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Assessing Innovation Patterns and Constraints in Developing East Asia

An Introductory Analysis

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Abstract

This paper sheds light on key innovation patterns and constraints within a selected set of developing East Asian countries (Cambodia, China, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Thailand, and Vietnam). It follows a comprehensive approach about national innovation systems while highlighting the supply and demand dimensions of innovation as well as the markets where firms make accumulation decisions for different forms of capital (knowledge capital, human capital. and physical capital). The paper presents a set of empirical exercises drawing from various data sets. The results corroborate the idea of the importance of adopting a broad view of innovation policy and investing in missing complementary factors. Although investment in research and development is key to boost innovation, it is also crucial to have business and regulatory environments that are conducive to overall firm performance and capital accumulation (not only knowledge capital), as they are expected to improve innovation returns. In addition, the results suggest that other innovation inputs aside from research and development matter for innovation activities, such as training for innovative activities, acquisition/licensing of technology, and managerial practices.

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Produced by the Research Support Team

Assessing Innovation Patterns and Constraints in Developing East Asia: An Introductory Analysis

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Keywords: innovation, national innovation systems, business environment, managerial practices
JEL codes: O31, O32, O35

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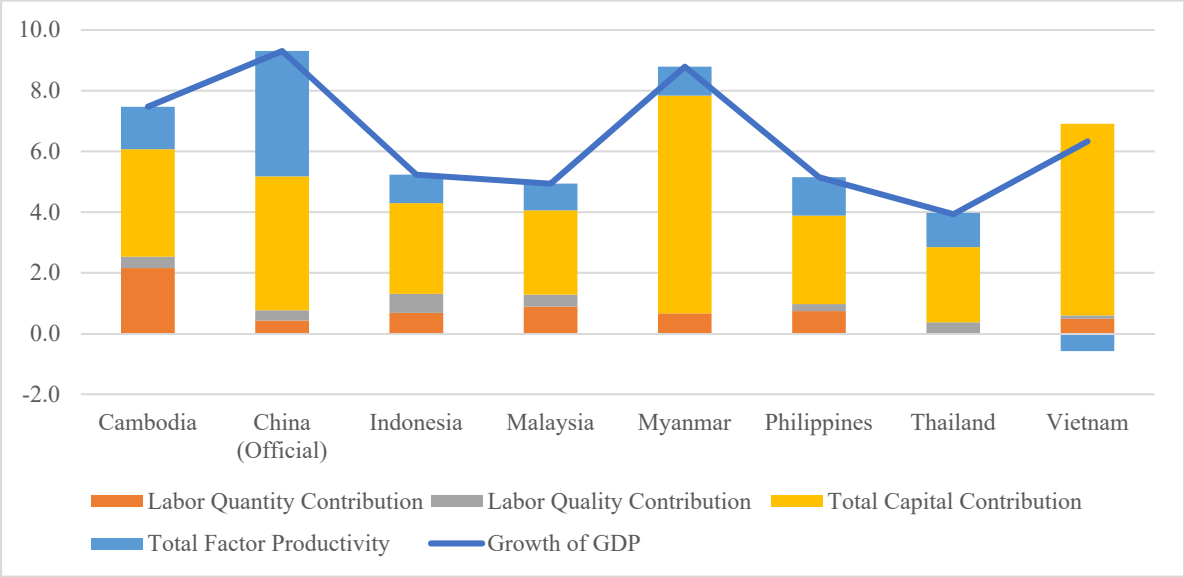
1. Introduction

Developing East Asia – here defined as the following set of countries: Cambodia, China, Indonesia, Lao People's Democratic Republic, Malaysia, Mongolia, Myanmar, the Philippines, Thailand and Vietnam – has been experiencing a consistent and steady pattern of economic growth in the past two decades. This successful performance can be attributed to a broad set of policies that can be grouped in three key pillars: outward orientation, investment in basic human capital and sound economic governance (Mason and Shetty, 2018). From a GDP growth accounting perspective, data for this set of countries show that physical and human capital accumulation (particularly labor quantity) were the main drivers of growth, while (total factor) productivity growth played a less important role.

