	(0.049)***	(0.049)***
Age	0.091	0.090	0.092	0.091	0.090	0.092	0.091	0.091
	(0.012)***	(0.021)***	(0.012)***	(0.013)***	(0.013)***	(0.013)***	(0.012)***	(0.013)***
Small	-0.173	-0.060	-0.175	-0.175	-0.175	-0.175	-0.172	-0.171
	(0.022)***	(0.035)***	(0.021)***	(0.022)***	(0.022)***	(0.022)***	(0.022)***	(0.022)***
Large	0.019	-0.032	0.024	0.022	0.023	0.024	0.030	0.025
	(0.028)	(0.046)	(0.028)	(0.028)	(0.028)	(0.028)	(0.029)	(0.029)
Exporter	0.311	0.225	0.312	0.313	0.316	0.310	0.307	0.303
	(0.025)***	(0.038)***	(0.025)***	(0.025)***	(0.025)***	(0.025)***	(0.026)***	(0.026)***
Government	0.015	-0.072	0.012	0.013	0.020	0.008	0.024	0.025
	(0.070)	(0.073)	(0.070)	0.070	(0.070)	(0.071)	(0.070)	(0.073)
Foreign	0.365	0.243	0.371	0.372	0.374	0.374	0.376	0.370
	(0.035)***	(0.054)***	(0.035)***	(0.035)***	(0.035)***	(0.035)***	(0.035)***	(0.036)***
Skilled	-0.0002	-0.0006	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002
	(0.0003)	(0.0006)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Constant	1.646	1.616	1.632	1.612	1.630	1.635	1.629	1.653
	(0.086)***	(0.212)***	(0.089)***	(0.086)***	(0.089)***	(0.089)***	(0.089)***	(0.090)***
Industry dummies	YES	YES	YES	YES	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES	YES	YES	YES	YES
City Size dummies	YES	YES	YES	YES	YES	YES	YES	YES
Observations	14385	5612	14470	14442	14343	14272	14160	13806
Number of countries	63	36	63	63	63	61	63	61
R^2	0.42	0.45	0.41	0.42	0.42	0.42	0.42	0.42

Table 7. Baseline Regression with Aggregated Innovation

The dependent variable is the log of firm-level output per worker. *Avg_Innovation* is average local innovation. It is measured by an average of *New product* (a dummy variable that takes the value 1 if the firm has developped a major new product line), *New technology* (a dummy variable that takes the value 1 if the firm has introduced new technology that has substantially changed the way the main product is produced), a sum of *New product* and *New technology* or a sum of all the innovation dummy variables in the survey. *Firm* are firm-level controls including capacity utilization, firm age, size, proportion of skilled workers, as well as dummies equal to 1 if the firm is owned by the government, if it is foreign-owned, and if it is an exporter. *Industry* are industry dummies, *City Size* are location dummies, and *Country* are country dummies. Robust standard errors are in parentheses; significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.

Dependent variable	Innovation measure				Controlling for capital per worker	
log of output per worker	New technology	New product	Core	Index	New technology	Core
	(1)	(2)	(3)	(4)	(5)	(6)
Avg_Innovation	0.257	0.171	0.138	0.067	0.289	0.518
	(0.051)***	(0.048)***	(0.029)***	(0.017)***	(0.044)***	(0.085)***
Capacity utilization	0.387	0.386	0.386	0.387		
	(0.049)***	(0.049)***	(0.049)***	(0.049)***		
Age	0.092	0.091	0.092	0.091	0.066	0.066
	(0.013)***	(0.013)***	(0.013)***	(0.013)***	(0.015)***	(0.015)***
Small	-0.194	-0.195	-0.193	-0.195	-0.209	-0.210
	(0.021)***	(0.021)***	(0.021)***	(0.021)***	(0.026)***	(0.027)***
Large	0.030	0.035	0.031	0.033	0.028	0.026
	(0.029)	(0.029)	(0.029)	(0.029)	(0.034)	(0.034)
Exporter	0.316	0.320	0.317	0.318	0.378	0.376
	(0.025)***	(0.025)***	(0.025)***	(0.025)***	(0.032)***	(0.032)***
Government	-0.005	-0.001	-0.002	-0.002	0.226	0.225
	(0.071)	(0.071)	(0.071)	(0.071)	(0.195)	(0.195)
Foreign	0.369	0.367	0.367	0.367	0.334	0.333
	(0.035)***	(0.035)***	(0.035)***	(0.035)***	(0.044)***	(0.044)***
Skilled	0.000	0.000	-0.0001	-0.0001	0.0000	0.0000
	(0.000)	(0.000)	(0.0003)	(0.0003)	(0.0004)	(0.0004)
Capital per worker					0.229	0.231
					(0.010)***	(0.010)***
Constant	1.560	1.612	1.549	1.632	1.531	1.563
	(0.094)***	(0.094)***	(0.096)***	(0.091)***	(0.108)***	(0.107)***
Industry dummies	YES	YES	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES	YES	YES
City Size dummies	YES	YES	YES	YES	YES	YES
No. of Countries	63	63	63	63	34	34
Observations	14640	14625	14625	14640	9213	9213
R^2	0.41	0.41	0.41	0.41	0.41	0.41

