

Landscape of innovation in developing Asia: Firm-level perspective

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(joint work with Mia Arao)

Background Research for the *Asian Development Outlook 2020: What Drives Innovation in Asia?*

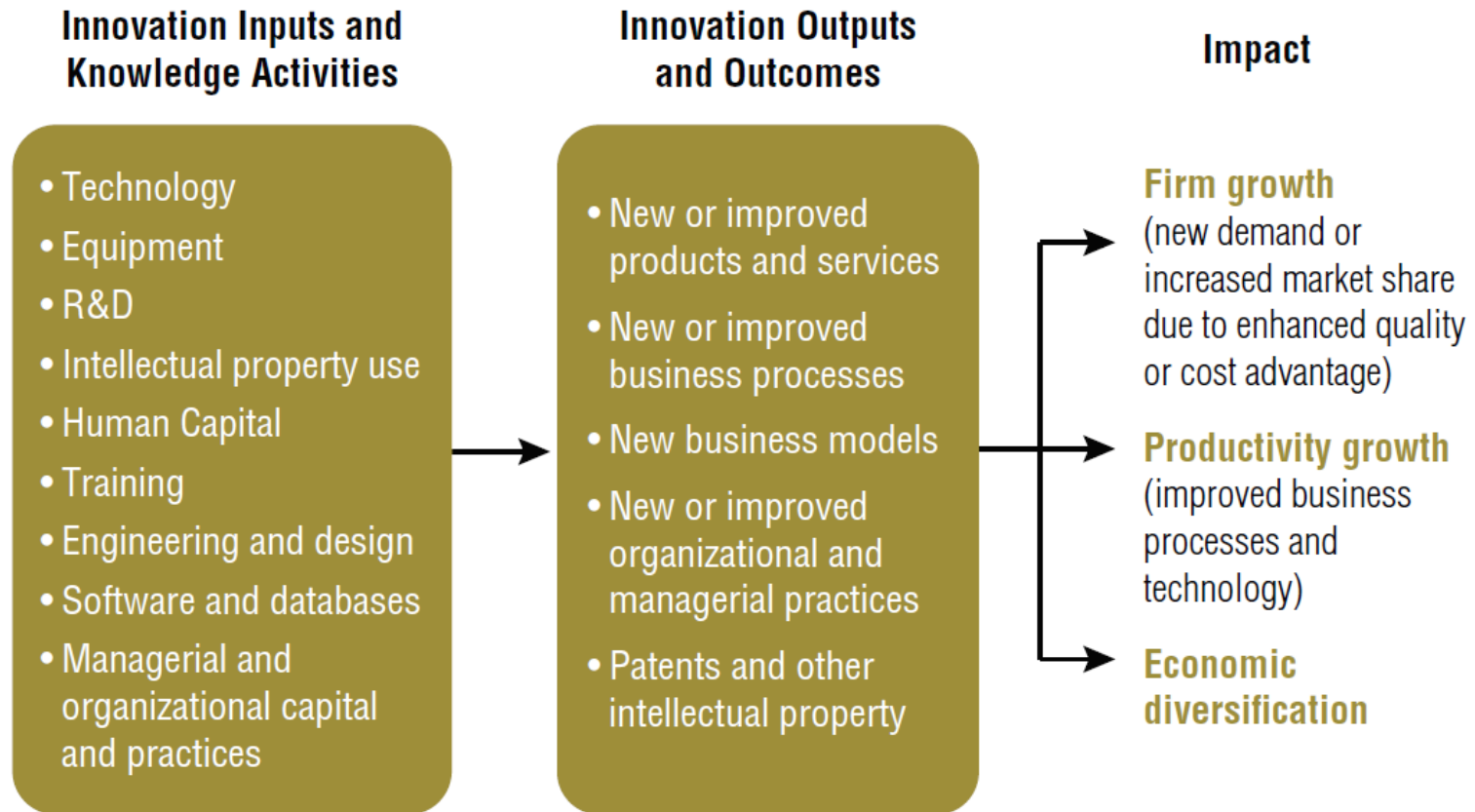
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What is innovation?

From the 2018 Oslo Manual:

- An *innovation* is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).
- First published in 1992, the Oslo Manual is the international reference guide for collecting and using data on innovation.
- Most recent edition is from 2018, which takes into account a broader range of innovation-related phenomena as well as the experience gained from recent rounds of innovation surveys in OECD countries and partner economies and organisations.

Why should we care about innovation?



Source: Cirera, Xavier, and William F. Maloney. 2017. *The Innovation Paradox: Developing-Country Capabilities and the Unrealized Promise of Technological Catch-Up*. Washington, DC:World Bank.

There are many types of innovation...



Note: Other aspects of innovation such as financing for innovation and measurement of innovation are not included in this framework.
 Source: Based on UN-IHE (UNESCO) summary of innovation studies.

...including ones focused on the poorest population

- “*Bottom of the pyramid*” innovation
 - Innovations that are directly relevant to low-income countries, and/or the poorest and most marginalized in LMIC and UMIC countries. E.g. mobile payments
- Other types – “*frugal innovation*” and “*indigenous innovation*”
- *Innovation for development* is about identifying more effective solutions that add value for the people affected by development challenges (UNDP).

Objective of the paper

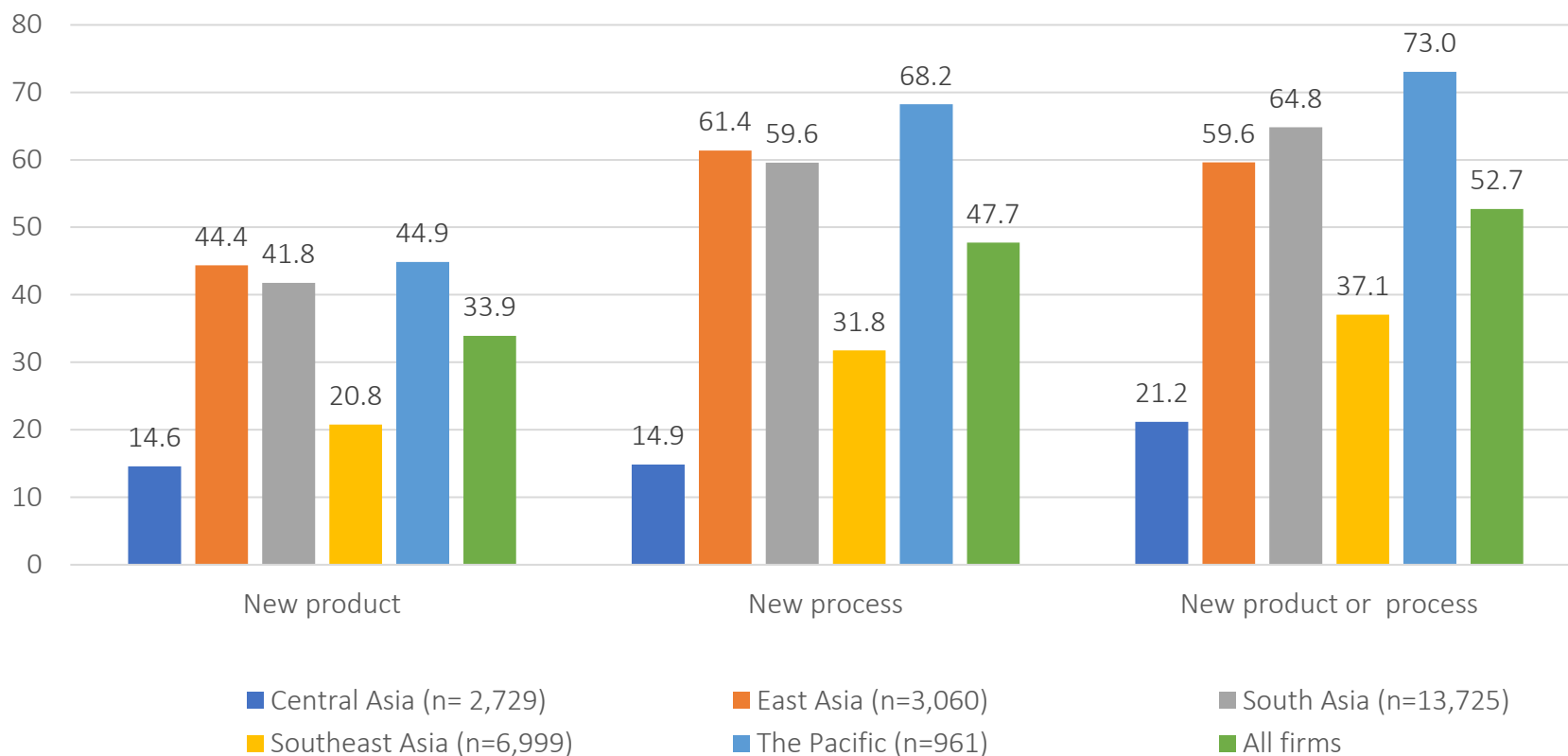
- To explain key stylized facts of innovation in Asia at the firm-level, which give us the broad contours of the current state of innovative activities in the region.
- To explore how firm's innovative behavior vary by industry and firm characteristics.
- We focus on product and/or process innovation as reported by firms.

- For each economy, we use the latest available survey year of World Bank Enterprise Survey (WBES) to analyze and describe firm behavior as it relates to innovation.
- Our final sample covers 26,855 firms from 27 countries in developing Asia.