Figure 1. Contribution to GDP growth in developing East Asia*
(percent, 2000-2017)



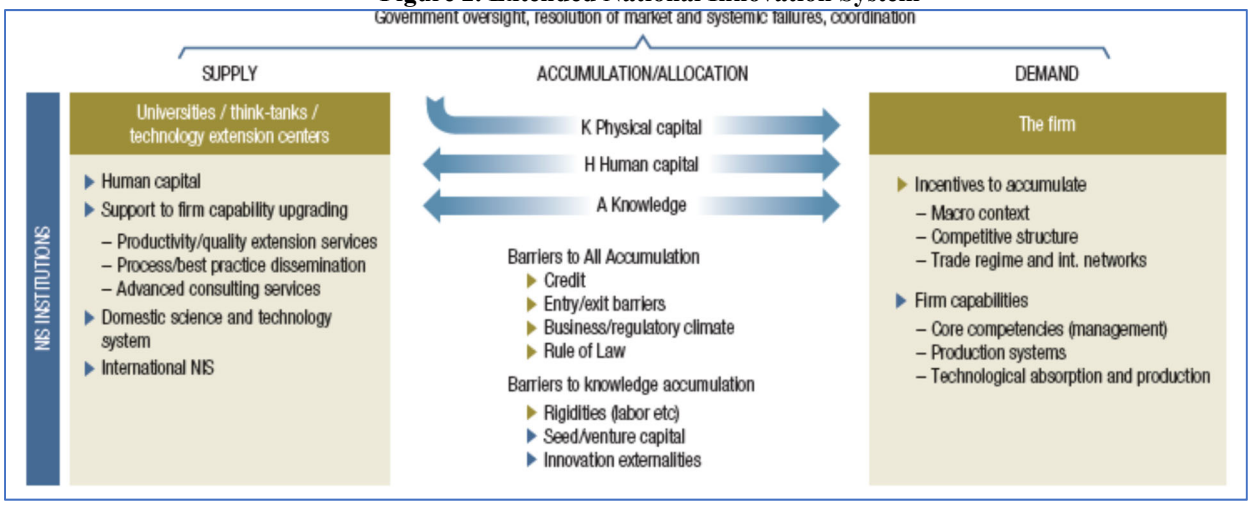
Source: Data from Total Economy Database. Note: *there was no data available for Mongolia and Lao PDR.

Looking forward, developing East Asian countries face a common challenge: the need to increase productivity which will depend on their ability to innovate. In this context, as these countries attempt to climb up the income ladder while being exposed to increasing competitive pressure, economic growth will depend on innovation, and specifically on their ability to build the resources and capabilities to innovate. This will be the ultimate driver to support diversification into new (and higher value added) areas of production, going beyond technology assimilation and production of standardized commodities.

In view of this, the current paper aims at shedding light on innovation performance and its determinants across developing East Asia. It follows a comprehensive approach about national innovation systems while highlighting the supply and demand dimensions of innovation as well as the markets where firms make accumulation decisions of different forms of capital (including knowledge). The overarching approach applied for the current analysis draws from the framework

presented at Cirera and Maloney (2017). Instead of focusing innovation policy only on R&D promotion and/or on any type of support restricted to institutions under science and technology domains, the authors highlight that overall innovation process results from the accumulation of knowledge capital, which then relies on the interaction of firms, institutions and markets. In this context, the authors document that developing countries innovate less than advanced countries, despite the vast return to innovation. This "Innovation Paradox" would be associated with the existence of barriers in three main fronts: weak firm capabilities to innovate; absence of innovation complementarities and weak government capabilities to manage the complexity of innovation policy. Figure 2 below summarizes the extended national innovation system approach where main innovation actors - firms, knowledge institutions and government - interact. Three dimensions are highlighted in this space: supply of knowledge capital; demand of knowledge capital; and, the locus where accumulation of knowledge capital, as well as of other inputs (labor and capital), takes place.

Figure 2. Extended National Innovation System



Source: Cirera and Maloney (2017)

Firms are the main actors in the *demand side* of the extended national innovation system, while knowledge institutions play a key role in the *supply side*. Two sets of variables are noteworthy under the *demand* space. First, the capabilities that enable a firm to identify opportunities and quantify the associated risks of accumulating capital knowledge, as well as to mobilize resources to reap the benefits from innovation. These capabilities encompass core managerial competencies, production systems, and higher-end capabilities for technological absorption and innovation. Second, the set of external factors that influences firms' incentives to innovate, notably the macro context, the competitive structure and trade regime. The knowledge institutions represent the main actors in the *supply side*. They encompass all sources of knowledge that support firm demand for innovation. Four sets of variables are noteworthy: supply of human capital; institutions (and associated services) to support firm innovation; the science and technology system that generates new or adapts existent knowledge; and the international innovation system where most new knowledge comes from, especially for developing countries.

