Reserve Bank of India Occasional Papers
Vol. 45, No. 1, 2024

Access to External Finance and Efficiency Gains from Firm's Innovation: Stochastic Frontier and Lewbel's Approach

Sadhan Kumar Chattopadhyay and Siddhartha Nath*

Received: September 28, 2023
Accepted: February 13, 2024

Based on World Bank's Enterprise Survey data for 17 emerging and developing countries, this paper finds that the gain in an enterprise's technical efficiency from its product/process innovations is higher when it has access to external finance for its short-term working capital needs. These findings hold for samples of small and medium enterprises, and for both manufacturing and services activities. Access to external finance for working capital is associated with higher spending on skilled workers, non-manufacturing workers and training, providing a possible explanation for the paper's findings.

JEL Classification: O31, O33, G21, L25.

Keywords: Innovation, digital adoption, access to finance, efficiency, World Bank's Enterprise Survey

Introduction

The empirical literature has established a robust link between finance and productivity growth[1]. Some of the channels through which financial development, financial frictions and access to finance influence firm

* Sadhan Kumar Chattopadhyay (skchattopadhyay@rbi.org.in) is Director and Siddhartha Nath (siddharthanath@rbi.org.in) is Assistant Adviser in the Department of Economic and Policy Research, Reserve Bank of India, Mumbai. The authors thank the Enterprise Analysis Unit of the Development Economics Global Indicators, Department of the World Bank Group for making the data available. The authors are thankful to Rajib Das, Pallavi Chavan, Rigzen Yangdol, an anonymous external referee and other participants of the DEPR Study Circle for their useful comments. Research Assistance by Shashank Bhujade is acknowledged. The views expressed in this article are those of the authors and do not represent views of the Reserve Bank of India.

1 See Heil (2017) for a review of literature.

productivity are investment in human capital (Becker, 1967; Black and Lynch, 1996; Blundell *et al*., 1999; and Madsen and Ang, 2016), investment in technologies (Ayyagari *et al*., 2011; Brown *et al*., 2009 and 2012; Hsu *et al*., 2014; Adegboye and Iweriebor, 2018; Kim *et al*., 2019; and Kaur *et al*., 2021), investment in institutional quality (Talke *et al*., 2010; and Xie *et al*., 2020), knowledge externality and outsourcing (Grupp, 1997; and Asimakopoulos, 2020), and research collaboration among firms and regions (Fritsch, 2004; Guan *et al*., 2016; and Fan *et al*., 2020). These investments bring in newer ways of making products and doing businesses, which are known as innovations[2].

External finance, apart from bringing in innovation, increases knowledge and level of technology in a firm (Pavitt and Wald, 1971). Productivity gains from innovation require capital investment towards changing the production process, company organisation and skill requirements of both workers and management. Citing the example of USA before 1970s, Pavitt and Wald (1971) argue that research-intensive firms not only employed relatively more scientists and engineers but also a larger workforce in production, sales, and non-production activities to maximise benefits from their research. Access to external finance, including venture capital from non-banking entities, also acted as a key enabler in this process. For the European countries, the sensitivity of a firm's productivity growth to its spending on innovations depended on financial constraints (Levine and Warusawitharana, 2021).

Although Wurgler (2000) and Levine and Warusawitharana (2021) provided insights from the point of view of allocation of funds, direct empirical support between a firm's access to external finance and the success of its innovation in the emerging and developing economies is limited. This paper tries to address this gap. Based on the World Bank's Enterprise Survey (WBES) data for 17 emerging and developing economies from 2010, the empirical analysis in this paper suggests that a firm's productivity gains from its product/process innovations and digital adoption are higher when the enterprise has access to external finance for short-term working capital needs.

Our paper is closely related to the branch of empirical literature which supports link between finance and productivity growth (Levine and Zervos,

---

[2] See Rogers (1998) for the definition of innovation. For the role of innovation into firm-level productivity growth, see Griliches and Mairesse, 1984; Griliches, 1986; Griliches, 1998; and Hall *et al*., 2009.

1998; Beck *et al*., 2000; Benhabib and Spiegel, 2000; Brown *et al*., 2009 and 2012; Andrews *et al*., 2014; Andrews and Cingano, 2014; Cole *et al*., 2016; and Madsen and Ang, 2016). These studies suggest that financial growth drives productivity through higher investments into innovation, human capital and diverting resources to productive uses. Our paper, in contrast, examines as to whether access to external finance leads to higher success/returns from the existing innovation. The paper extends findings of Wurgler (2000) at the firm-level in the emerging and developing countries, while supporting finance as a condition for the success of innovation, as hypothesised in Pavitt and Wald (1971).

Investments in basic research and innovations have gained prominence as the drivers of sustainable growth of enterprises (IMF, 2022). However, a firm's productivity gain to its innovations varies significantly across countries and sectors (Nasierowski and Arcelus, 2003; Wang, 2007; Bai, 2013; Goa and Chou, 2015; and Aldierdi *et al*., 2021). For a developing country with limited resources allocated for innovation (Dutz, 2017), maximising benefits from its innovation is crucial for achieving sustained economic progress. A relatively recent strand of empirical literature provides evidence suggesting that variations in institutional, organisational and macroeconomic factors influence returns on innovation at the firm level. For instance, the firm's ownership structure, size, age (Zhang *et al*., 2003; and Su *et al*., 2023), political connections (Song *et al*., 2015), and fiscal incentives (Guan and Yam, 2015; and Hong *et al*., 2016) are found to influence a firm's efficiency gains from its innovations. The role of financial development towards the success of a firm's innovations, however, has largely remained an unexplored area, which has been studied in our paper. The paper is divided into the following sections: Sections II and III discuss data and empirical methodology, respectively. Section IV discusses results and Section V the concluding observations.

Section II

Data

We use enterprise-level data from WBES for the following countries: Bangladesh (2013, 2022), China (2012), Czech Republic (2013, 2019), Egypt (2013, 2020), Hungary (2013, 2019), India (2014, 2022), Indonesia (2015), Kenya (2013, 2018), Malaysia (2015, 2019), Myanmar (2014, 2016),

Nigeria (2014), Pakistan (2013, 2022), Philippines (2015), Russia (2012, 2019), Thailand (2016), Turkey (2013, 2019) and Vietnam (2015)[3]. We use the 'combined' dataset from the survey's official website consisting of the commonly available indicators across all countries. We use survey rounds only since the post-Global Financial Crisis period, *i.e*., after 2010, as this period has attracted debates regarding slowing innovation, on account of investment slowdown and policy uncertainties across the globe (Aghion *et al*., 2012; and López-García *et al*., 2013). We have not used the Organisation for Economic Cooperation and Development (OECD) countries as no enterprise survey was available for these countries before 2020, which may significantly bias our findings. We use the post-COVID-19 rounds for Bangladesh, India and Pakistan along with one pre-COVID-19 round, so that the year-specific effects could be controlled. We use the International Monetary Fund's (IMF) definition of emerging economies[4]. We exclude Argentina and Colombia from the analysis since these are defined as 'commodity dependent', by United Nations Conference on Trade and Development (UNCTAD)[5]. No data was available for Brazil, Chile, Mexico and South Africa after 2010, while for Saudi Arabia, the only survey round available was after 2020.

The WBES provides a representative sample of an economy's private sector covering business environment, access to finance, corruption, infrastructure, competition, innovation, and performance measures. The survey covers enterprises from both manufacturing and services sectors which are registered and have five or more employees. Enterprises with 100 per cent government/state ownership are not included in the survey. Standard classification of activities within manufacturing and services sectors is provided in the survey based on International Standard Industrial Classification of All Economic Activities (ISIC) (Revisions 3.1 and 4). We use the terms 'enterprise' and 'firm' interchangeably to refer similar entities throughout this paper.

---

3 Parentheses show the survey year(s).

4 See https://www.imf.org/external/pubs/ft/fandd/2021/06/the-future-of-emerging-markets-duttagupta-and-pazarbasioglu.htm. We include Nigeria for our study as it satisfies criteria other than only per capita income to be classified as an emerging economy.

5 See Figure 2 in page 3 of https://unctad.org/system/files/official-document/ditccom2021d2_en.pdf

Our main variables of interest are firm-level efficiency, access to finance and innovation. We estimate firm-level efficiency following Kumbhakar and Lovell (2000) (see Section III.1). We define access to finance in the following ways. First, whether an enterprise has reported any type of bank loan of any tenure, or line of credit from the supplier/customer. Second, whether the enterprise has access to any external sources for financing its working capital. Third, whether any proportion of the working capital of an enterprise is financed through bank loan. Fourth, whether any proportion of the investment of an enterprise is financed through bank loan, and last, whether any proportion of the investment of an enterprise is financed through the sale of equity shares. We use two measures of innovation: first, whether an enterprise introduced a new product/service, undertook process innovation, or spent on research and development during the survey reference period, and second, whether an enterprise has or uses its own website/email to communicate with clients/customers which represents an aspect of digital innovation. Due to the nature of survey *per se*, we measure access to finance and innovation as binary variables, assuming only values 0 and 1, where 1 represents an affirmative response. The descriptive statistics are given in Table A.1 in the Annex; Charts A.1 to A.6 in Annex show basic survey characteristics.