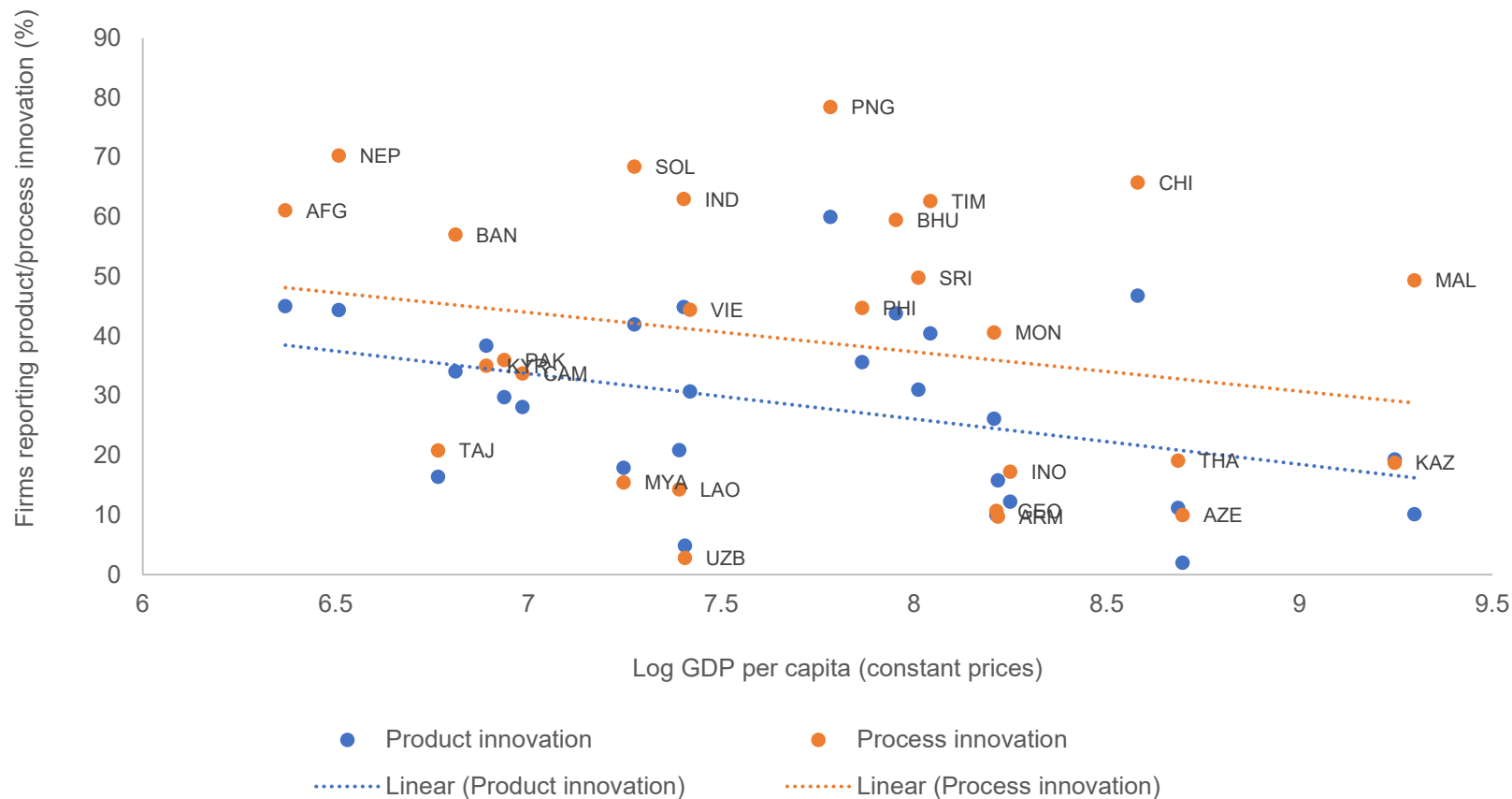
Firms in developing Asia tend to report high levels of innovation



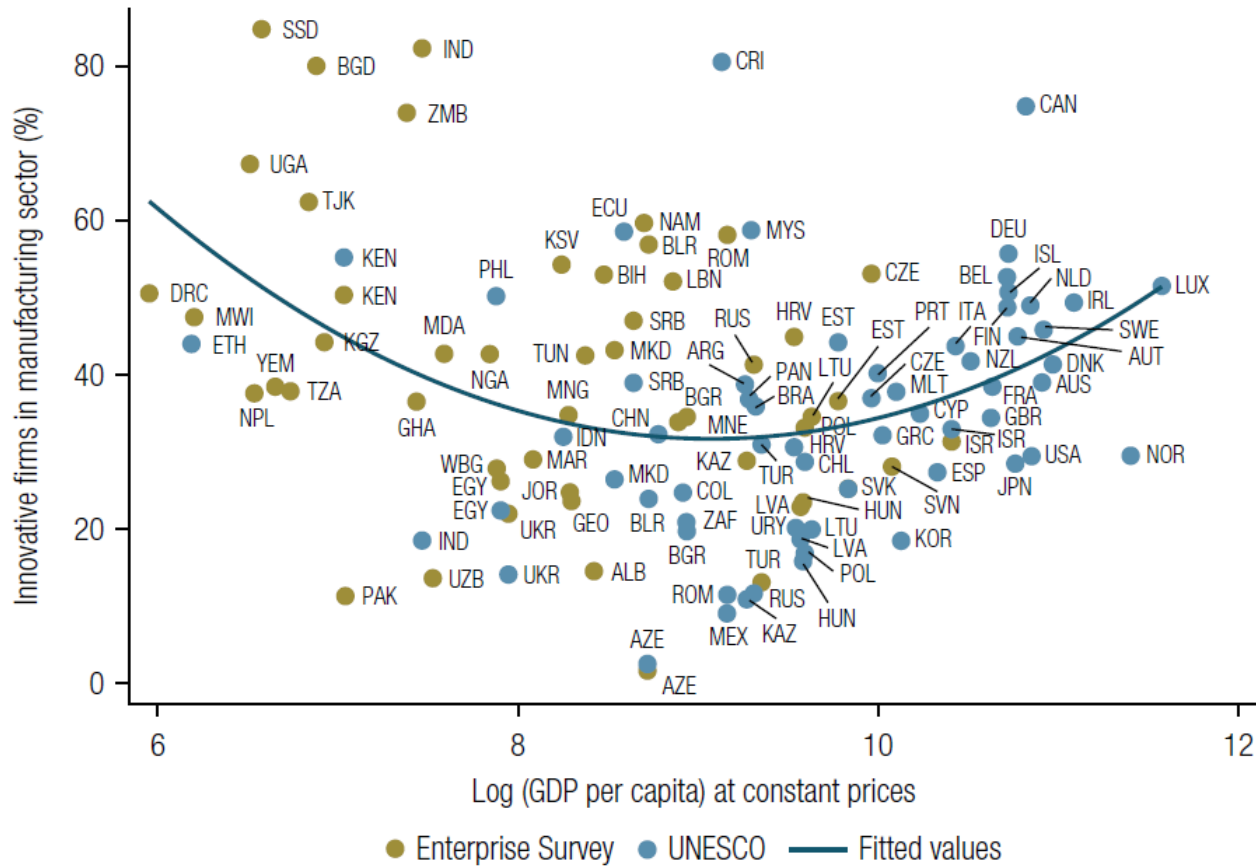
% of firms reporting a new product or process by region



Reported rates of introducing a new product or process tend to be higher in low-income countries



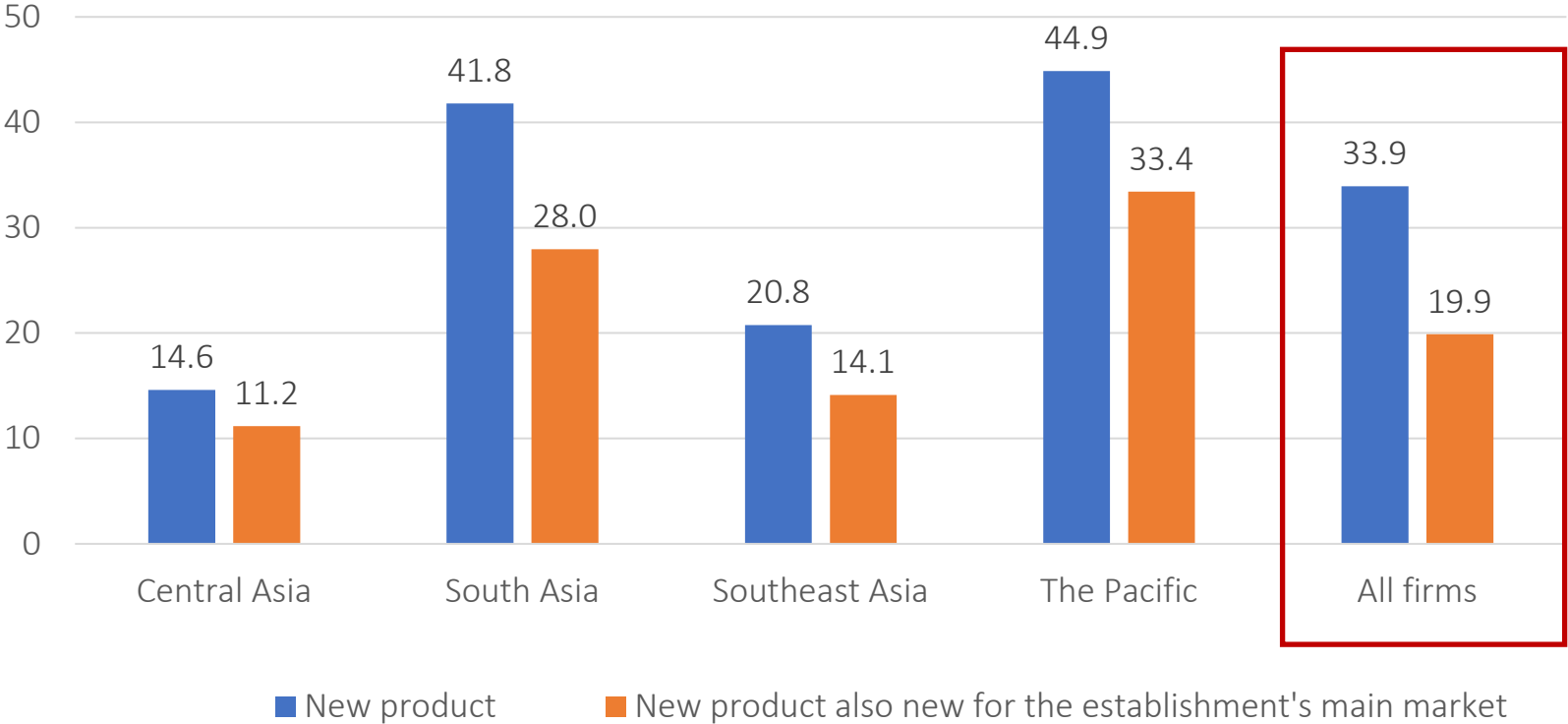
In larger sample, we see a U-Shaped relationship between innovation and GDP per capita