Table 8. Financial Development and Innovation: Interaction Effects

The dependent variable is the log of firm-level output per worker. *Avg_Innovation* is average local innovation. It is measured by an average of New product (a dummy variable that takes the value 1 if the firm has developped a major new product line), New technology (a dummy variable that takes the value 1 if the firm has introduced new technology that has substantially changed the way the main product is produced), a sum of New product and New technology or a sum of all the innovation dummy variables in the survey. *Firm* are firm-level controls including capacity utilization, firm age, size, as well as dummies equal to 1 if the firm is owned by the government, if it is foreign-owned, and if it is an exporter. Fin_dev is measured by private credit to GDP, stock market capitalization, financial openness or access to financial services. *Industry* are industry dummies and *Country-city* are country-city dummies. Robust standard errors are in parentheses; significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.

Dependent variable	Financial development measure			
log of output per worker	Private credit	Stock mkt capitalization	Financial openness	Access to financial services
	(1)	(2)	(3)	(4)
Avg_Innovation X Fin. Dev	2.706	7.361	0.994	0.025
	(1.011)***	(2.559)***	(0.348)***	(0.009)***
Capacity utilization	0.412	0.486	0.425	0.439
	(0.049)***	(0.054)***	(0.050)***	(0.053)***
Age	0.096	0.106	0.095	0.099
	(0.013)***	(0.014)***	(0.013)	(0.014)***
Small	-0.190	-0.146	-0.183	-0.175
	(0.022)***	(0.023)***	(0.022)***	(0.023)
Large	0.025	0.044	0.026	0.052
	(0.029)	(0.031)	(0.029)	(0.031)*
Exporter	0.322	0.335	0.325	0.347
	(0.025)***	(0.027)***	(0.026)***	(0.027)***
Foreign	0.368	0.354	0.366	0.356
	(0.035)***	(0.039)***	(0.036)***	(0.039)***
Government	0.021	0.101	0.069	0.098
	(0.070)	(0.080)	(0.073)	(0.091)
Skilled	-0.0001	0.0000	-0.0001	-0.0001
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Constant	0.388	-1.265	0.108	-1.252
	(0.145)***	(0.091)***	(0.179)	(0.093)***
Industry dummies	YES	YES	YES	YES
Country-city dummies	YES	YES	YES	YES
Number of countries	63	47	59	44
Observations	14640	12465	14359	12844
R^2	0.42	0.43	0.41	0.42

Table 9. Productivity, Innovation, and Financial Development: High Tech and Low Tech Industries

The dependent variable is the log of firm-level output per worker. Innovation is a measure of firm-level innovation as measured by New Technology. Avg_I*nnovation* is a city-size/country cell average of the innovation measure. *New technology* (a dummy variable that takes the value 1 if the firm has introduced new technology that has substantially changed the way the main product is produced). *F* irm-level controls include capacity utilization, firm age, size, proportion of skilled workers, as well as dummies equal to 1 if the firm is owned by the government, if it is foreign-owned, and if it is an exporter. *Fin_dev* is measured by the ratio of private credit to GDP. *Industry* are industry dummies and *Country-city* are country-city dummies. Robust standard errors are in parentheses; significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.