Section III
Empirical Methodology

III.1. Technical Efficiency

In the literature, the terms productivity and efficiency have been used interchangeably while referring to gains from innovation. While both these terms refer to similar concepts of maximising output with given inputs, productivity is generally measured over time, while efficiency is more useful for comparisons across units at a given point of time. Given the discrete nature of WBES, we use firm-level efficiency, following Kumbhakar and Lovell (2000) to measure returns from innovation.

We measure returns from innovation by an enterprise through incremental technical efficiency (TE). In general, TE measures how efficiently a firm uses the available factor inputs, namely labour and capital. With the same levels of factor inputs, higher value-added would indicate higher TE. We use Stochastic Frontier approach of Kumbhakar and Lovell (2000) to

estimate TE of a firm. In this approach, a 'best-practice technology frontier' is estimated for a set of firms. The frontier usually takes the form of a standard neo-classical production function. This approach considers the 'distance' of a firm from the best-practice frontier as a combination of its own technical inefficiency, and random 'noise' beyond its control, thus making the entire frontier 'stochastic'. Under the assumption that the production function of a representative enterprise takes the Cobb-Douglas form, the estimated equation has the following form:

$$\log\_va_i = \beta_0 + \beta_1 \log\_l_i + \beta_2 \log\_k_i + v_i - u_i \quad (1)$$

where, log_va, log_l and log_k are natural logarithms of i^{th} firm's value added, *i.e.,* total annual sales of the establishment *minus* total annual cost of inputs; total annual cost of labour; and the replacement value of machinery, vehicles, and equipment, respectively. All these variables are available in constant 2009 USD from the survey data. The technical inefficiency u_i is assumed to follow a half-normal distribution, *i.e*., truncated on its left at 0, and v_i is the idiosyncratic white-noise error term following usual two-sided normal distribution. v_i and u_i are assumed to be distributed independent of each other, and of the regressors. The heteroskedasticity of both v_i and u_i are explicitly modeled in these estimates using natural logarithm of total annual sales of the establishments. We do not include any time-trend in the construction of TE. Equation (1) includes dummy variables for countries and years to account for unobserved country-specific characteristics, such as institutions, and unobserved year-specific shocks[6]. A firm's TE is estimated using Equation (2).

$$TE_i = \exp\{-\widehat{u_i}\}$$

where, $\widehat{u_i}$ is the maximum likelihood estimator $M(u_i|\varepsilon_i)$.

---

[6] Levinsohn and Petrin (2003) or LP corrects for endogenous selection of capital stock/ investment by a firm by using intermediate inputs as instrument. Since Stochastic Frontier involves estimation of production function, we adopted this element of LP and witnessed an improvement in the measurement of capital's elasticity to value added, although technically combining LP and SF is beyond the scope of this paper. We first regressed logarithm of firms' replacement value of machinery, vehicles, and equipment, a proxy for capital stock on their total annual cost of intermediate inputs, and obtained the fitted values. In the second step, we used this fitted 'capital stock' to estimate equation (1).

$$M(u_i|\varepsilon_i) = -\varepsilon_i\left(\frac{\sigma_u^2}{\sigma_u^2+\sigma_v^2}\right) \text{ if } \varepsilon_i \leq 0, \text{ 0 otherwise}^7. \quad (2)$$

The results are discussed in Section IV.

III.2. Cross-section Estimates

The following regressions are estimated for the impact of access to external finance on efficiency gains through product/process innovation and digital adoption:

$$TE_i = \alpha_0 + \alpha_1 innovation_i + \alpha_2 access_i + \alpha_3(innovation_i * access_i) + \varphi_i^1 \quad (3)$$

$$TE_i = \alpha_0 + \alpha_1 adoption_i + \alpha_2 access_i + \alpha_3(adoption_i * access_i) + \varphi_i^2 \quad (4)$$

Innovation, *adoption* and *access* are binary responses, consisting of 0 and 1. An enterprise *i* reporting access to finance, product/process innovation and adoption of website/email is assigned value 1 for the variables access, innovation and adoption, respectively, and 0 otherwise. We use pooled cross-section data across enterprises for equations (1) to (4).

Equations (3) and (4) are subject to 'endogeneity' issues since more efficient firms can afford innovations and are also likely to have access to external finance. To mitigate these concerns, we use the following variables from the survey as instruments for our explanatory variables: (a) average number of electrical outages at an enterprise in a month; (b) average duration (in hours) of an electrical outage; (c) a binary response showing whether an enterprise had women among their top managers; (d) percentage of annual sales spent as security cost by an enterprise; and (e) number of years of experience by the top manager of an enterprise in the sector.

A necessary condition requires that these instruments be strictly exogenous to the firm but are correlated with the explanatory variables. In our case, power outages can be faced equally by every firm in a certain area and are beyond the direct control of a firm. On the other hand, infrastructure gap, including power shortages, can directly impact firm-level innovations (Sivak *et al*., 2011). Second, the presence of women in an enterprise in general, and among the top positions in a company are found to be strongly associated with improved investor perception and sustainability expenses, which can

[7] $\varepsilon_i = v_i - u_i$, σ_u^2/σ_v^2 are the standard deviations.

be strong drivers of both innovation and access to finance (Gillan *et al*., 2021). Third, security expenses may suggest an enterprise's perception about security threats to its operation. Law and order, stability and governance can significantly impact how the financial institutions would expose itself to the business entities in an area (Sivak *et al*., 2011)[8]. Lastly, although more efficient enterprises may be able to hire more experienced senior managers (Dahl and Klepper, 2007), medium and small enterprises (with employee size less than 100 employees), which occupy large share in this survey (see Chart A.3 in the Annex), are less likely to hire experienced but expensive top managers from outside, and hence, their managers' experience could mostly be gathered from within the firm's operations. Therefore, in small and medium enterprises, the causality is more likely to run from managers' experience to the firm's efficiency, and not reverse, where a more efficient firm hires experienced managers[9].

The 'exclusion restriction' requires that a valid instrument impacts the dependent variable only through explanatory variable, and not directly. This condition, however, could not be ensured for our instruments. For instance, while power outages can influence a firm's decision regarding undertaking of innovations, power outages can also directly reduce a firm's TE by suspending activities. Lewbel (2012) suggests an Instrumental Variable (IV) estimator using model heteroskedasticity as an additional instrument, when either no exogenous instruments are available, or the conventionally chosen instruments can be 'suspected'. Lewbel (2018) suggests that Lewbel (2012) remains valid when the endogenous regressors are binary[10]. The Sargan-Hansen orthogonality tests under Lewbel (2012, 2018) are used to make decisions on the inclusion of instruments in estimation. We weight the observations by (stratified) sample weight assigned by the survey.

---

[8] Table A.3 in Annex suggests that collateral requirement (as per cent of loan value) by a financial institution (*i.e.,* risk perception by financial institutions) is positively associated with the percentage of annual sales towards security cost (*i.e.,* risk perception by enterprises). The existing literature suggests that collateral requirement is associated with lower credit demand from formal institutions by firms (Rand, 2007).

[9] Inclusion of managers' experience as an instrument is also associated with improved performance of the Sargan-Hansen orthogonality tests under Lewbel (2012, 2018), our empirical strategy. Hence, we retained this variable as our instrument despite some doubt about its exogeneity.

[10] We estimate equations (3) and (4) using Lewbel (2012, 2018) by executing the Stata command ivreg2h (Baum and Schaffer, 2021).

III.3. Estimates in Difference for Product/Process Innovations

We use more than one round of the WBES for most countries in our sample. The survey comes with a unique panel identifier for each enterprise, which remains unchanged between successive rounds of WBES in the same country. This gives us a chance to look at the change in TE, the change in the status of access to external finance and the change in innovation for an enterprise between two survey rounds[11]. We use this information to estimate equation (5) using Lewbel (2012).

$$\Delta TE_i = \gamma_0 + \gamma_1 \Delta innovation_i + \gamma_2 \Delta access_i + \gamma_3 (\Delta innovation_i * \Delta access_i) + \varphi_i^2 \quad (5)$$

In this specification, we use change in an enterprise's TE between two survey rounds as the dependent variable. First, we categorise firms into two: those which did not have access to external finance in the first round, and second, those which did not report any change in the access to external finance between two rounds[12]. Then we define the following categories based on changes in innovation. We assign 1 to an enterprise if it did not report innovation in the first round but reported innovation in the second round of the survey; -1 to an enterprise that reported innovation in the first round of the survey but did not report innovation in the second round; 0 to the remaining enterprises which reported no change in innovation between two rounds. We categorise the changes in instruments also in the similar way[13]. We use survey data for India, Kenya, Russia and Turkey, as relevant data was available only for these countries[14].

The estimation of equation (5), however, potentially suffers from 'attrition bias' as some weaker firms may discontinue their operation after the

[11] We do not estimate this relationship for digital adoption, as digital adoptions are generally non-reversible changes in an enterprise. An enterprise adopting access to digital means of communication are least likely to give them away, although an enterprise undertaking certain product/process innovation in one period may choose not to do so at a future date.

[12] We dropped those firms which had access to external finance in the first round, but lost the access in the second round to avoid any issues arising from asymmetric effects of gaining/losing access to external finance.