Source: Cirera, Xavier, and William F. Maloney. 2017. *The Innovation Paradox: Developing-Country Capabilities and the Unrealized Promise of Technological Catch-Up*. Washington, DC: World Bank.

If we consider the novelty of the product introduced to the market, reported rates fall

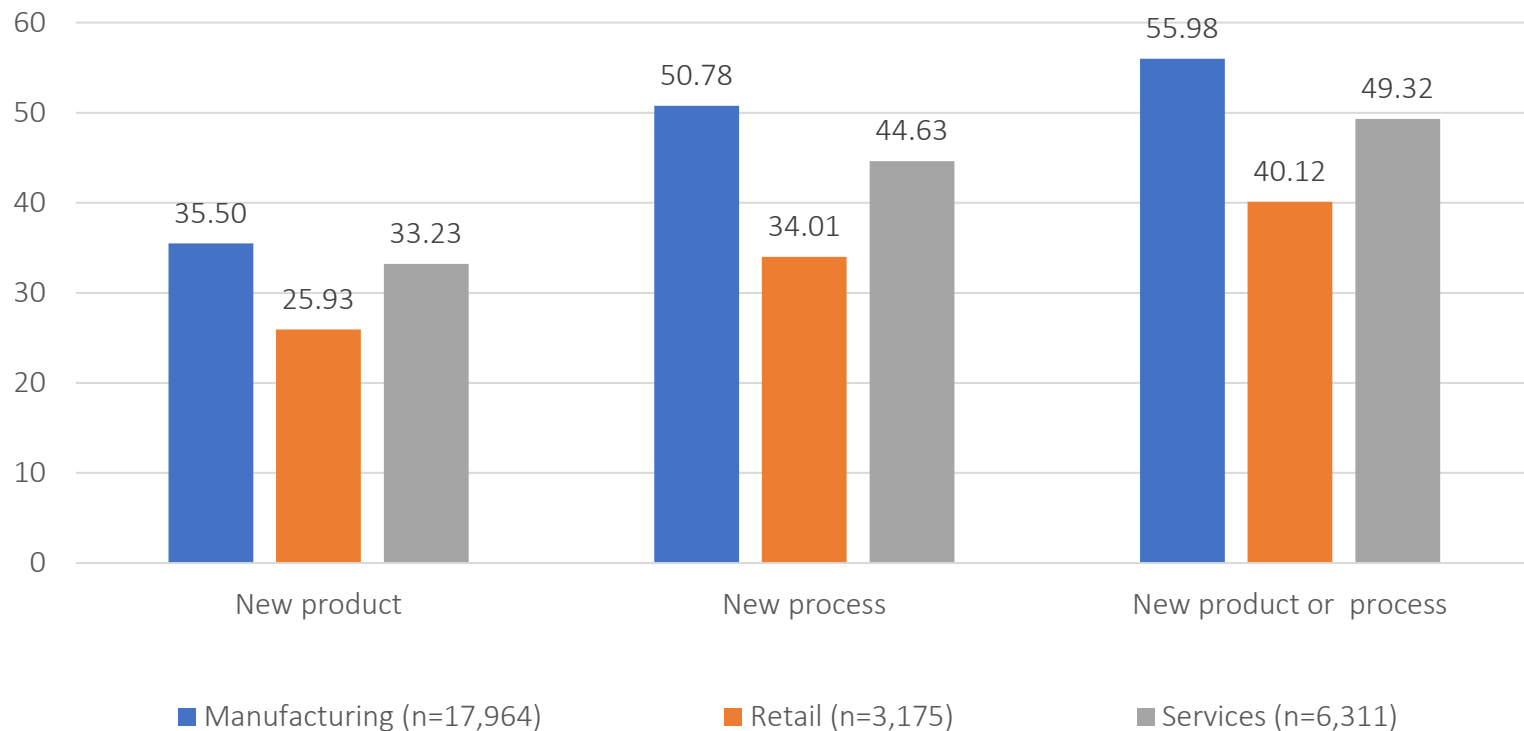
% of firms reporting a new product



*Note: *East Asia regional average includes Mongolia only. The Pacific regional average includes Papua New Guinea, Solomon Islands, and Timor-Leste only.

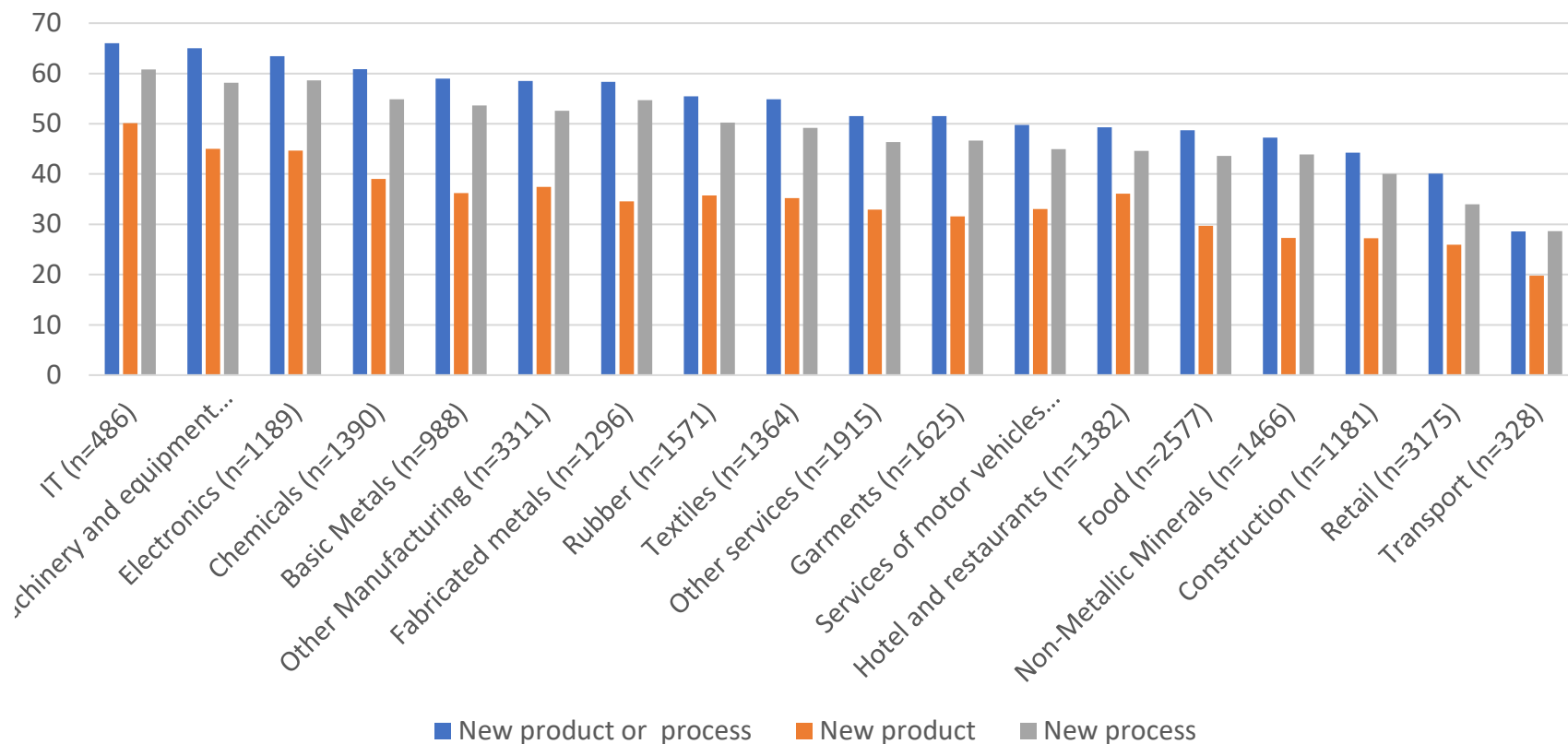
A higher percentage of firms in the manufacturing sector report introducing a new product or process

Product Innovation by sector (% of all firms)