Dependent variable log of output per worker	High-Tech industries [1]	Low-Tech industries [2]	High-Tech industries [3]	Low-Tech industries [4]
Innovation (New technology)	0.147	0.154		
	(0.037)***	(0.022)***		
Avg_Innovation X Private Credit			6.112	1.382
			(2.356)***	(1.1)
Capacity utilization	0.432	0.345	0.469	0.382
	(0.097)***	(0.056)***	(0.100)***	(0.057)***
Age	0.089	0.093	0.097	0.097
	(0.024)***	(0.015)***	(0.025)***	(0.015)***
Small	-0.13	-0.193	-0.141	-0.2
	(0.042)***	(0.025)***	(0.043)***	(0.025)***
Large	0.059	0.019	0.045	0.016
	(0.053)	(0.034)	(0.055)	(0.035)
Exporter	0.274	0.312	0.282	0.327
	(0.046)***	(0.031)***	(0.046)***	(0.031)***
Foreign	-0.034	0.042	0.406	0.356
	(0.098)	(0.094)	(0.064)***	(0.043)***
Government	0.4	0.366	0.016	0.047
	(0.062)***	(0.042)***	(0.097)	(0.094)
Skilled	0.002	-0.0008	0.002	-0.0008
	(0.0006)***	(0.0004)**	(0.0007)	(0.0004)**
Constant	1.741	1.669	0.331	0.462
	(0.210)***	(0.098)***	(0.235)	(0.167)***
Industry dummies	YES	YES	YES	YES
Country-city dummies	YES	YES	YES	YES
Number of countries	63	63	63	63
Observations	4344	10296	4344	10296
R^2	0.41	0.41	0.41	0.41

Table 10. Baseline Regression -TFP

The dependent variable is the log of firm-level output per worker. *Innovation* is a measure of firm-level innovation. It is measured by *New product* (a dummy variable that takes the value 1 if the firm has developped a major new product line), *New technology* (a dummy variable that takes the value 1 if the firm has introduced new technology that has substantially changed the way the main product is produced), a sum of *New product* and *New technology* or a sum of all the innovation dummy variables in the survey. *Firm* are firm-level controls including capacity utilization, firm age, size, proportion of skilled workers as well as dummies equal to 1 if the firm is owned by the government, if it is foreign-owned, and if it is an exporter. *Industry* are industry dummies, *City Size* are location dummies, and *Country* are country dummies. Robust standard errors are in parentheses; significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.

Dependent variable	Innovation measure			
TFP	New technology	New product	Core	Index
	(1)	(2)	(3)	(4)
Innovation	0.164	0.156	0.109	0.104
	(0.023)***	(0.025)***	(0.013)***	(0.013)***
Age	0.065	0.065	0.065	0.065
	(0.014)***	(0.014)***	(0.014)***	(0.014)***
Small	-0.182	-0.188	-0.179	-0.177
	(0.026)***	(0.026)***	(0.026)***	(0.026)***
Large	0.035	0.036	0.033	0.031
	(0.033)	(0.033)	(0.033)	(0.033)
Exporter	0.380	0.384	0.379	0.375
	(0.031)***	(0.031)***	(0.031)***	(0.031)***
Government	0.196	0.192	0.199	0.202
	(0.196)	(0.195)	(0.195)	(0.194)
Foreign	0.361	0.360	0.359	0.362
	(0.042)***	(0.042)***	(0.042)***	(0.042)***
Skilled	0.0001	0.0002	0.0001	0.0001
	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Constant	1.765	1.778	1.736	1.738
	(0.094)***	(0.095)***	(0.095)***	(0.095)***
Industry dummies	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES
City Size Dummies	YES	YES	YES	YES
No. of Countries	34	34	34	34
Observations	9088	9077	9077	9088
R^2	0.31	0.31	0.31	0.31

Table 11. Financial Development and Innovation: Interaction Effects – TFP Measure

The dependent variable is the log of firm-level output per worker. Avg_Innovation is average local innovation. It is measured by an average of New product (a dummy variable that takes the value 1 if the firm has developped a major new product line), New technology (a dummy variable that takes the value 1 if the firm has introduced new technology that has substantially changed the way the main product is produced), a sum of New product and New technology or a sum of all the innovation dummy variables in the survey. Firm are firm-level controls including capacity utilization, firm age, size, proportion of skilled workers, as well as dummies equal to 1 if the firm is owned by the government, if it is foreign-owned, and if it is an exporter. Fin_dev is measured by private credit to GDP, stock market capitalization, financial openness or access to financial services.Industry are industry dummies and Country-city are country-city dummies. Robust standard errors are in parentheses; significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.