[13] For instance, increases (decreases) in power outage (number and duration), security cost and top manager's experience are assigned 1 (-1), while those with unchanged values are assigned 0. We construct separate variables for changes for all the instruments.

[14] See Chart A.7 in Annex for relative sample size by country.

first round of survey and may not show up in the second round. In order to overcome this bias, we estimated equation (5) following Wooldridge (2010) where we included the Inverse Mills Ratio (IMR) obtained from a Probit model on survival of a firm in the second round as an additional explanatory variable[15]. In the Probit model, we use an enterprise's sector of operation, ownership type and country as the explanatory variables for a binary dependent variable which assumes value 1 if the enterprise existed in both the rounds, 0 otherwise.

Section IV
Findings

IV.1 Technical Efficiency

The distribution of estimated firm-level TEs is given in Chart 1[16]. The left panel shows that TE has longer tails on the left, *i.e.,* towards 0. The distribution broadly remains unchanged, with slightly fatter left-tail and reduced probability of the higher values when we exclude India and China, which together constitute about 40 per cent of our sample. The right panel in Chart 1 shows the distribution of TE within sample countries across all the surveyed enterprises. The horizontal line in the middle of the box provides the median value, and the height of the boxes, the difference between TE in the 25th and 75th percentiles.

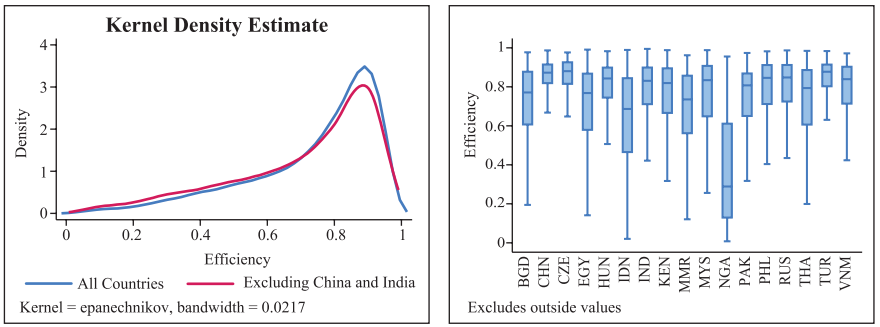
Chart 2 suggests that, among the firms which reported product/ process innovation and/or digital adoption, the group which had access to external finance, had higher median value of TE as compared to firms which did not have such access except Vietnam. Chart 2, however, is subject to wide inter-quartile variation represented by the height of the boxes.

---

[15] The innovations in the second round could have been stronger/more powerful (and *vice versa*) and a binary measure may not fully account for that. Quantitative measures such as R&D expenditure and patent applications/approvals are not available in the survey, and their limitations are also well recognised in the literature (Mansfield, 1984).

[16] We provide a robustness check for these estimates by excluding 5 per cent enterprises from both lower and upper ends of the value-added distribution within each country-sector combination. The t-test in Table A.2 in Annex fails to reject the null hypothesis (H_0) of '*no-difference*' in the sector-wise mean of both the samples at 5 per cent levels of significance, except Metals and Machinery, Electronics and Auto. Although the test fails to reject H_0, the difference in means for these sectors is not large.

Chart 1: Distribution of Technical Efficiencies



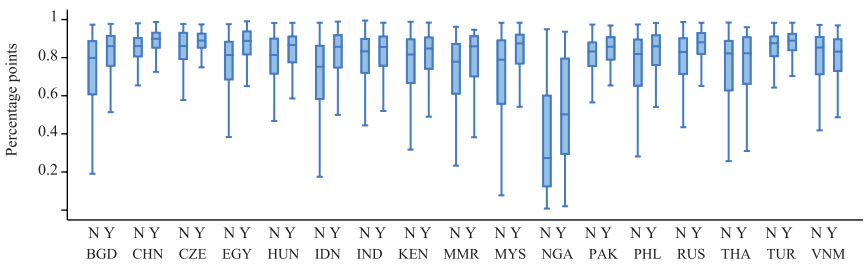
Note: World Bank Country Codes are as follows: BGD (Bangladesh), CHN (China), CZE (Czech Republic), EGY (Egypt), HUN (Hungary), IDN (Indonesia), IND (India), KEN (Kenya), MMR (Myanmar), MYS (Malaysia), NGA (Nigeria), PAK (Pakistan), PHL (Philippines), RUS (Russia), THA (Thailand), Tur (Turkey) and VNM (Vietnam). Enterprise-level TEs are aggregated using log of annual sales as weight.
Source: Authors' estimates.

Therefore, we estimate an empirical model to build more robust inferences after accounting for heterogeneity across firms.

IV.2 Regression Estimates

The estimated coefficients from equation (3) suggesting sensitivity of an enterprise's TE to its product/process innovation on access to external finance are given in Table 1. The coefficients of innovation are positive and statistically significant in all the models, suggesting that the enterprises which reported any product/process innovation experienced improved TE. The dummy variable for the access to finance had mixed signs. In Models (1) and (2), access to external finance of any type (*i.e.*, bank loan or line of credit

Chart 2: Technical Efficiency for Innovative Firms: Firm Category by Access to Finance



Note: World Bank Country Codes are as follows: BGD (Bangladesh), CHN (China), CZE (Czech Republic), EGY (Egypt), HUN (Hungary), IDN (Indonesia), IND (India), KEN (Kenya), MMR (Myanmar), MYS (Malaysia), NGA (Nigeria), PAK (Pakistan), PHL (Philippines), RUS (Russia), THA (Thailand), Tur (Turkey) and VNM (Vietnam). Enterprise-level TEs are aggregated using log of annual sales as weight.
Source: Authors' estimates.

Table 1: Product/Process Innovation and Efficiency under Access to Finance: All Firms

	Bank Loan/Line of Credit (LoC)		External Finance for Working Capital		Bank Loan for Working Capital		Bank Loan for Investment		Sale of Equity	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent Variable: Technical Efficiency										
Innovation=1	0.100*** (0.0072)	0.094*** (0.0075)	0.22*** (0.0076)	0.034* (0.020)	0.23*** (0.0075)	0.20*** (0.0094)	0.065*** (0.014)	0.058*** (0.014)	0.12*** (0.0085)	0.12*** (0.0084)
Access to Finance=1	0.097*** (0.0081)	0.088*** (0.0087)	-0.063*** (0.0081)	-0.047*** (0.011)	-0.015 (0.013)	-0.034*** (0.010)	0.11*** (0.026)	0.077** (0.033)	0.19*** (0.048)	0.240*** (0.047)
(Innovation=1)* (Access to Finance=1)		0.026* (0.015)		0.083*** (0.015)		0.058*** (0.020)		-0.033 (0.036)		-0.167* (0.098)
Chi-sq	7.114	7.069	0.341	6.051	1.154	2.883	8.502	0.429	0.002	1.592
Prob (Chi-sq)	0.0285	0.0292	0.8434	0.0139	0.5615	0.2365	0.0143	0.8069	0.9630	0.2071
Number of Observations	21649	21649	21677	21647	21431	21532	13628	13628	5650	5650

Note: Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Sargan-Hansen's orthogonality test statistic (Chi-sq) suggests that the tests 'fail to reject' the null hypothesis that 'Instruments are Valid' at 5 per cent level of significance.
Source: Authors' estimates.

for any purpose) was positively associated with TE, supporting the general finance-productivity linkage hypotheses (Heil, 2017). The interaction between innovation and access to finance in Model (2) was positive and statistically significant at 10 per cent, suggesting that the sensitivity of an enterprise's TE to product/process innovation was higher when the enterprise had access to external finance.

Models (3) and (4) provide estimates using access to external finance for working capital for meeting an enterprise's day-to-day operational expenses. The coefficients for innovation were positive and statistically significant. The coefficients for the access to finance were negative[17]. The interaction between

[17] There is consensus that long-term financing enables productivity improvement by allowing firms to expand productivity-enhancing activities (Heil, 2017). Nakatani (2023) also suggests that a long maturity of debt reduces the liquidity risk of firms, enabling productivity enhancing activities. Nakatani (2023), which so far remains the only major work relating debt maturity with productivity growth suggests that the effects of short-term debt on productivity growth of firm weakens, especially when financial market grows, and long-term debt to large firms starts to dominate. At this stage, the positive disciplinary effects of short-term debt, especially to the small and medium enterprises, weaken due to the lack of stricter monitoring of such debt.

innovation and access to finance was positive and statistically significant in Model (4). We found similar evidence for Models (5) and (6), when working capital of an enterprise was funded through bank loans.

Models (7) and (8) present estimates for the access to external finance for long-term investments through bank loans, and Models (9) and (10) provide estimates when an enterprise issued equity shares for raising external funds. The coefficients of both innovation and access to finance were positive and statistically significant. The interaction between innovation and access to finance, however, was not statistically significant in Model (8) (financing of investment through bank loans), while it became negative in Model (10) (issuance of equity shares).