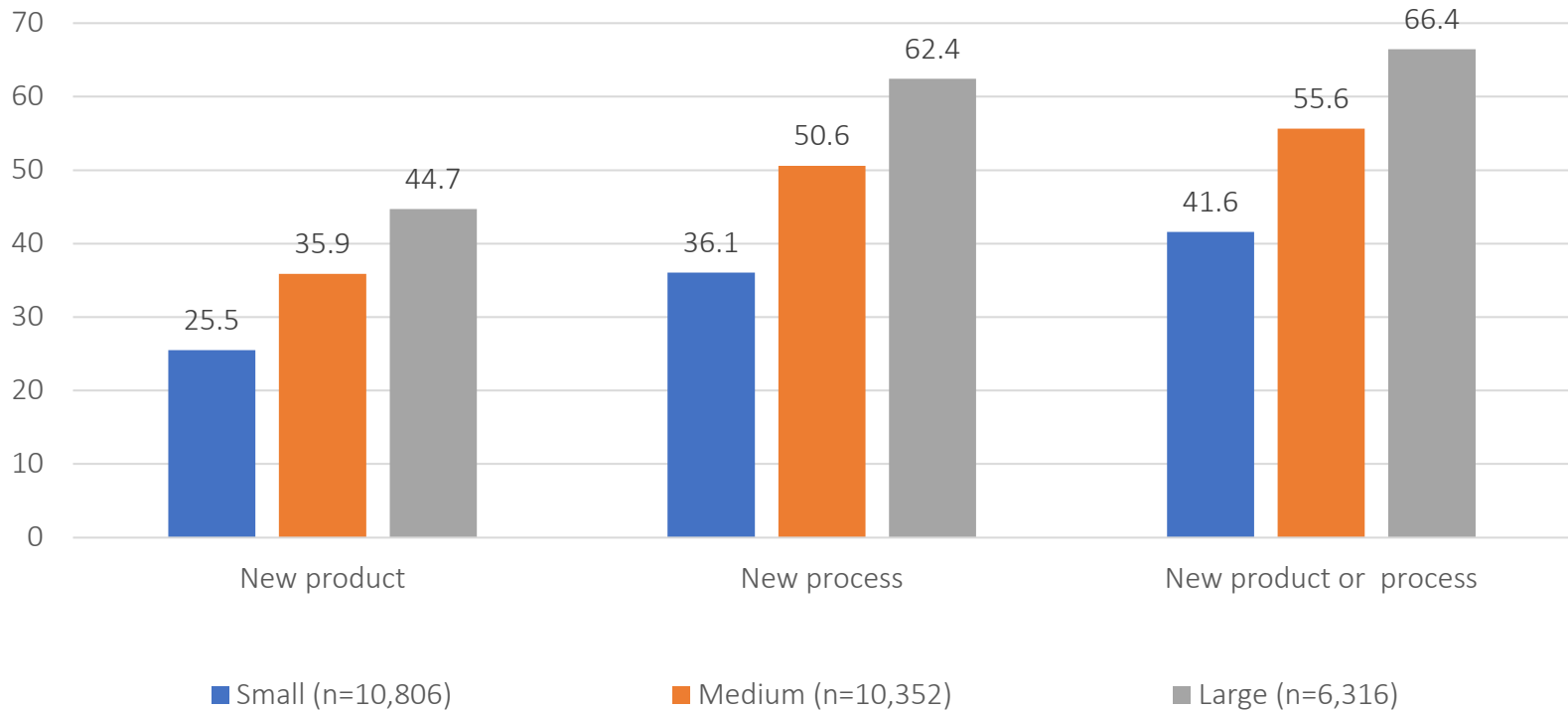
Higher percentage of firms in IT and high-tech manufacturing report introducing a new product or process

% of firms reporting a new product or process, by sub-sector



Greater share of large firm report introducing a new product or process than SMEs in developing Asia

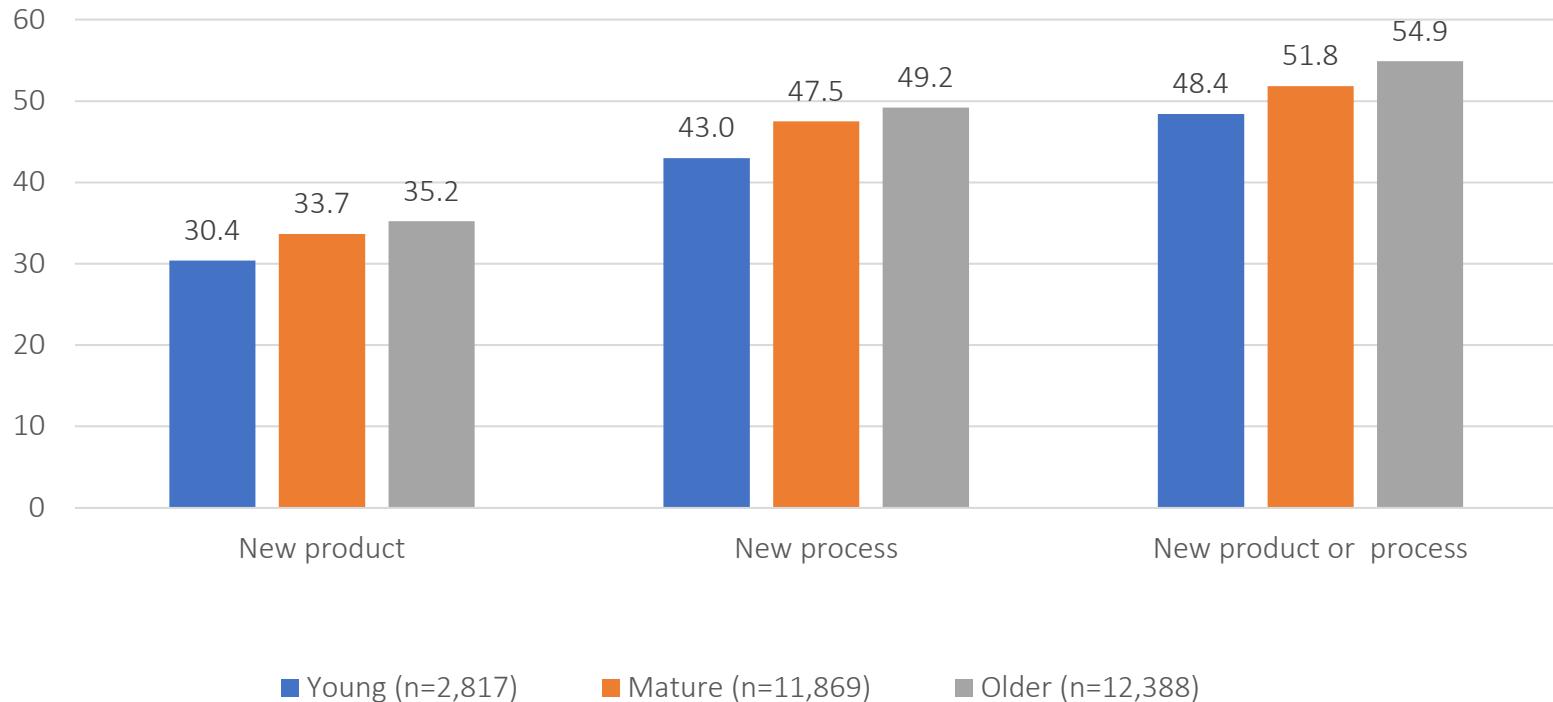
% of firms reporting a new product or process, by size



Note: Small refers to firms with <20 employees; medium firms are those with 20-99 employees; and large firms are those with 100+ employees.

Meanwhile, greater share of older firm report introducing a new product or process

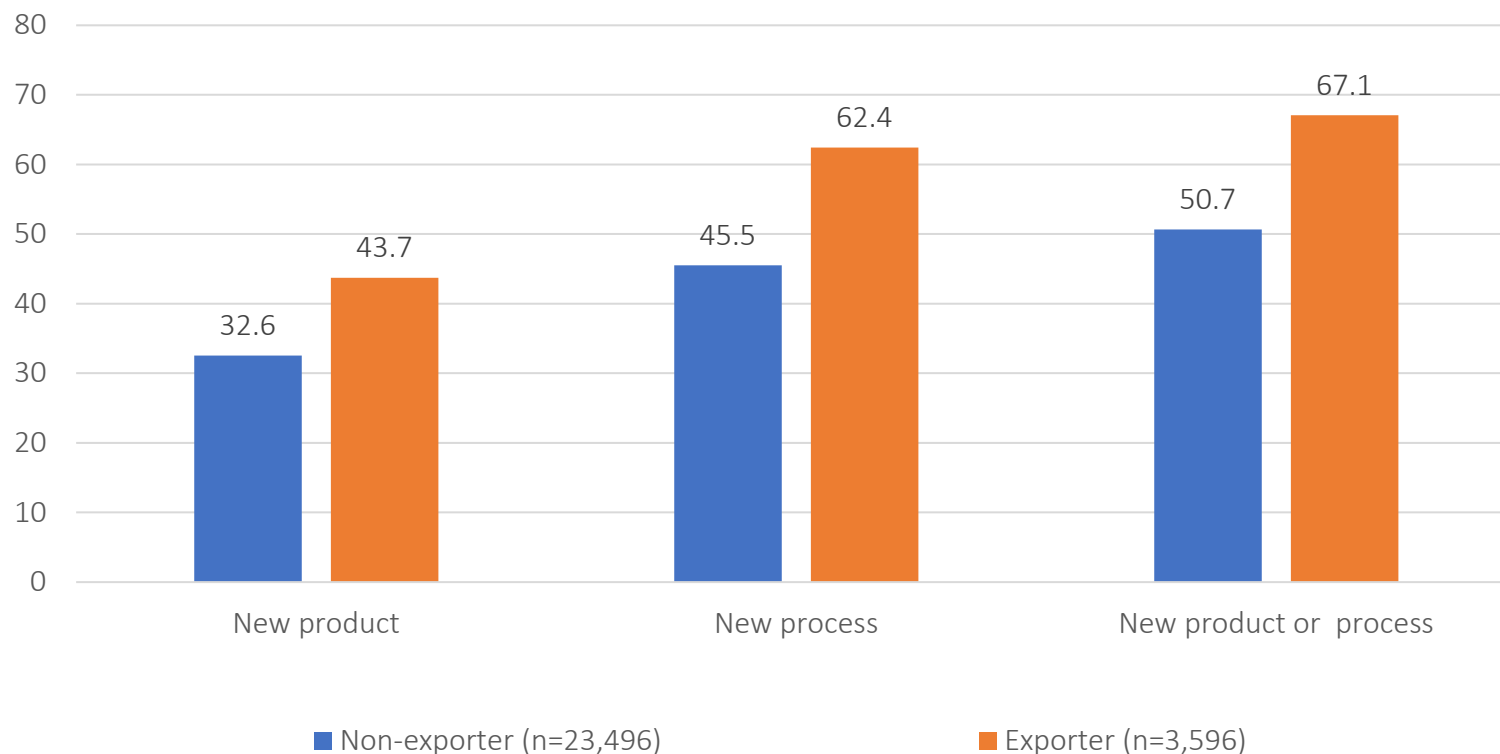
% of firms reporting a new product or process, by age