As important as the actors leading the innovation process is the locus where accumulation process of different types of inputs, not only knowledge capital takes place. In this regard, several factors are at play and exert influence, directly or indirectly, on the expected rate of return for

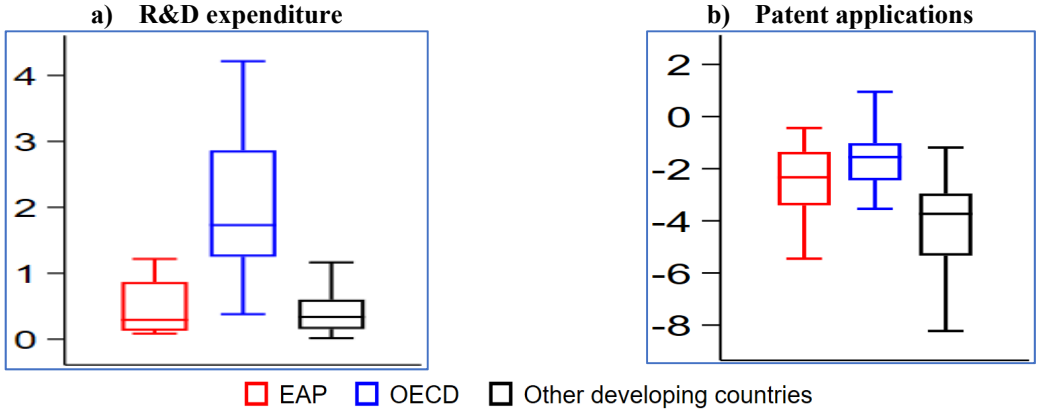
innovation. They include precisely barriers related to overall input accumulation, both physical capital and knowledge capital - such as capital markets, business environment, rule of law - as well as specific barriers to accumulate knowledge capital, such as supply of risk capital financing, restrictions on the workforce, and standard information-related market failures.

Against this backdrop, the paper is structured along two main sets of empirical exercises that draw from different data sets (at the country and firm levels) covering a subset of developing East Asian countries, precisely: Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Thailand and Vietnam. The paper has four sections including this introduction. Section 2 draws from country-level data and presents a benchmarking type of exercise to assess the overall innovation performance of developing East Asian countries while trying to identify key policy induced factors that might explain this performance. Section 3 sheds light on the firm-level dimension of the extended innovation system; it uses firm-level data to explore key patterns of innovation within this set of countries while throwing light on both output from and inputs for innovation. Section 4 concludes.

2. Benchmarking the overall innovation performance of developing East Asian countries

How does the East Asian region (as a whole) perform in terms of use of and investment on innovation inputs and outputs? At first sight, data suggest that countries in the region tend to underinvest in innovation inputs, while performing better than expected on innovation outputs. Two standard aggregate measures are used, one from the input-side (research and development expenditure as a percentage of GDP) and another from the output angle (patent applications per million people). Results suggest that countries in the region spend less than OECD countries in terms of R&D (Figure 3a): median R&D expenditure in East Asia is only 0.29 percent of GDP, a fraction of the OECD's median of 1.73 percent of GDP. On the other hand, East Asian countries do better in terms of patent applications relative to the OECD (Figure 3b); their median is only slightly lower than the OECD's.

Figure 3. Distribution of innovation input and output levels, by country category



Source: Larson and Mishra (2018) using data from WDI

Though illustrative, these figures can be misleading. They might suggest that boosting R&D expenditures would automatically lead to higher innovation returns, when in fact there are several innovation-related market failures or policy driven stringencies that affect the overall innovation performance. To address this issue, a benchmarking exercise of innovation performance of

selected developing East Asian countries is conducted. The exercise draws from the 2017 Global Innovation Index (GII) data set[2] which covers 127 countries; the only developing East Asian countries covered are the following: Cambodia, China, Indonesia, Malaysia, the Philippines, Thailand, and Vietnam. This data set captures overall innovation capacity through a mix of indicators encompassing both innovation enabling factors (called as "inputs") as well as innovation outputs. It has a multi-level structure with two sub-indices and 7 pillars which are then divided into three sub-pillars, each of which is composed of individual indicators of different types (composite indicators, survey questions and hard data indicators),[3] totaling 81 indicators. Scores (of index, sub-index, pillars and sub-pillars) are normalized in the 0-100 range. Figure 4 below displays the indicator schemata. Despite its drawbacks – particularly regarding the lack of comparability over time – this database provides a single source of information that allows the comparison of performance of national innovation systems across economies in a given year.