The estimates for digital adoption in Table 2 based on equation (4) corroborated our findings in Table 1. The interaction between digital adoption and access to finance was positive and statistically significant in all the specifications, except under Model (10), suggesting that the sensitivity

Table 2: Digital Adoption and Efficiency under Access to Finance: All Firms

	Bank Loan/ LoC		**External Finance for Working Capital**		**Bank Loan for Working Capital**		**Bank Loan for Investment**		**Sale of Equity**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent Variable: Technical Efficiency										
Adoption=1	0.048*** (0.016)	0.12*** (0.0098)	0.081*** (0.015)	0.16*** (0.018)	0.052*** (0.017)	0.059*** (0.0095)	0.16*** (0.0099)	0.063*** (0.012)	0.21*** (0.015)	0.20*** (0.015)
Access to Finance=1	0.15*** (0.017)	0.057** (0.026)	0.078*** (0.021)	-0.061*** (0.016)	0.10*** (0.025)	-0.010 (0.012)	0.29*** (0.059)	-0.028 (0.031)	-0.040 (0.042)	0.061 (0.085)
(Adoption=1)* (Access to Finance=1)		**0.066** ** **(0.029)**		**0.047** ** **(0.023)**		**0.12** *** **(0.019)**		**0.091** *** **(0.035)**		-0.091 (0.095)
Chi Sq.	1.811	2.274	4.178	2.357	1.614	3.959	3.131	1.096	0.006	1.142
Prob (Chi Sq.)	0.1784	0.3208	0.0410	0.1247	0.2040	0.1382	0.0768	0.5781	0.9362	0.2852
Number of Observations	24713	22619	24747	21782	24465	21432	15452	13630	5664	5664

Note: Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Sargan-Hansen's orthogonality test statistic (Chi-sq) suggests that the tests 'fail to reject' the null hypothesis that 'Instruments are Valid' at 5 per cent level of significance.
Source: Authors' estimates.

of an enterprise's TE to digital adoption was generally higher when the enterprise had access to external finance. The interaction coefficient was negative, although not statistically significant in Model (10), *i.e.,* under the issuance of equity shares. In Model (8), *i.e.,* when an enterprise met its long-term investment needs through bank loans, the coefficient was positive and statistically significant. The coefficients were positive and statistically significant in Models (4) and (6), when an enterprise's short-term working capital needs were financed through external sources, including banks.

Our estimates in Tables 1 and 2 suggested that the sensitivity of an enterprise's TE to its product/process innovation and digital adoption was higher when the enterprise had access to external finance. Our separate estimates based on WBES suggested that an enterprise's likelihood of spending on formal trainings (Model (2) in Table A.4 in the Annex) and the proportion of workers to whom it offered formal training (Models (3) and (4) in Table A.5 in the Annex), both were positively associated with the enterprise's access to external finance[18]. An enterprise's access to short-term external finance[19], on the other hand, was positively associated with both the proportion of non-production workers in total number of permanent workers (Model (1) in Table A.4 in the Annex) and the proportion of skilled workers in all workers (Model (2) in Table A.5 in the Annex), compared to enterprises which either did not have any access to external finance or had access to external finance only for the long-term financial needs[20].

IV.3 Robustness Checks

We conducted several robustness checks for our estimates on the access to external finance for working capital needs. To illustrate, our earlier findings based on Tables 1 and 2 were robust for separate samples of small and medium enterprises (Table 3).

Estimates in Table 1 could be subject to a variation in sample sizes. We provide a robustness check for the estimates in Models (3) to (6) given in

[18] There was no significant difference between an enterprise's access to only long-term finance and its access to short-term finance.

[19] Including cases where there is access to both long and short-term finances, and only short-term finance.

[20] Non-production workers include clerks, superintendents, sales people, *etc*.

Table 3: Robustness Check for the Access to External Finance for Working Capital on Firm Size

Variable	Small (5-20)	Medium (20-99)	Small (5-20)	Medium (20-99)
	(1)	(2)	(3)	(4)
Dependent Variable: Technical Efficiency				
Innovation=1	0.034* (0.018)	0.063** (0.028)		
Digital Adoption=1			0.10* (0.064)	0.067* (0.035)
Access to Finance=1	-0.054*** (0.018)	-0.038** (0.015)	-0.11*** (0.031)	-0.073 (0.051)
(Innovation=1)*(Access to Finance=1)	**0.060** (0.028)**	**0.040** (0.019)**		
(Digital Adoption=1)*(Access to Finance=1)			**0.11** (0.044)**	**0.13** (0.058)**
Chi Sq. Prob (Chi sq)	11.207 0.0037	3.757 0.0526	1.082 0.5822	3.782 0.0518
Number of Observations	6921	8553	6945	8951

Note: Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Sargan-Hansen's orthogonality test statistic (Chi-sq) suggests that the tests 'fail to reject' the null hypothesis that 'Instruments are Valid' at 5 per cent level of significance in models (2) to (4).
Source: Authors' estimates.

Table 1 (*i.e.*, access to finance for working capital) by limiting the enterprises to a set of common firms which appear in all models. Table 4 suggests that the

Table 4: Product/Process Innovation and TE under Access to Finance: Common Firms

Variable	Bank Loan/LoC of Any Type	External Finance for Working Capital	Bank Loan for Working Capital
	(1)	(2)	(3)
Innovation=1	0.23*** (0.021)	0.098*** (0.0096)	0.11*** (0.0098)
Access to Finance=1	-0.071*** (0.017)	-0.077*** (0.013)	-0.079*** (0.014)
(Innovation=1)*(Access to Finance=1)	-0.0056 (0.034)	**0.094*** (0.018)**	**0.095*** (0.019)**
Chi Sq. Prob (Chi Sq.)	0.046 0.8302	4.895 0.0865	3.509 0.1730
Number of Observations	5659	5851	5851

Note: Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Sargan-Hansen's orthogonality test statistic (Chi-sq) suggests that the tests 'fail to reject' the null hypothesis that 'Instruments are Valid' at 5 per cent level of significance.
Source: Authors' estimates.

Table 5: Firm Efficiency under Access to Finance for Working Capital: By Sector

Dependent Variable: Firm-level Technical Efficiency				
Variable	**Product/Process Innovation**		**Digital Adoption**	
	Manufacturing	**Services**	**Manufacturing**	**Services**
	(1)	(2)	(3)	(4)
Innovation=1	0.058**	-0.25***		
	(0.024)	(0.092)		
Digital Adoption=1			0.15***	0.18***
			(0.018)	(0.020)
Access to Finance=1	-0.067***	-0.026	-0.064***	0.094***
	(0.017)	(0.054)	(0.016)	(0.019)
(Innovation=1)*(Access to Finance=1)	**0.18***	**0.24***		
	(0.028)	**(0.076)**		
(Digital Adoption=1)*(Access to Finance=1)			**0.054****	**0.046***
			(0.023)	**(0.027)**
Chi Sq.	2.986	1.465	2.679	3.819
Prob (Chi Sq.)	0.2247	0.4806	0.1017	0.1482
Number of Observations	20945	1660	20182	1665

Note: Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Sargan-Hansen's orthogonality test statistic (Chi-sq) suggests that the tests 'fail to reject' the null hypothesis that 'Instruments are Valid'.
Source: Authors' estimates.

estimated coefficients for the interaction term between innovation and access to finance for working capital were positive and statistically significant in a sub-sample of common firms in Models (2) and (3), *i.e.,* access to external finance for working capital.

Separate estimates for manufacturing and services sectors in Table 5 are also in line with the earlier findings[21]. Models (1) and (2) in Table 5 pertain to product/process innovations, while Models (3) and (4) pertain to digital adoption by an enterprise. The interaction terms between innovation and access to finance under both Models (1) and (2) were positive and statistically significant. Similar effects were also seen with regard to the sensitivity of an enterprise's TE to its adoption of digital technologies in both manufacturing and services sectors under Models (3) and (4), respectively.

[21] Sector codes below 20 from WBES are considered as 'Manufacturing', while codes above 20 are considered as 'Services'.

Table 6: Innovation and Efficiency under Access to Finance: Estimates on Differences

Variable	Bank Loan/LoC	External Finance for Working Capital
	(1)	(2)
Innovation	0.16*	-0.21*
	(0.086)	(0.12)
Access to Finance	-0.041	0.27**
	(0.056)	(0.13)
(Innovation)*(Access to Finance)	**-0.047**	**0.24****
	(0.15)	**(0.11)**
Chi Sq.	1.36	0.40
Prob (Chi Sq.)	0.51	0.82
Number of observations	665	674

Notes: 1. Standard errors in parentheses. Significance levels are as follows: * p < 0.10, ** p < 0.05, *** p < 0.01
2. Estimates are obtained from two-step procedure based on Wooldridge (2010) to control for panel attrition bias in the second round.
3. The sample is restricted to a common set of firms for which both access to finance in overall category and working capital were observed.
4. Observations are weighted by the survey weight from the first round.
5. Sargan-Hansen's orthogonality test statistic (Chi-sq) suggests that the tests 'fail to reject' the null hypothesis that 'Instruments are Valid'.

Source: Authors' estimates.

IV.4 Estimates on Differences

The results from equation (5) are illustrated in Table 6. This model was estimated based on the change in TE, innovation and access to finance between two rounds of the WBES for a smaller set of countries and enterprises[22]. Model (1) in Table 6 provided estimates for the access to external finance for any purpose, including long-term and short-term, whereas Model (2) provided estimates only for the access to external finance for short-term working capital. Both the models are estimated using Lewbel (2012). The coefficient of (gaining) access to external finance is positive and statistically significant only in Model (2), *i.e.,* in case of the access to external finance for working capital, while the coefficient of (adopting) innovation turns negative and statistically significant at 10 per cent. The interaction term between access

[22] See Section III.3 for details.

to external finance and innovation in Model (2) is positive and statistically significant, corroborating our earlier results[23].