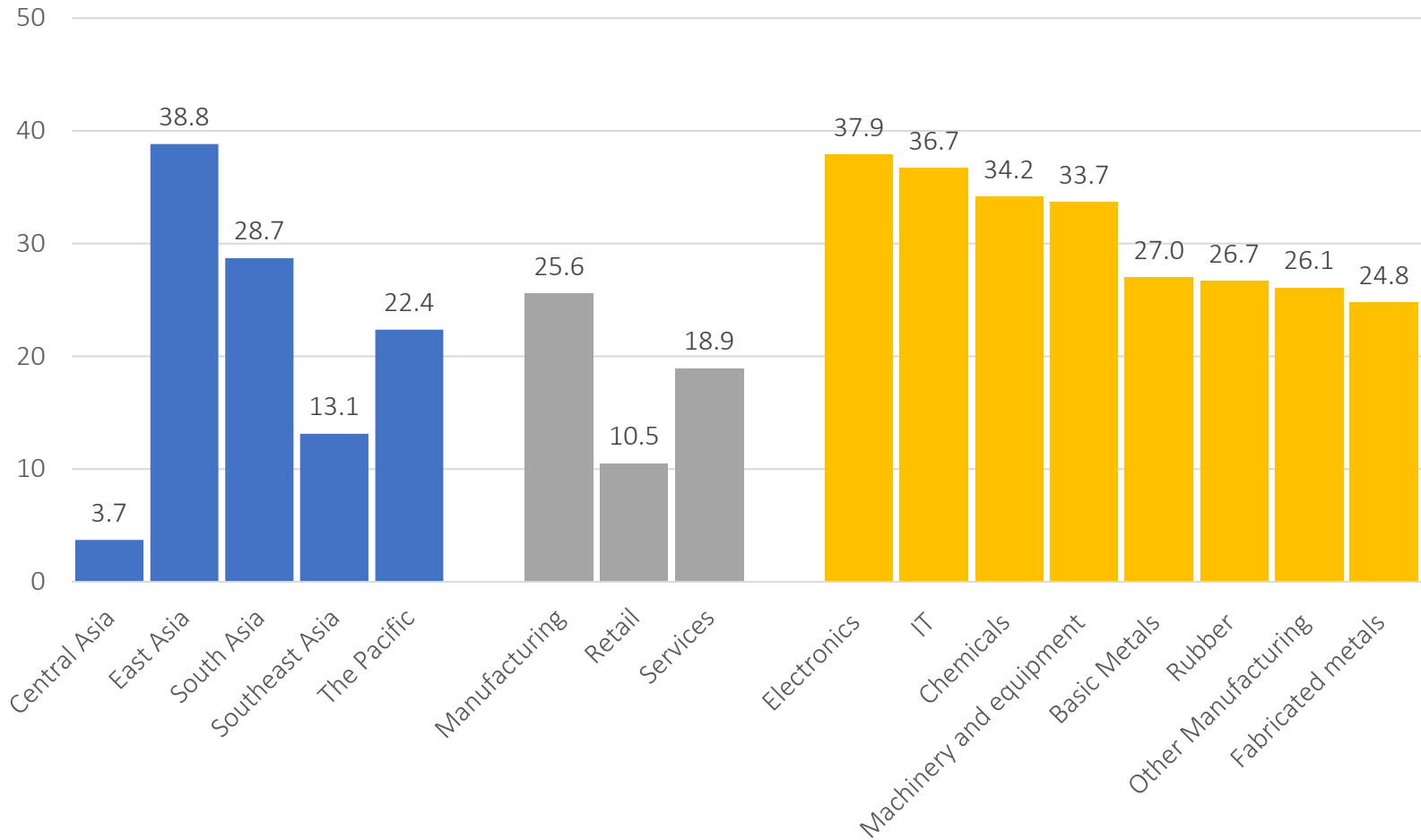
Note: Young refers to firms in operation for at least 5 years; mature firms are those in operation for 6 to 15 years; and older firms are those in business for more than 16 years.

Exporting firms tend to be more innovative

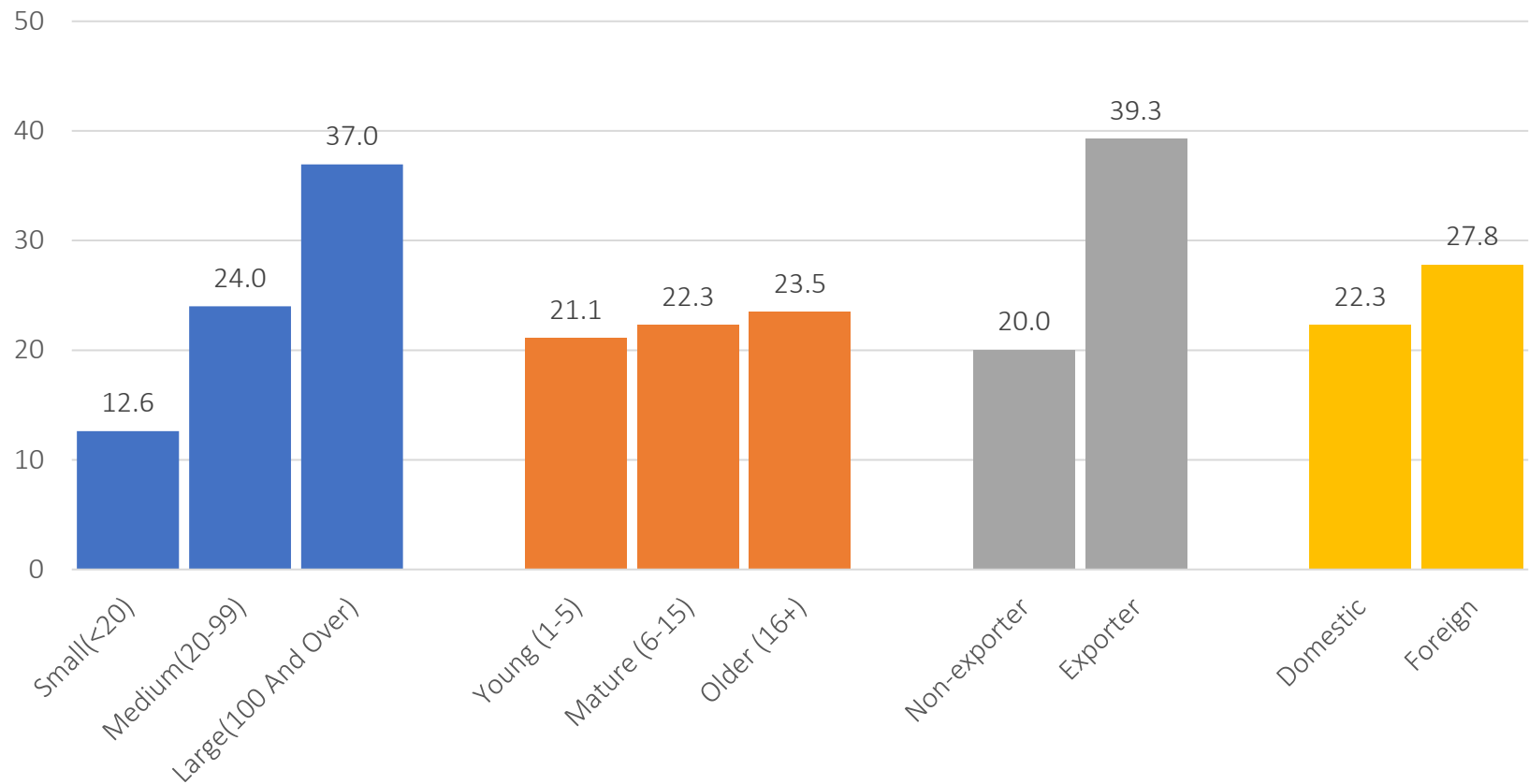
Innovation by exporting activity (% of all firms)