Dependent variable	Financial development measure			
log of output per worker	Private credit	Stock mkt capitalization	Financial openness	Access to financial services
	(1)	(2)	(3)	(4)
Avg_Innovation X Fin. Dev	3.013	8.998	1.208	0.028
	(0.984)***	(2.991)***	(0.392)***	(0.009)***
Capacity utilization	0.502	0.609	0.516	0.505
	(0.059)***	(0.066)***	(0.060)***	(0.063)***
Age	0.076	0.090	0.073	0.074
	(0.014)***	(0.016)***	(0.015)***	(0.015)***
Small	-0.181	-0.128	-0.175	-0.177
	(0.026)***	(0.028)***	(0.026)***	(0.027)***
Large	0.0135	0.0262	0.0085	0.0228
	(0.033)	(0.037)	(0.034)	(0.035)
Exporter	0.374	0.379	0.377	0.389
	(0.031)***	(0.033)***	(0.031)***	(0.032)***
Foreign	0.362	0.353	0.364	0.335
	(0.042)***	(0.049)***	(0.043)***	(0.047)***
Government	0.2249	0.391	0.2587	0.2729
	(0.183)	(0.200)*	(0.191)	(0.210)
Skilled	0.0002	(0.000)	0.0001	0.0001
	(0.000)	0.0004	(0.000)	(0.000)
Constant	0.0424	(2.005)	-0.2845	0.5705
	(0.144)	(0.342)***	(0.189)	(0.500)
Industry dummies	YES	YES	YES	YES
Country-city dummies	YES	YES	YES	YES
Number of countries	34	22	31	23
Observations	9088	7589	8879	8147
R2	0.32	0.33	0.31	0.32

Table 12. Robustness Tests

The dependent variable is the log of firm-level output per worker. I*nnovation* is a measure of firm-level innovation. It is measured by *New technology* (a dummy variable that takes the value 1 if the firm has introduced new technology that has substantially changed the way the main product is produced). Avg_Innovation is average local innovation. Fin_dev is measured by private credit to GDP. Firm-level controls include capacity utilization, firm age, size, proportion of skilled workers, as well as dummies equal to 1 if the firm is owned by the government, if it is foreign-owned, and if it is an exporter. *Industry* are industry dummies, *City size* are location dummies, and *Country* are country dummies. Robust standard errors are in parentheses; significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.

Dependent variable	Robustness measure			
log of output per worker	Without three biggest countries	Competition	Without three biggest countries	Competition
	[1]	[2]	[3]	[4]
Innovation (New technology)	0.131	0.057		
	(0.020)***	(0.027)**		
Avg_Innovation X Fin_Dev			3.327	1.676
			(1.496)**	(0.321)***
Capacity utilization	0.265	-0.025	0.292	-0.021
	(0.050)***	(0.078)	(0.051)***	(0.079)
Age	0.054	0.005	0.058	-0.007
	(0.014)***	(0.02)	(0.014)	(0.019)
Small	-0.225	-0.097	-0.234	-0.101
	(0.022)***	(0.030)***	(0.023)***	(0.031)***
Large	0.047	0.044	0.049	0.033
	(0.029)	(0.042)	(0.023)*	(0.044)
Exporter	0.198	0.067	0.21	0.071
	(0.027)***	(0.034)**	(0.027)***	(0.034)**
Government	0.01	-0.076	0.378	0.216
	(0.067)	(0.056)	(0.035)***	(0.046)***
Foreign	0.385	0.232	0.03	-0.061
	(0.035)***	(0.046)***	(0.066)	(0.059)
Skilled	-0.0002	0.0002	-0.0001	0.0001
	(0.0003)	(0.0005)	(0.0003)	(0.0005)
Competition		0.011		0.015
		(0.012)		(0.012)
Constant	1.708	3.025	0.539	2.79
	(0.093)***	(0.162)***	(0.154)***	(0.228)***
Industry dummies	YES	YES	YES	YES
Country dummies	YES	YES		
City Size dummies	YES	YES		
Country-city dummies			YES	YES
No. of Countries	60	29	60	29
Observations	10829	3151	10829	3151
R^2	0.46	0.71	0.47	0.71