Section V
Conclusion

Investments in research and innovations have gained prominence as the drivers of enterprise growth in the backdrop of subdued global economic weaknesses over the last decade and multipronged challenges, including climate change and the pandemic (IMF, 2022). Our paper analyses whether access to finance from external sources makes a difference to the sensitivity of an enterprise's technical efficiency from the innovation activities that it undertakes.

Using WBES rounds for 17 emerging and developing economies conducted after 2010, we observe that the sensitivity of an enterprise's technical efficiency to both product/process innovation and digital adoption are higher when the enterprise gets access to external finance, especially for its short-term working capital needs. These findings remain robust in separate samples of small and medium enterprises, for manufacturing and services sectors, and within a smaller set firms based on changes in each of these attributes between two survey rounds.

We also observe that an enterprise's likelihood of spending on formal trainings and the proportion of workers to whom it offers formal trainings are positively associated with the enterprise's access to external finance of any kind (both short and long-term). On the other hand, an enterprise's access to short-term external finance is associated with higher values of both the proportion of non-production workers in total number of permanent workers and the proportion of skilled workers in all workers, compared to enterprises which either do not have access to external finance or have access to external finance only for the long-term financial needs. Overall, our analysis suggests higher efficiency gains from product/process innovation when firms get

[23] The coefficients of innovation and access to finance without interaction, however, change their signs from earlier findings. It may be noted that India alone accounts for almost 90 per cent of the data in this estimate (Chart A.3 in the Annex). For India, the second round of the available WBES was conducted in 2022, right after the COVID-19 pandemic, when the economic recovery was still under progress. Results from Table 6, therefore, need more careful reading and further research.

access to external finance for short-term working capital. The lack of access to finance not only makes innovations unviable due to their large sunk cost, but also reduces rewards from the existing innovations.

The study can be improved further depending upon availability of data. First, while one of our main explanatory variables is access to finance, we rely upon a binary variable whether an enterprise has access to external finance or not. Availability on data on the magnitude and cost of such finance could be more relevant for a firm's efficiency and productivity and strengthen the analysis. While quantitative information is available in WBES, it is limited, and cannot be verified through the enterprises' balance sheets. Second, data on the quality and/or the intensity of innovations could provide a better understanding of the linkage between access to finance and innovations. Although there is disagreement regarding the measure of innovation, a firms' expenditure on different heads such as R & D, environment-risk mitigation, and royalties paid can be useful. Third, a panel data could be more helpful and powerful relative to pooled cross-sectional data in analysing the impact of access to finance on innovations in a more dynamic sense.

References

Adegboye, A. C., & Iweriebor, S. (2018). Does access to finance enhance SME innovation and productivity in Nigeria? Evidence from the World Bank Enterprise Survey. *African Development Review*, *30(4),* 449-461.

Aghion, P., Askenazy, P., Berman, N., Cette, G., & Eymard, L. (2012). Credit constraints and the cyclicality of R&D investment: Evidence from France. *Journal of the European Economic Association*, *10*(5), 1001-1024.

Aghion, P., Fally, T., & Scarpetta, S. (2007). Credit constraints as a barrier to the entry and post-entry growth of firms. *Economic Policy*, *22*(52), 732-779.

Aldieri, L., Barra, C., Paolo Vinci, C., & Zotti, R. (2021). The joint impact of different types of innovation on firm's productivity: evidence from Italy. *Economics of Innovation and New Technology*, *30*(2), 151-182.

Andrews, D., & Cingano, F. (2014). Public policy and resource allocation: evidence from firms in OECD countries. *Economic Policy, 29(78)*, 253-296.

Andrews, D., Criscuolo, C., & Menon, C. (2014). Do resources flow to patenting firms? Cross-country evidence from firm level data.

Arping, S., Lóránth, G., & Morrison, A. D. (2010). Public initiatives to support entrepreneurs: Credit guarantees versus co-funding. *Journal of Financial Stability*, *6*(1), 26-35.

Asimakopoulos, G., Revilla, A. J., & Slavova, K. (2020). External knowledge sourcing and firm innovation efficiency. *British Journal of Management*, *31*(1), 123-140.

Ayyagari, M., Demirgüç-Kunt, A., & Maksimovic, V. (2008). How important are financing constraints? The role of finance in the business environment. *The World Bank Economic Review*, *22*(3), 483-516.

Ayyagari, M., Demirgüç-Kunt, A., & Maksimovic, V. (2010). Formal versus informal finance: Evidence from China. *The Review of Financial Studies*, *23*(8), 3048-3097.

Ayyagari, M., Demirgüç-Kunt, A., & Maksimovic, V. (2011). Firm innovation in emerging markets: The role of finance, governance, and competition. *Journal of Financial and Quantitative Analysis*, *46*(6), 1545-1580.

Bai, J. (2013). On regional innovation efficiency: Evidence from panel data of China's different provinces. *Regional Studies*, *47*(5), 773-788.

Baum, C., & Schaffer, M. (2021). IVREG2H: Stata module to perform instrumental variables estimation using heteroskedasticity-based instruments.

Beck, T., Demirguc-Kunt, A. S. L. I., Laeven, L., & Levine, R. (2008). Finance, firm size, and growth. *Journal of Money, Credit and Banking, 40(7),* 1379-1405.

Beck, T., Levine, R., & Loayza, N. (2000). Finance and the sources of growth. *Journal of Financial Economics* 58, 261-300.

Becker, G. S. (1967). Human capital and the personal distribution of income: An analytical approach (No. 1). Institute of Public Administration.

Benhabib, J., & Spiegel, M. M. (2000). The role of financial development in growth and investment. *Journal of Economic Growth*, 5, 341-360.

Black, S. E., & Lynch, L. M. (1996). Human-capital investments and productivity. *The American Economic Review*, *86*(2), 263-267.

Blundell, R., Dearden, L., Meghir, C., & Sianesi, B. (1999). Human capital investment: the returns from education and training to the individual, the firm and the economy. *Fiscal Studies*, *20*(1), 1-23.

Brown, J. R., Fazzari, S. M., & Petersen, B. C. (2009). Financing innovation and growth: Cash flow, external equity, and the 1990s R&D boom. *The Journal of Finance*, *64(1),* 151-185.

Brown, J. R., Martinsson, G., & Petersen, B. C. (2012). Do financing constraints matter for R&D? *European Economic Review*, *56*(8), 1512-1529.

Caggese, A. (2019). Financing constraints, radical versus incremental innovation, and aggregate productivity. *American Economic Journal: Macroeconomics*, *11*(2), 275-309.

Carpenter, R. E., & Petersen, B. C. (2002). Is the growth of small firms constrained by internal finance? *Review of Economics and Statistics*, *84*(2), 298-309.

Cole, H. L., Greenwood, J., & Sanchez, J. M. (2016). Why doesn't technology flow from rich to poor countries? *Econometrica, 84(4),* 1477-1521.

Dahl, M. S., & Klepper, S. (2007). Who do new firms hire? Working Paper.

Dutz, M. (Ed.). (2007). Unleashing India's innovation: toward sustainable and inclusive growth. World Bank Publications.

Enterprise Surveys (http://www.enterprisesurveys.org), The World Bank.

Fan, F., Lian, H., & Wang, S. (2020). Can regional collaborative innovation improve innovation efficiency? An empirical study of Chinese cities. *Growth and Change*, *51*(1), 440-463.

Fazzari, S., Hubbard, R. G., & Petersen, B. C. (1987). Financing constraints and corporate investment.

Fritsch, M. (2004). Cooperation and the efficiency of regional R&D activities. *Cambridge Journal of Economics*, *28*(6), 829-846.

Gao, W., & Chou, J. (2015). Innovation efficiency, global diversification, and firm value. *Journal of Corporate Finance*, *30*, 278-298.

Gillan, S. L., Koch, A., & Starks, L. T. (2021). Firms and social responsibility: A review of ESG and CSR research in corporate finance. *Journal of Corporate Finance*, *66*, 101889.

Griliches, Z., Mairesse, Jacques, (1984). Productivity and R&D at the firm level. In: Griliches, Z. (Ed.), *R&D, Patents, and Productivity*. Univ. of Chicago Press, Chicago, pp. 339–374.

Griliches, Z. (1985). Productivity, R&D, and basic research at the firm level in the 1970s. *National Bureau of Economic Research,* (No. w1547).

Griliches, Z. (1998). Introduction to R&D and Productivity: The Econometric Evidence. *R&D and Productivity: The Econometric Evidence* (pp. 1-14). University of Chicago Press.

Grupp, H. (1997). External effects as a microeconomic determinant of innovation efficiency. *International Journal of the Economics of Business*, *4*(2), 173-188.

Guan, J., & Yam, R. C. (2015). Effects of government financial incentives on firms' innovation performance in China: Evidences from Beijing in the 1990s. *Research Policy*, *44*(1), 273-282.