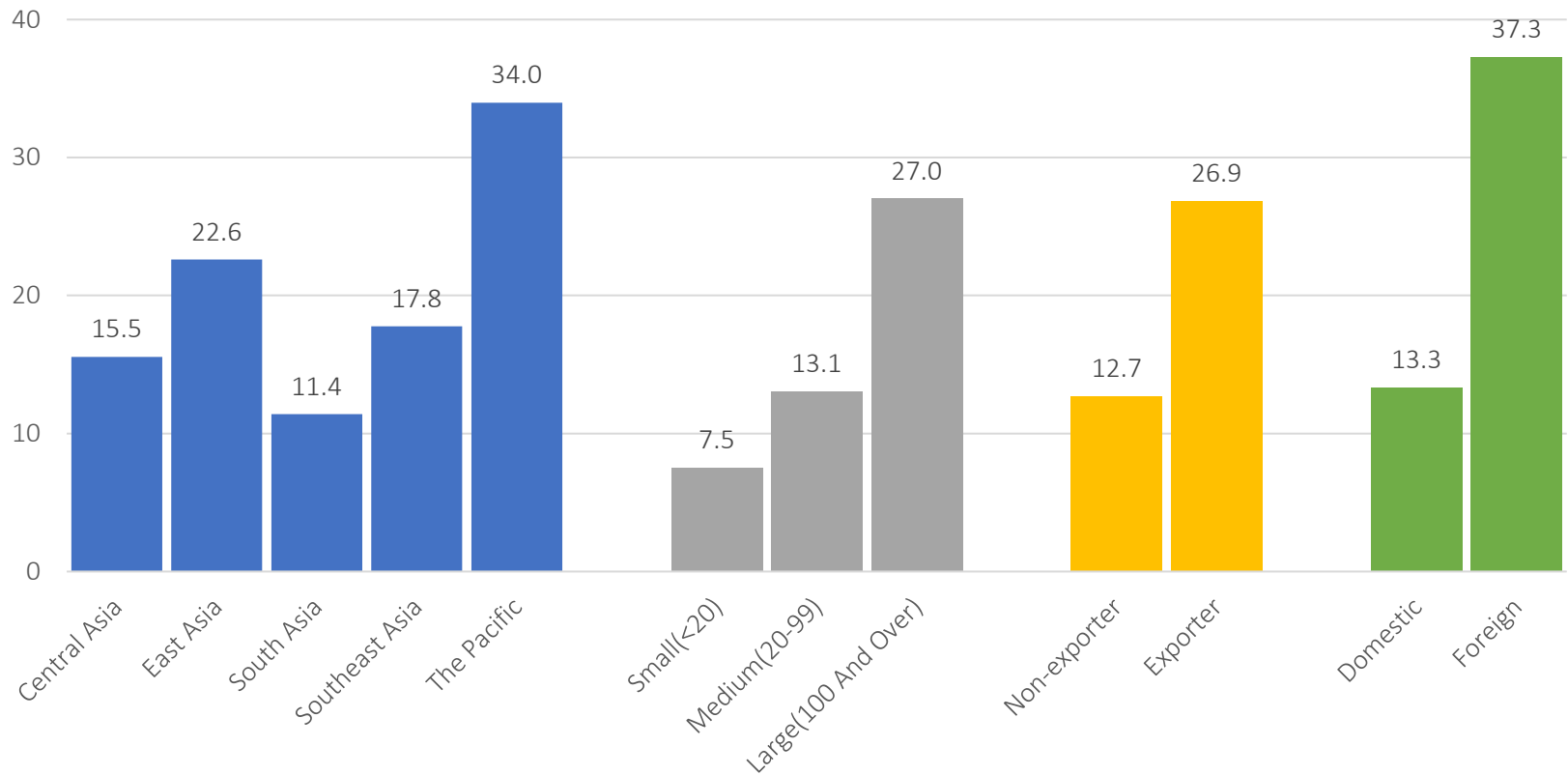
The share of firms that report **spending on R&D** is highest in East Asia and high-tech manufacturing



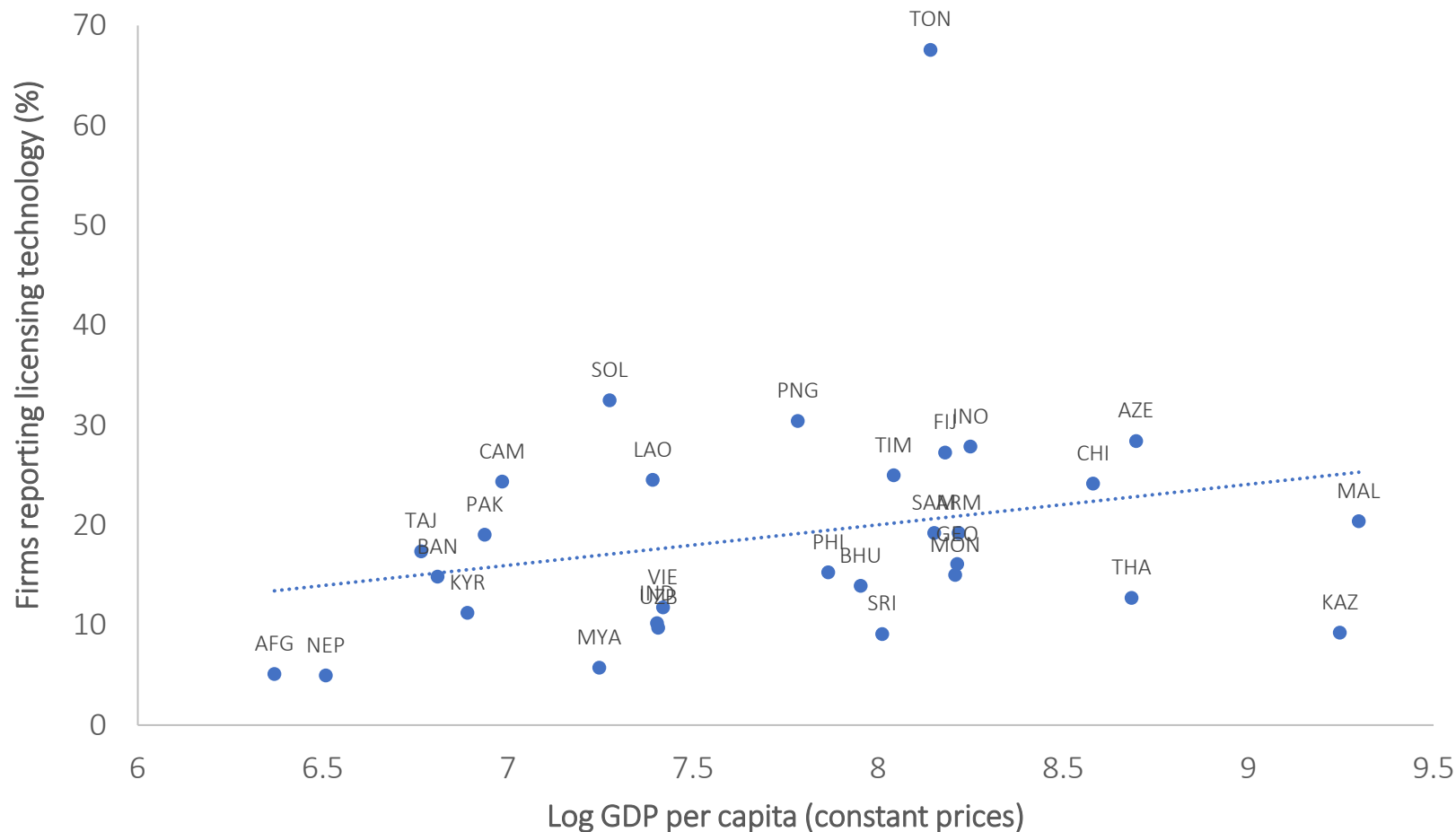
A higher proportion of large firms and exporters report **spending on R&D**



A higher share of large firms, exporters and foreign-owned firms report using technology licensed from foreign companies



Technology licensing is lower in less developed countries



Key messages

- Firm level-innovation in developing Asia is relatively high, but consists of marginal improvements to existing products
- By industry, IT and high-tech manufacturing are the most innovative
- By firm characteristics, large firms, older firms, and exporters are more innovative
- Differences in innovation rates by region and by firm characteristics present similar patterns vis-à-vis spending in R&D and licensing of technology
 - *E.g., regions with a higher share of firms reporting product/process innovation also have a higher share of firms reporting spending on R&D and a higher share of firms reporting licensing foreign technology*

Human capital and innovation at the firm-level

Research context

- Human capital (HC) is an essential part of innovation.
 - HC refers to the set of skills, knowledge, competencies, and other attributes embodied in people. HC supports the absorptive capacity of firms to new knowledge and allows firms to develop new knowledge.
- Few studies have examined how human capital drives innovation at the firm-level. Most studies focus on firm size, age, technology acquisition, R&D activities as determinants of innovation.
 - Previous studies find a robust positive association between human capital and innovation output at the firm-level (Ayyagari et al. 2011; Robson et al. 2009; Toner 2011; Dostie 2018; Van Uden et al. 2016)

Objectives

- To contribute to the literature on the role of human capital in promoting firm-level innovation in developing Asia.
- To explore how *human capital endowment* and *firm-level practices* impact the firm's propensity to engage in innovation.

Empirical specification

- We use data from WBES covering 27 countries from developing Asia
- Our final sample includes 26,855 firms from manufacturing, retail and services sector
- To analyze the role of human capital on firm-level innovation, we first estimate the likelihood of the firm being innovative, controlling for broad firm characteristics as follows:

$$\text{Innovate}_{ijc} = FC_{ijc} + I_j + I_c + \epsilon_{ijc} \quad (1)$$

Empirical specification (2)

- We then introduce measures of human capital (HC_{ijc}) into the regression to examine how this will impact the firm's innovative activities.

$$Innovate_{ijc} = FC_{ijc} + HC_{ijc} + I_j + I_c + \epsilon_{ijc} \quad (2)$$

- Again, we estimate eq. (2) using maximum likelihood (Probit).