Appendix 1. Data Variables and Sources

Country specific variables		
GDP per capita	Logarithm of real GDP in USD, in current prices (as of the year of the survey).	WEO
Private credit to GDP	Private Credit by Deposit Money Banks divided by GDP.	FSD
Stock market capitalization	Stock Market Capitalization / GDP.	FSD
Financial Openness	Cross-border assets plus liabilities over GDP.	MF
Access to Financial Services	Composite measure of access to financial services.	DB
Firm specific variables		
Sales	Total sales, converted from LCU into USD using the average exchange rate.	WBES
Output per w orker	Logarithm of sales divided by the average number of permanent w orkers over the last fiscal year.	WBES
Age	Logarithm of year of the survey minus year the firm started operations.	WBES
Capacity Utilization	Average capacity utilization over last year (in %) (Capacity utilization is the amount of output actually produced relative to the maximum amount that could be produced w ith existing machinery and equipment and regular shifts).	WBES
Small	Dummy that takes on the value of one if the firm has less than 20 permanent employees.	WBES
Medium	Dummy that takes on the value of one if the firm has betw een 20 and 100 permanent employees.	WBES
Large	Dummy that takes on the value of one if the firm has more than 100 employees.	WBES
Exporter	Dummy that takes on the value of one if the firm generates any sales from exports.	WBES
Government	Dummy that takes on the value of one if the government ow ns a share of the firm.	WBES
Foreign ow ned	Dummy that takes on the value of one if a foreign entity ow ns a share of the firm.	WBES
New technology	Dummy that takes on the value of one if the firm has answ ered 'yes' to 'Introduced new technology that has substantially changed the w ay that the main product is produced'.	WBES
New product	Dummy that takes on the value of one if the firm has answ ered 'yes' to 'Developed a major new product line'.	WBES
Core	Sum of 'New technology' and 'New product'.	
Index7	A measure that adds one for every initiative the firm has undertaken in the three years before the survey from the menu of 'Developed a major new product line', 'Upgraded an existing product line', 'Introduced new technology…', 'Agreed a new joint venture w ith foreign partner', 'Obtained a new licensing agreement', 'Outsourced a major production activity' and 'Brought in-house a major production activity'.	
Obstacle: Access to Finance	Obstacle variable: a value of 0 indicates no problem, values of 1-4 indicate a slight to major problem, respectively.	WBES
Obstacle: Electricity	Obstacle variable: a value of 0 indicates no problem, values of 1-4 indicate a slight to major problem, respectively.	WBES
Obstacle: Transportation	Obstacle variable: a value of 0 indicates no problem, values of 1-4 indicate a slight to major problem, respectively.	WBES
Obstacle: Business Licensing and Operating Permits	Obstacle variable: a value of 0 indicates no problem, values of 1-4 indicate a slight to major problem, respectively.	WBES
Obstacle: Crime, Theft and Disorder	Obstacle variable: a value of 0 indicates no problem, values of 1-4 indicate a slight to major problem, respectively.	WBES
Obstacle: Anti-Competitive and Informal Practices	Obstacle variable: a value of 0 indicates no problem, values of 1-4 indicate a slight to major problem, respectively.	WBES
Average city innovation	Average value of the innovation measure in the country and city w here the firm is located.	Authors' computation
TFP	Solow residual from production function/cost share approach.	Authors' computation
Exchange rate	Exchange rate: LCU per USD, end of period, period average (period refers to the survey year).	IFS
Capital	Net book value of total assets of the firm, w here necessary converted from LCU into USD.	WBES
Labor	Average number of w orkers over last fiscal year.	WBES
Compensation	Total compensation OR Manpow er costs, w here necessary converted from LCU into USD.	WBES
Capital costs	Assumed to equal 10% of total assets.	Authors' computation
City size	A coded variable taking on the values of 1 (Capital City), 2 (other city > 1 Mill.), 3 (250K – 1 Mill.) 4 (50K-250K) and 5 (<50K)C38.	WBES

Abbreviations:

DB: *Finance for All? Policies and Pitfalls in Expanding Access*, World Bank, November 13, 2007, Asli Demirgüç-Kunt and Thorsten Beck http://go.worldbank.org/S3EWEOI440

IFS: International Financial Statistics

MF: Philip R. Lane and Gian Maria Milesi-Ferretti (2006) "The External Wealth of Nations Mark II: Revised and Extended Estimates of Foreign Assets and Liabilities, 1970-2004", IMF Working Paper 06/69

FSD: Financial Structure Dataset

Thorsten Beck, Asli Demirgüç-Kunt and Ross Levine, (2000), "A New Database on Financial Development and Structure," World Bank Economic Review 14, 597-605

WEO: World Economic Outlook

WBES: World Bank Enterprise Survey