Guan, J., Zuo, K., Chen, K., & Yam, R. C. (2016). Does country-level R&D efficiency benefit from the collaboration network structure? *Research Policy*, *45*(4), 770-784.

Gutierrez, E., Rudolph, H. P., Homa, T., & Beneit, E. B. (2011). Development banks: role and mechanisms to increase their efficiency. *World Bank Policy Research Working Paper*, (5729).

Hall, B. H., Lotti, F., & Mairesse, J. (2009). Innovation and productivity in SMEs: empirical evidence for Italy. *Small Business Economics*, *33*, 13-33.

Heil, M. (2017). Finance and productivity: A literature review.

Hong, J., Feng, B., Wu, Y., & Wang, L. (2016). Do government grants promote innovation efficiency in China's high-tech industries? *Technovation*, *57*, 4-13.

Hsu, P. H., Tian, X., & Xu, Y. (2014). Financial development and innovation: Cross-country evidence. *Journal of Financial Economics*, *112*(1), 116-135.

IMF, 2022. Sailing into Headwinds. Regional Economic Outlook: Asia and the Pacific. October.

Jaffee, D. M., & Russell, T. (1976). Imperfect information, uncertainty, and credit rationing. *The Quarterly Journal of Economics*, *90*(4), 651-666.

Kaur, P., Kaur, N., & Kanojia, P. (2022). Firm innovation and access to finance: firm-level evidence from India. *Journal of Financial Economic Policy*, *14*(1), 93-112.

Kim, W. J., Hoi, T. V., Tuan, L. N., & Trung, N. N. (2019). R&D, training and accessibility to finance for innovation: a case of Vietnam, the country in transition. *Asian Journal of Technology Innovation*, *27*(2), 172-193.

Kumbhakar, S., & Lovell, K. (2000). Stochastic frontier analysis. Cambridge: Cambridge University Press.

Levine, O., & Warusawitharana, M. (2021). Finance and productivity growth: Firm-level evidence. *Journal of Monetary Economics*, *117*, 91-107.

Levine, R., & Zervos, S. (1998). Stock markets, banks, and economic growth. *American Economic Review,* 537-558.

Levinsohn, J., & Petrin, A. (2003). Estimating production functions using inputs to control for unobservables. *The Review of Economic Studies*, *70*(2), 317-341.

Lewbel, A. (2012). Using heteroscedasticity to identify and estimate mismeasured and endogenous regressor models. *Journal of Business & Economic Statistics*, *30*(1), 67-80.

Lewbel, A. (2018). Identification and estimation using heteroscedasticity without instruments: The binary endogenous regressor case. *Economics Letters*, *165*, 10-12.

López-García, P., Montero, J. M., & Moral-Benito, E. (2013). Business cycles and investment in productivity-enhancing activities: evidence from Spanish firms. *Industry and Innovation*, *20*(7), 611-636.

Madsen, J. B., & Ang, J. B. (2016). Finance-led growth in the OECD since the nineteenth century: how does financial development transmit to growth? *Review of Economics and Statistics*, *98*(3), 552-572.

Nasierowski, W., & Arcelus, F. J. (2003). On the efficiency of national innovation systems. *Socio-Economic Planning Sciences*, *37*(3), 215-234.

Nickell, S., & Nicolitsas, D. (1999). How does financial pressure affect firms? *European Economic Review*, *43*(8), 1435-1456.

Organisation for Economic Co-operation and Development, Pavitt, K., & Wald, S. (1971). *The Conditions for Success in Technological Innovation*. Organisation for Economic Co-operation and Development.

Rajan, R., & Zingales, L. (1998). Financial development and growth. *American Economic Review*, *88*(3), 559-586.

Rand, J. (2007). Credit constraints and determinants of the cost of capital in Vietnamese manufacturing. Small Business Economics, 29, 1-13.

Rogers, M., & Rogers, M. (1998). The definition and measurement of innovation (Vol. 98). Parkville, VIC: *Melbourne Institute of Applied Economic and Social Research*.

Sivak, R., Caplanova, A., & Hudson, J. (2011). The impact of governance and infrastructure on innovation. *Post-Communist Economies*, *23*(02), 203-217.

Song, M., Ai, H., & Li, X. (2015). Political connections, financing constraints, and the optimization of innovation efficiency among China's private enterprises. *Technological Forecasting and Social Change*, *92*, 290-299.

Su, W., Wang, Z., Zhang, C., & Balezentis, T. (2023). Determinants of the innovation efficiency of strategic emerging enterprises: evidence from the robust frontiers. *Economic Change and Restructuring*, *56*(3), 1433-1465.

Talke, K., Salomo, S., & Rost, K. (2010). How top management team diversity affects innovativeness and performance via the strategic choice to focus on innovation fields. *Research Policy*, *39*(7), 907-918.

Valls Martinez, M. D. C., Cruz Rambaud, S., & Parra Oller, I. M. (2019). Gender policies on board of directors and sustainable development. *Corporate Social Responsibility and Environmental Management*, *26*(6), 1539-1553.

Wang, E. C. (2007). R&D efficiency and economic performance: A cross-country analysis using the stochastic frontier approach. *Journal of Policy Modeling*, *29*(2), 345-360.

Wooldridge, J. M. (2010). Econometric analysis of cross section and panel data. MIT press.

Wurgler, J. (2000). Financial markets and the allocation of capital. *Journal of Financial Economics*, *58*(1-2), 187-214.

Xie, L., Zhou, J., Zong, Q., & Lu, Q. (2020). Gender diversity in R&D teams and innovation efficiency: Role of the innovation context. *Research Policy*, *49*(1), 103885.

Zhang, A., Zhang, Y., & Zhao, R. (2003). A study of the R&D efficiency and productivity of Chinese firms. *Journal of Comparative Economics*, *31*(3), 444-464.

Annex

Table A.1: Descriptive Statistics[24]

Mean (Standard Deviation) [Number of Observations]						
Country	**Log (Value Added)**	**Log (Cost of Labour)**	**Log (Replacement Value for Machinery and Vehicle)**	**Log (Value of Intermediate Inputs)**	**Log (Sales)**	**Weights**
Bangladesh	12.0 (1.9)[1572]	10.5 (1.7)[2335]	11.4 (2.4)[1612]	12.0 (2.4)[1581]	12.4 (2.1)[2317]	6.6 (10.6)[2429]
China	14.3 (1.5)[1508]	12.6 (1.4)[2608]	13.1 (1.6)[1365]	13.7 (1.7)[1510]	14.7 (1.6)[2640]	364.3 (784.8)[2700]
Czech Republic	14.4 (1.7)[333]	12.6 (1.8)[645]	14.0 (2)[337]	13.9 (2)[334]	14.5 (1.8)[701]	124.8 (119.5)[756]
Egypt, Arab Rep.	12.2 (2)[3402]	10.6 (1.6)[5444]	12.2 (2.2)[3463]	11.7 (2.3)[3525]	12.6 (2)[5169]	61.6 (120.7)[5801]
Hungary	13.6 (1.6)[425]	12.2 (1.6)[823]	13.2 (1.8)[419]	13.0 (1.9)[427]	14.1 (1.7)[968]	60.9 (72)[1113]
India	13.0 (1.8)[11021]	11.3 (1.6)[17656]	11.7 (2.3)[7443]	13.0 (2.1)[11039]	13.5 (2)[17266]	122.7 (285.8)[18352]
Indonesia	11.7 (2.2)[902]	10.6 (1.9)[1218]	10.3 (2.4)[893]	10.6 (2.3)[902]	12.1 (2.2)[1167]	163.1 (394)[1307]
Kenya	13.0 (2.3)[593]	10.6 (2)[1453]	12.7 (2.6)[589]	11.8 (2.5)[611]	12.9 (2.2)[1476]	7.7 (15.3)[1781]
Malaysia	13.3 (2.1)[1093]	11.6 (1.6)[1926]	12.9 (2.3)[840]	12.3 (2.3)[1099]	13.4 (2)[2029]	83.2 (239)[2143]
Myanmar	12.0 (1.8)[552]	10.8 (1.6)[1196]	11.5 (2)[590]	11.5 (1.8)[568]	12.6 (1.8)[1117]	21.4 (36.6)[1239]
Nigeria	9.3 (1.9)[397]	7.0 (3.4)[1588]	7.5 (3.3)[328]	7.5 (2.7)[439]	9.5 (2.1)[1880]	8.3 (27.9)[2646]
Pakistan	12.6 (1.8)[1069]	10.6 (1.7)[1765]	12.4 (2.6)[1085]	12.0 (2.2)[1090]	12.8 (2)[1759]	50.8 (94.8)[2485]
Philippines	13.3 (2.2)[787]	11.6 (2)[1110]	11.7 (2.4)[302]	12.8 (2.6)[790]	13.8 (2.4)[1173]	33.0 (74.8)[1308]
Russian Federation	13.4 (1.9)[1271]	11.7 (1.7)[3746]	12.5 (2.5)[963]	12.6 (2.2)[1329]	13.7 (1.8)[4149]	80.9 (302.5)[5543]
Thailand	12.7 (2)[543]	11.3 (1.6)[832]	10.8 (2.4)[575]	11.4 (2.6)[544]	12.9 (2)[884]	43.8 (92)[951]
Turkey	14.3 (1.6)[1020]	12.2 (1.7)[1912]	13.0 (2.3)[1215]	12.8 (1.8)[1089]	14.6 (1.7)[2395]	68.6 (149.8)[3007]
Vietnam	13.0 (1.9)[522]	11.3 (1.7)[882]	12.6 (2.3)[448]	12.4 (2.5)[523]	13.6 (1.9)[946]	96.4 (172.8)[992]
Total	**12.9 (2.1)[27010]**	**11.1 (2)[47139]**	**12.0 (2.5)[22467]**	**12.5 (2.4)[27400]**	**13.2 (2.2)[48036]**	**95.1 (288.3)[54553]**

Source: Authors' estimates.