1) Share of employees that completed high school

- proxy for the stock of generic skills and basic knowledge available within the firm.
- *H1: The higher the share of employees who completed at least high school education, the higher the probability of engaging in innovation activities.*

2) Number of years of experience of the top manager

- captures the role more senior, more experienced people have on innovative output.
- *H2: Industry-specific experience of the top-manager positively affects the firm's decision to innovate.*

3) Providing formal training to employees

- considers how firm-level practices that increase or develop the level of human capital impact innovation
- *H3: A firm that provides training to its employees has a higher likelihood of engaging in innovation compared to firms that do not provide formal training.*

Empirical specification (3)

$$\text{Innovate}_{ijc} = FC_{ijc} + HC_{ijc} + \text{training\#skills}_{\text{constraint}} + \text{training\#educ} + I_j + I_c + \epsilon_{ijc}$$

- *training#skills_constraint*
 - captures how formal training can differentially impact firms facing constraints related to skills of the workforce
 - *H4: The impact of training is higher for firms facing constraints to doing business due to an inadequately educated workforce.*
- *training#educ*
 - captures whether the positive effects on innovation of having more educated workforce differ for firms that provide training vs those that do not
 - *H5: The combination of employee schooling and formal training leads to a higher propensity to innovate.*

Summary stats (selected variables)

Variable	Definition	Obs	Mean	Std. Dev.	Min	Max
Dependent variable: Innovation						
Innovation	Dummy variable equal to 1 if the firm introduced <u>either</u> a new product or process in the three years before the survey; zero otherwise.	26,736	0.527	0.499	0	1
Product Innovation	Dummy variable equal to 1 if the firm introduced new or significantly improved products or services in the last three years; zero otherwise.	26,640	0.339	0.473	0	1
Process Innovation	Dummy variable equal to 1 if the firm introduced new or significantly improved process in the last three years; zero otherwise.	25,395	0.477	0.499	0	1
Independent variables: Human capital						
Workforce with High School Education (%)	Percentage of the full-time workers who completed high school; zero otherwise.	22,847	56.549	35.369	0	100
Training	Dummy variable equal to 1 if the firm provides internal or external training to its workers; zero otherwise.	26,667	0.398	0.490	0	1
Manager experience	Natural logarithm of the number of years of experience of the top manager working in the sector.	26,750	2.507	0.737	0	4.263
Control variables						
R&D	Dummy variable equal to 1 if the firm has design and R&D expenditures (e.g., labor costs with R&D personnel, materials or subcontracting costs); zero otherwise.	25,567	0.226	0.418	0	1

Probit regression results

VARIABLES	Either Product or Process Innovation				Product Innovation				Process Innovation			
	Model (1)	Model (2)	Model (3)	Model (4)	Model (1)	Model (2)	Model (3)	Model (4)	Model (1)	Model (2)	Model (3)	Model (4)
Medium (default: small)	0.234*** (0)	0.213*** (0)	0.211*** (0)	0.213*** (0)	0.179*** (3.87e-10)	0.149*** (8.61e-07)	0.149*** (6.85e-07)	0.149*** (8.18e-07)	0.239*** (0)	0.226*** (0)	0.224*** (0)	0.226*** (0)
Large (100+)	0.437*** (0)	0.353*** (0)	0.353*** (0)	0.353*** (0)	0.318*** (0)	0.238*** (7.41e-08)	0.237*** (1.23e-07)	0.238*** (7.85e-08)	0.453*** (0)	0.376*** (0)	0.375*** (0)	0.376*** (0)
Mature (default: young)	0.0591* (0.0939)	0.0502 (0.228)	0.0524 (0.213)	0.0498 (0.232)	0.0734** (0.0220)	0.0781** (0.0342)	0.0806** (0.0316)	0.0776** (0.0357)	0.0763** (0.0420)	0.0557 (0.182)	0.0560 (0.184)	0.0553 (0.185)
Older	0.0859** (0.0169)	0.0613 (0.120)	0.0593 (0.131)	0.0610 (0.122)	0.118*** (0.00366)	0.104** (0.0159)	0.104** (0.0165)	0.104** (0.0161)	0.0616 (0.127)	0.0280 (0.504)	0.0251 (0.549)	0.0277 (0.508)
Foreign-Owned	0.00999 (0.845)	-0.0491 (0.380)	-0.0488 (0.387)	-0.0515 (0.355)	0.0828 (0.104)	0.0490 (0.384)	0.0524 (0.352)	0.0476 (0.398)	-0.0266 (0.597)	-0.0516 (0.345)	-0.0506 (0.357)	-0.0533 (0.328)
Exporter	0.107*** (0.00397)	0.101** (0.0132)	0.0978** (0.0163)	0.101** (0.0131)	0.0543 (0.105)	0.0278 (0.441)	0.0265 (0.466)	0.0284 (0.429)	0.0958*** (0.00498)	0.0948*** (0.00823)	0.0908** (0.0111)	0.0951*** (0.00812)
R&D	1.353*** (0)	1.284*** (0)	1.284*** (0)	1.283*** (0)	1.039*** (0)	0.979*** (0)	0.977*** (0)	0.979*** (0)	1.282*** (0)	1.199*** (0)	1.201*** (0)	1.198*** (0)
Workforce with High School Education (%)		0.00140** (0.0297)	0.00135** (0.0356)	0.00113 (0.113)		0.00136** (0.0127)	0.00137** (0.0125)	0.00109* (0.0952)		0.000958 (0.136)	0.000942 (0.145)	0.000740 (0.300)
Training		0.244*** (1.59e-10)	0.214*** (4.35e-07)	0.198*** (0.00104)		0.235*** (0)	0.201*** (4.81e-09)	0.197*** (0.00219)		0.244*** (3.01e-09)	0.233*** (1.54e-07)	0.209*** (0.000754)
Manager experience		0.0390** (0.0268)	0.0382** (0.0339)	0.0395** (0.0248)		0.0471*** (0.00618)	0.0468*** (0.00712)	0.0477*** (0.00569)		0.0275 (0.162)	0.0269 (0.179)	0.0279 (0.154)
Skills constraint			0.0588 (0.244)				-0.0654 (0.322)				0.0844* (0.0774)	
Training#SkillsConstraint			0.199** (0.0139)				0.235*** (0.00216)				0.0397 (0.640)	
Training#HSeducation				0.000803 (0.323)				0.000669 (0.449)				0.000616 (0.449)
Constant	0.173 (0.152)	-0.0331 (0.792)	-0.0843 (0.481)	-0.0191 (0.881)	-0.345*** (0.000647)	-0.575*** (3.55e-06)	-0.580*** (2.45e-06)	-0.561*** (1.13e-05)	-0.0469 (0.738)	-0.216 (0.186)	-0.256 (0.109)	-0.204 (0.214)
Observations	24,952	20,714	20,610	20,714	24,883	20,670	20,567	20,670	24,700	20,532	20,428	20,532

Source: Authors' calculations based on data from the World Bank Enterprise Surveys.

Notes: (i) The table reports coefficients from Probit regressions. (ii) Robust p-values in parentheses. Standard errors are clustered by industry and country. (iii) * significant at 10%, ** significant at 5%, *** significant at 1%.

Probit regression results: Marginal effects

VARIABLES	Either Product or Process Innovation				Product Innovation				Process Innovation			
	Model (1)	Model (2)	Model (3)	Model (4)	Model (1)	Model (2)	Model (3)	Model (4)	Model (1)	Model (2)	Model (3)	Model (4)
Medium (default: small)	0.0718*** (0)	0.0658*** (0)	0.0653*** (0)	0.0659*** (0)	0.0529*** (5.36e-10)	0.0459*** (1.11e-06)	0.0460*** (8.81e-07)	0.0460*** (1.06e-06)	0.0725*** (0)	0.0711*** (0)	0.0705*** (0)	0.0712*** (0)
Large (100+)	0.133*** (0)	0.108*** (0)	0.108*** (0)	0.108*** (0)	0.0965*** (0)	0.0744*** (1.18e-07)	0.0742*** (1.96e-07)	0.0744*** (1.25e-07)	0.138*** (0)	0.118*** (0)	0.118*** (0)	0.118*** (0)
Mature (default: young)	0.0177* (0.0944)	0.0152 (0.229)	0.0159 (0.215)	0.0151 (0.234)	0.0214** (0.0211)	0.0238** (0.0332)	0.0245** (0.0307)	0.0236** (0.0347)	0.0227** (0.0421)	0.0172 (0.183)	0.0173 (0.185)	0.0170 (0.186)
Older	0.0257** (0.0172)	0.0186 (0.121)	0.0180 (0.132)	0.0185 (0.124)	0.0348*** (0.00324)	0.0318** (0.0145)	0.0317** (0.0151)	0.0317** (0.0148)	0.0183 (0.127)	0.00862 (0.505)	0.00775 (0.550)	0.00855 (0.509)
Foreign-Owned	0.00299 (0.845)	-0.0149 (0.380)	-0.0148 (0.387)	-0.0156 (0.356)	0.0249 (0.108)	0.0152 (0.387)	0.0163 (0.355)	0.0148 (0.401)	-0.00792 (0.596)	-0.0159 (0.344)	-0.0156 (0.356)	-0.0164 (0.328)
Exporter	0.0322*** (0.00403)	0.0304** (0.0130)	0.0295** (0.0161)	0.0305** (0.0130)	0.0163 (0.108)	0.00862 (0.443)	0.00821 (0.468)	0.00881 (0.431)	0.0287*** (0.00521)	0.0293*** (0.00830)	0.0280** (0.0112)	0.0294*** (0.00819)
R&D	0.408*** (0)	0.380*** (0)	0.380*** (0)	0.380*** (0)	0.363*** (0)	0.348*** (0)	0.348*** (0)	0.348*** (0)	0.410*** (0)	0.384*** (0)	0.385*** (0)	0.384*** (0)
Workforce with High School Education (%)		0.000424** (0.0299)	0.000410** (0.0357)	0.000427** (0.0279)		0.000421** (0.0121)	0.000424** (0.0119)	0.000427** (0.0108)		0.000295 (0.137)	0.000290 (0.146)	0.000298 (0.131)
Training		0.0749*** (1.62e-10)	0.0729*** (9.73e-10)	0.0742*** (1.58e-10)		0.0747*** (0)	0.0728*** (0)	0.0742*** (0)		0.0767*** (3.42e-09)	0.0747*** (1.18e-08)	0.0761*** (3.36e-09)
Manager experience		0.0118** (0.0266)	0.0116** (0.0337)	0.0120** (0.0246)		0.0146*** (0.00592)	0.0145*** (0.00679)	0.0147*** (0.00544)		0.00847 (0.160)	0.00830 (0.178)	0.00860 (0.153)
Skills constraint			0.0377*** (0.00496)			0.0110 (0.435)				0.0304** (0.0421)		
Observations	24,952	20,714	20,610	20,714	24,883	20,670	20,567	20,670	24,700	20,532	20,428	20,532