[24] World Bank Country Codes are as follows: BGD (Bangladesh), CHN (China), CZE (Czech Republic), EGY (Egypt), HUN (Hungary), IDN (Indonesia), IND (India), KEN (Kenya), MMR (Myanmar), MYS (Malaysia), NGA (Nigeria), PAK (Pakistan), PHL (Philippines), RUS (Russia), THA (Thailand), Tur (Turkey) and VNM (Vietnam).

Table A.2: Robustness Check for Efficiency

(5 per cent sample truncated on both side based on value added)

H0: Mean 1 (full sample) = Mean 2 (truncated sample)

Sector Id	Sector Name	Mean 1	Mean 2	Difference (Mean 1 -Mean 2)	S.E. 1	S.E. 2	Difference (S.E. 1 - S.E. 2)	t-stat (t)	Pr (|T| > |t|)
1 & 3	Textile	0.75	0.75	0.005	0.003	0.003	-0.0003	1.39	0.16
5	Food	0.72	0.72	0.004	0.003	0.004	-0.0003	0.78	0.43
7	**Metals and Machinery**	**0.75**	**0.74**	**0.014**	**0.002**	**0.003**	**-0.0003**	**3.87**	**0.00**
8	**Electronics**	**0.73**	**0.71**	**0.020**	**0.005**	**0.006**	**-0.0010**	**2.46**	**0.01**
9	Chemicals and Pharmaceuticals	0.73	0.72	0.009	0.004	0.005	-0.0006	1.36	0.17
11	Wood and Furniture	0.70	0.70	-0.006	0.007	0.007	-0.0004	-0.61	0.54
12	Non-metallic and Plastic	0.75	0.75	0.007	0.003	0.003	-0.0003	1.68	0.09
15	**Auto**	**0.78**	**0.76**	**0.019**	**0.004**	**0.005**	**-0.0006**	**3.13**	**0.00**
2 & 16	Misc. Manufacturing	0.77	0.78	-0.005	0.006	0.006	-0.0003	-0.63	0.53
21	Retail and Wholesale Trade	0.77	0.77	0.005	0.009	0.010	-0.0009	0.42	0.67
22	Hotels and Restaurants	0.68	0.69	-0.006	0.011	0.010	0.0002	-0.39	0.70
23	Other Services	0.79	0.78	0.013	0.005	0.006	-0.0005	1.66	0.10

Note: S.E.: Standard Error. Mean 1 and S.E. 1 pertain to full sample. Mean 2 and S.E. 2 pertain to truncated sample.

Misc. Manufacturing includes leather (Sector Id 2).

Source: Authors' estimates.

Table A.3: Security Cost - A Proxy for Risks (Tobit Estimates)

	(1)	(2)
	Without FE	**Country x Sector FE**
Dependent Variable: Security costs (Per cent of Annual Sales)		
Proportion of Loans Requiring Collateral	0.010***	0.0100***
	(0.0015)	(0.0015)
Number of Observations	11123	11123
Pseudo R-Sq	0.0220	0.0010

Note: Standard errors in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Authors' estimates.

Table A.4: Firms' Spending and Worker Composition on Access to External Finance Category

	(1)	(2)
Variable	**Tobit: Proportion of Non-production Workers in Permanent Workers**	**Probit: Firm Spending on Formal Trainings**
Access: Only long-term (Dummy = 1)	0.31 (0.41)	0.32*** (0.065)
Access: Long & short-term (Dummy = 2)	**0.41**** **(0.18)**	**0.21***** **(0.042)**
Number of Observations	32,449	53,018
R-sq./Pseudo R-sq.	0.0089	0.1529

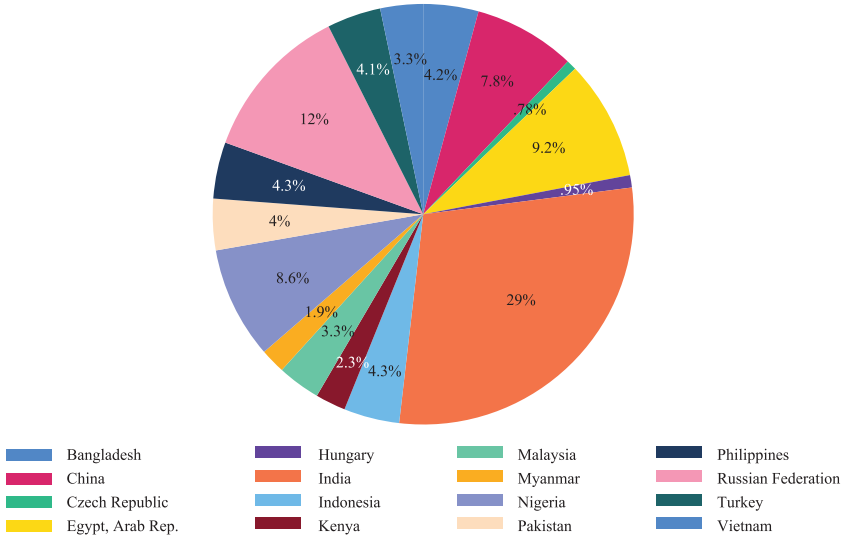
Note: Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Regressions control for unobserved country, year and sector effects.
Firms with no access to external finance (Dummy = 0) serve as the base category.
The categorical dependent variable takes value 0 for enterprises with no access to external finance, 1 for enterprises which have access to finance only for long-term investment and equity sales, and 2 for enterprises whose access to finance extends to short-term capital needs (*i.e.,* either for both long and short-term capital needs or only short-term).
Source: Authors' estimates.

Table A.5: Firms' Worker Composition and Access to External Finance Category: Tobit Estimates

Variable	**Proportion of Skilled Workers out of all Workers**		**Proportion of Workers offered Formal Training within a Firm**	
	(1)	(2)	(3)	(4)
	No Access *vs.* Only long-term	**Only Long-term *vs.* Long & short-term**	**No Access *vs.* Only long-term**	**Only Long-term *vs.* Long & short-term**
Access to Finance: Prob.#	15.0** (6.19)	22.2*** (5.61)	81.5*** (14.5)	11.9 (10.8)
Constant	86.4*** (5.93)	57.8*** (5.07)	21.1 (14.2)	69.1*** (10.5)
Number of Observations	12,499	14,597	2,773	3,887
Pseudo-R Sq.	0.0216	0.0149	0.0442	0.0290

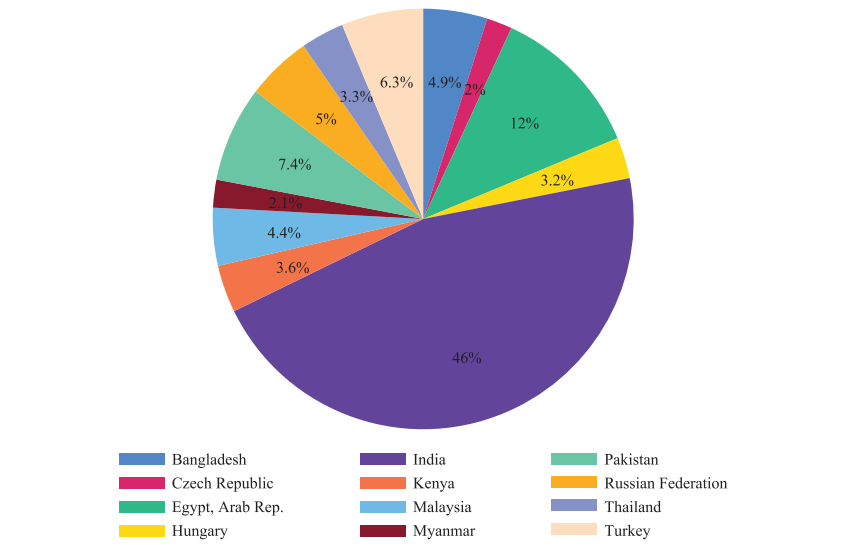
Note: Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
#: Estimated probabilities from a multinomial logit model where the categorical variable indicating *Access to External Finance Category* is regressed on the four instruments used in the regressions, *viz*., 1. the number of electrical outages faced by an enterprise in a month, 2. whether an enterprise had women among their top managers, 3. percentage of annual sales spent on security cost, and 4. number of years of experience by the top manager of the firm in the sector. The categorical dependent variable in the multinomial logit model takes value 0 for enterprises with no access to external finance, 1 for enterprises which has access to finance only for long-term investment and equity sales, and 2 for enterprises whose access to finance extends to short-term capital needs (*i.e*., either for both long and short-term capital needs or only short-term).
Regressions control for unobserved country, year and sector effects.
Source: Authors' estimates.

Chart A.1: Surveyed Enterprise by Country: Round 1 (On or Before 2015)



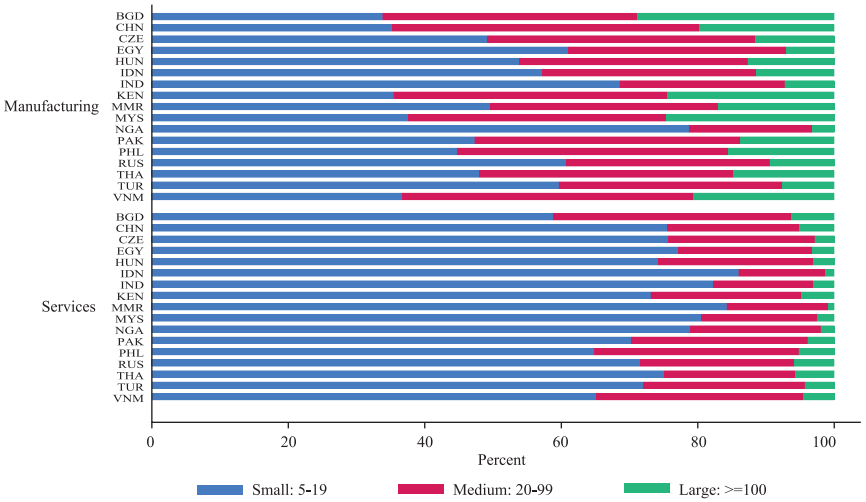
Source: World Bank Enterprise Survey.

Chart A.2: Surveyed Enterprise by Country: Round 1 (After 2015)



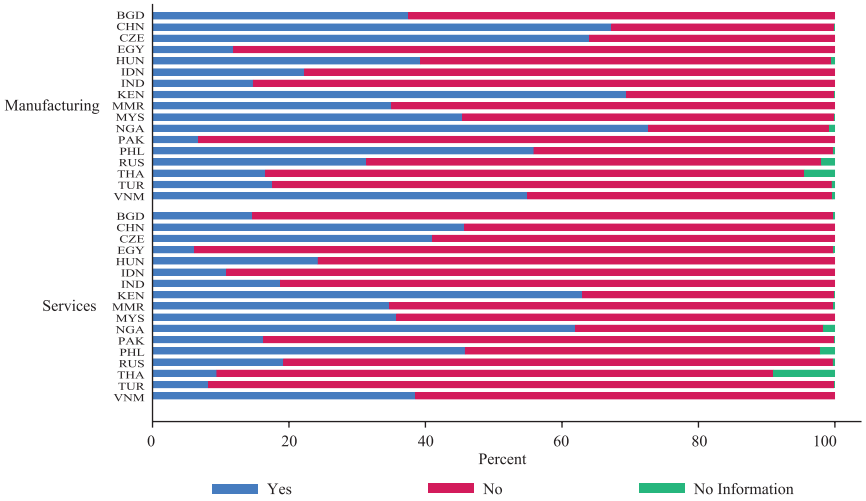
Source: World Bank Enterprise Survey.

Chart A.3: Surveyed Enterprise by Size



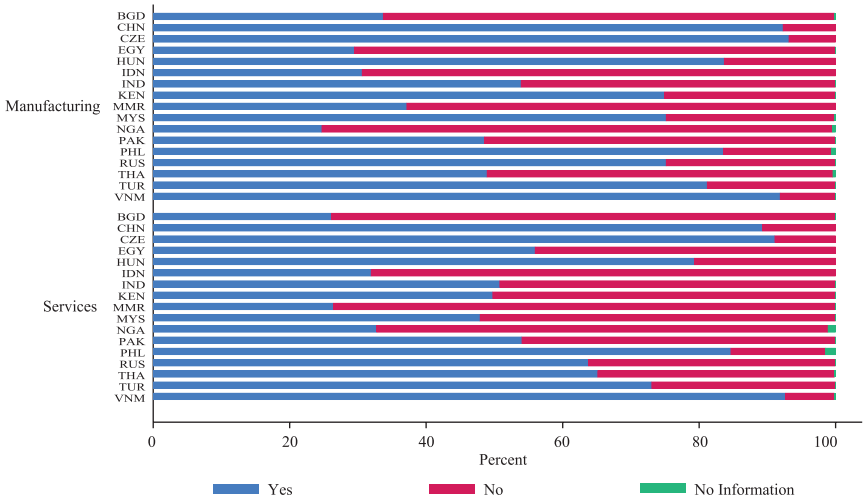
Note: World Bank Country Codes are as follows: BGD (Bangladesh), CHN (China), CZE (Czech Republic), EGY (Egypt), HUN (Hungary), IDN (Indonesia), IND (India), KEN (Kenya), MMR (Myanmar), MYS (Malaysia), NGA (Nigeria), PAK (Pakistan), PHL (Philippines), RUS (Russia), THA (Thailand), Tur (Turkey) and VNM (Vietnam). Weighted by Sample (Stratification) Weight.
Source: World Bank Enterprise Survey.

Chart A.4: Surveyed Enterprise by Status of Innovation



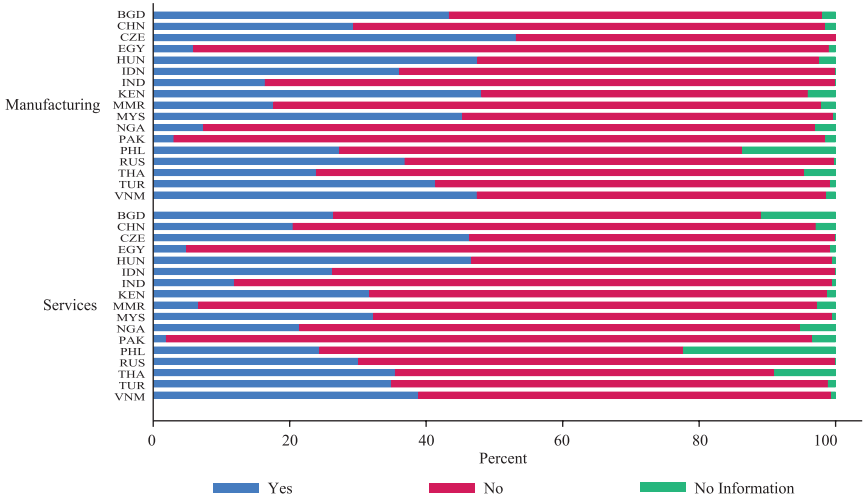
Note: World Bank Country Codes are as follows: BGD (Bangladesh), CHN (China), CZE (Czech Republic), EGY (Egypt), HUN (Hungary), IDN (Indonesia), IND (India), KEN (Kenya), MMR (Myanmar), MYS (Malaysia), NGA (Nigeria), PAK (Pakistan), PHL (Philippines), RUS (Russia), THA (Thailand), Tur (Turkey) and VNM (Vietnam). Weighted by Sample (Stratification) Weight.
Source: World Bank Enterprise Survey.

Chart A.5: Surveyed Enterprise by Status: Digital Adoption



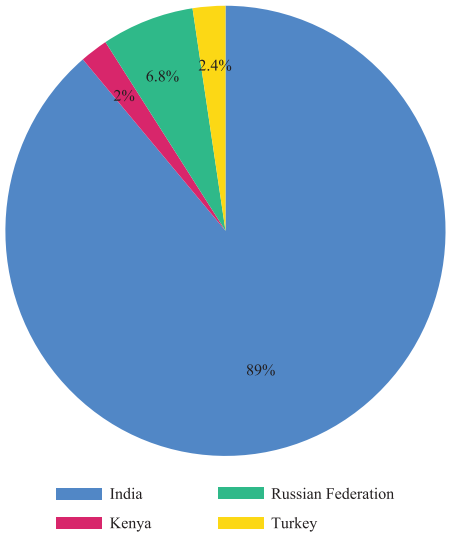
Note: World Bank Country Codes are as follows: BGD (Bangladesh), CHN (China), CZE (Czech Republic), EGY (Egypt), HUN (Hungary), IDN (Indonesia), IND (India), KEN (Kenya), MMR (Myanmar), MYS (Malaysia), NGA (Nigeria), PAK (Pakistan), PHL (Philippines), RUS (Russia), THA (Thailand), Tur (Turkey) and VNM (Vietnam). Weighted by Sample (Stratification) Weight.
Source: World Bank Enterprise Survey.

Chart A.6: Surveyed Enterprise by Status of Access to External Finance



Note: World Bank Country Codes are as follows: BGD (Bangladesh), CHN (China), CZE (Czech Republic), EGY (Egypt), HUN (Hungary), IDN (Indonesia), IND (India), KEN (Kenya), MMR (Myanmar), MYS (Malaysia), NGA (Nigeria), PAK (Pakistan), PHL (Philippines), RUS (Russia), THA (Thailand), Tur (Turkey) and VNM (Vietnam). Weighted by Sample (Stratification) Weight.
Source: World Bank Enterprise Survey.

Chart A.7: Surveyed Enterprise by Country: Difference Between Two Rounds



Source: Authors' estimates based on WBES.