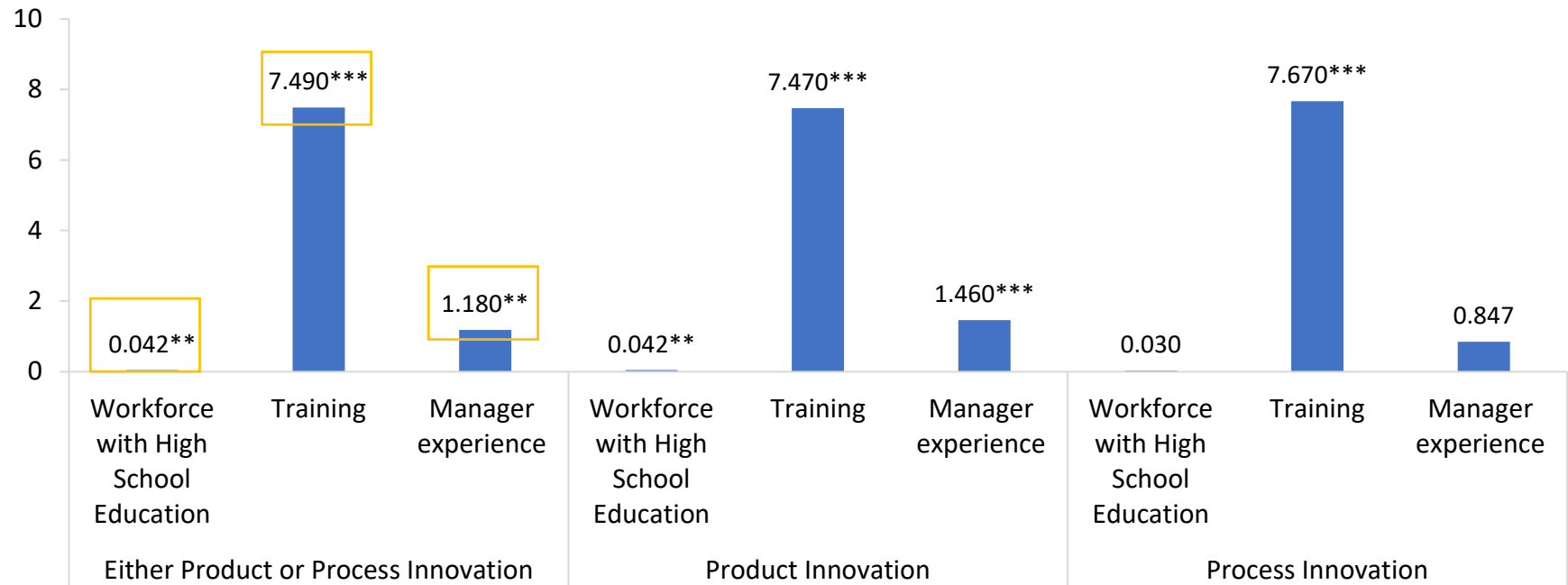
Source: Authors' calculations based on data from the World Bank Enterprise Surveys.

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Effect of human capital on innovation: Positive and significant

Probit regression results: Marginal effects

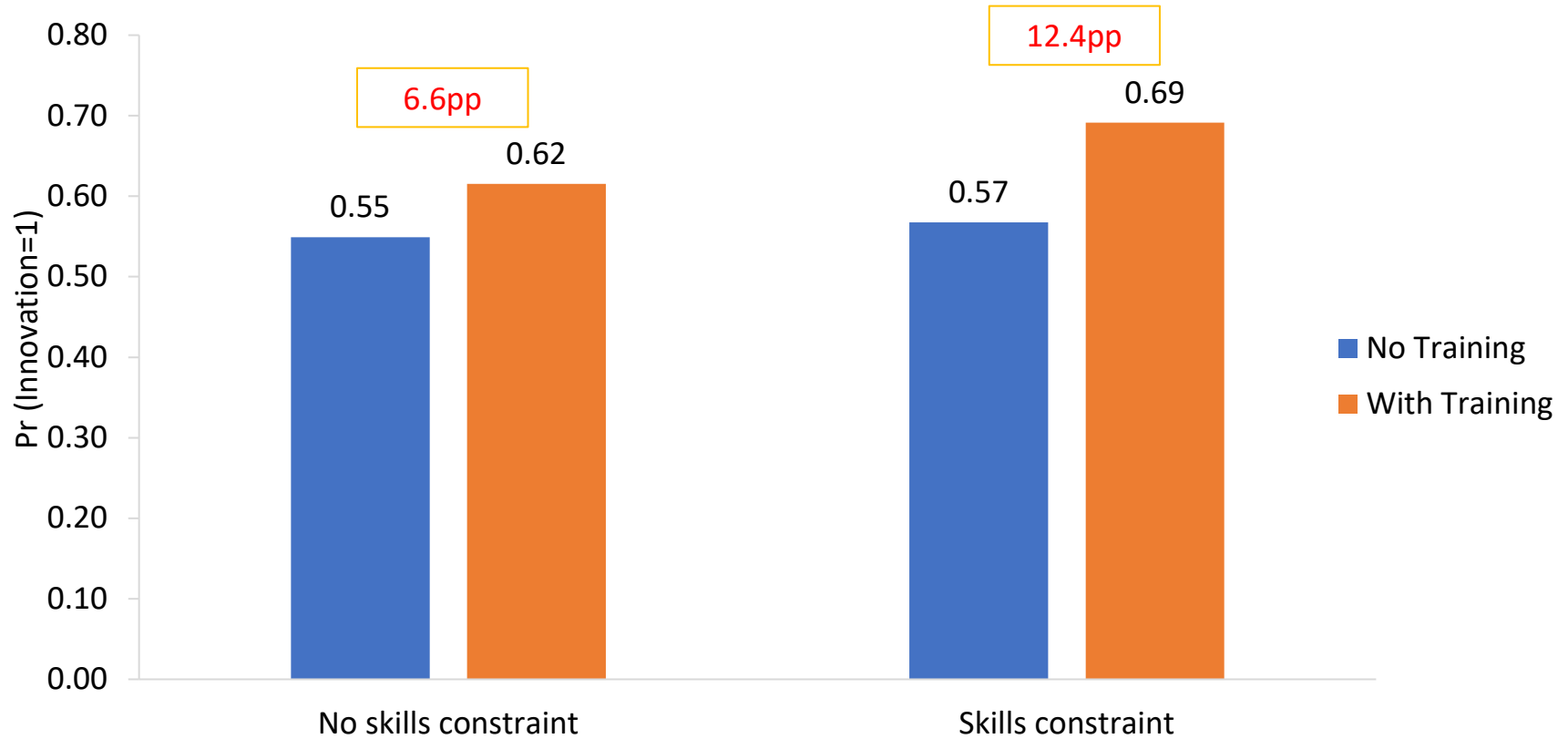
(in percentage points)



Source: Authors' calculations based on data from the World Bank Enterprise Surveys.

Notes: (i) This graph reports average marginal effects on the firm's probability to innovate from Probit regressions. (ii) significant at 10%, ** significant at 5%, *** significant at 1%.

Effect of training is higher, especially for firms who report facing constraints related to the skills and education of the workforce



Source: Authors' calculations based on data from the World Bank Enterprise Surveys.
 Note: * significant at 10%, ** significant at 5%, *** significant at 1%.

Limitations

- For each economy, we only use a single year of data. Thus, we cannot go beyond establishing an association between human capital and firm-level innovation.
- Subjective nature of the innovation data which could overestimate innovation rates.
- Our data only covers formal firms and a significant proportion of firms in developing Asia are informal.
- Measures of human capital used here is limited by data availability.

Key messages

- Results show that the firm's human capital—*measured by the percentage of the workforce with high school education, incidence of on-the-job training, and managerial experience*—positively influences the firm's likelihood to engage in innovation.
- Overall, **we find that providing training to employees has a more significant effect size compared to other measures of human capital, especially for firms facing constraints to their operations due to inadequately skilled workers.**