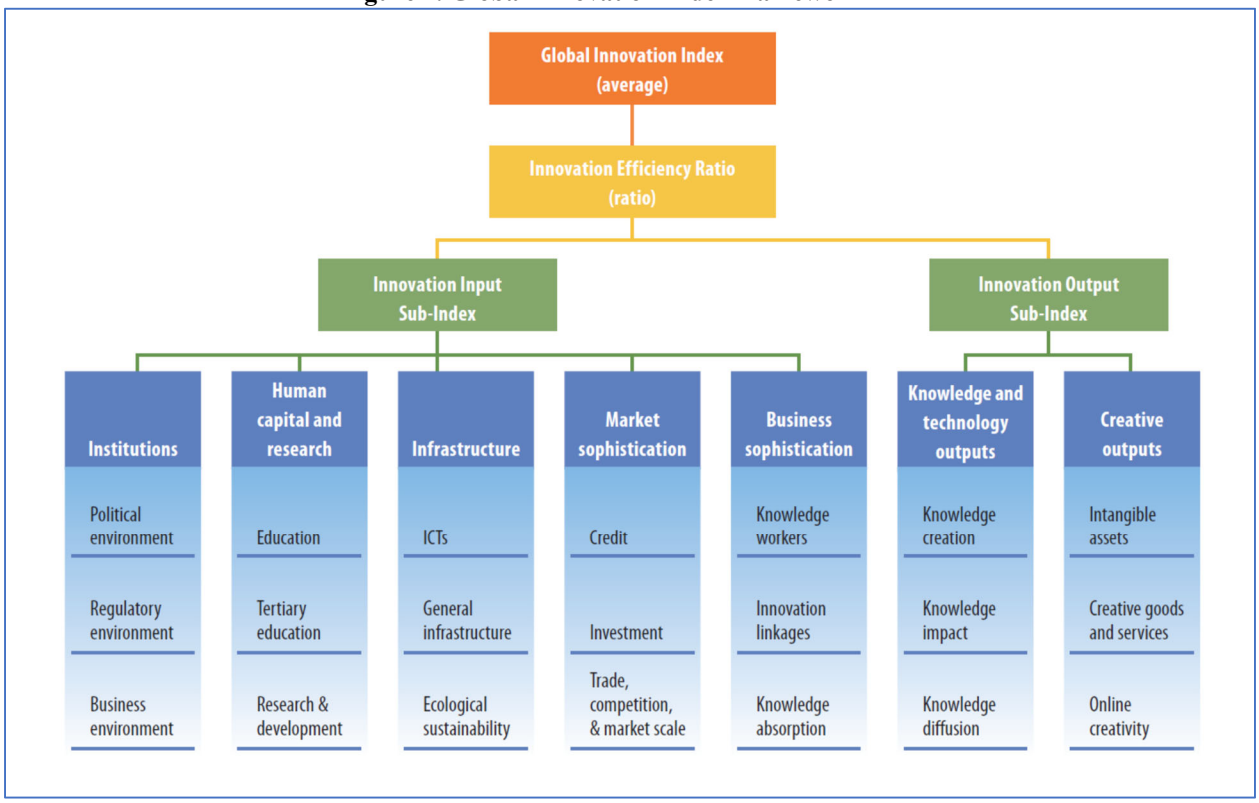
According to this data set structure, the innovation enabling factors encompass five main pillars. The *Institutions* pillar captures the institutional framework of a country and measures the extent to which this framework is conducive to attract private sector business by providing good governance and the correct levels of investment protection. The *Human capital and research* pillar reflects both the standard and level of education and research activity, which are prime determinants of a country's capacity to innovate. The *Infrastructure* pillar measures the extent to which a country is served with good and ecologically friendly communication, transport and energy infrastructures; all these factors are key facilitators to production and exchange of goods and services and ideas. The *Market sophistication* pillar reflects the underlying market conditions that are relevant for business operation and innovation activities; it includes availability of credit; conditions to support investment and access to international markets. The *Business sophistication* pillar measures the extent to which firms are conducive to innovation activity; it measures the employment of qualified workers by firms, the presence of innovation linkages and public/private academic partnerships in the economy, and the capacity of firms in the country to absorb knowledge. From the output side, the results of innovative activities within the economy are captured by two main pillars. The *Knowledge and technology outputs* pillar comprises the traditional fruits of innovation, and includes measures of knowledge creation, impact and diffusion. Finally, the "*Creative outputs*" pillar captures the extent to which the country makes use of intangible assets, the country's capacity to produce creative goods and services and online creativity.[4]

[2] See Global Innovation Index (2017) for further details.

[3] See Global Innovation Index (2017), Annex 1 for further methodological details.

[4] It is worth highlighting the connections between the extended approach of national innovation system displayed in Figure 2 and the measurement scheme applied by the GII data set, displayed in Figure 4. The supply and demand dimensions of innovation as well as the markets where knowledge accumulation takes place – highlighted in Figure 2 - are somehow captured across the innovation enabling pillars displayed in Figure 4. For instance, the set of external factors that influences the firm's incentives to innovate highlighted in Figure 2 (macro context, the competitive structure and trade regime) are somehow captured by the *Market sophistication* enabling pillar in Figure 4. The same happens with the supply of human capital highlighted as one of the supply side factors in Figure 2, which is captured by the *Human capital and research* pillar in Figure 4.

Figure 4. Global Innovation Index framework

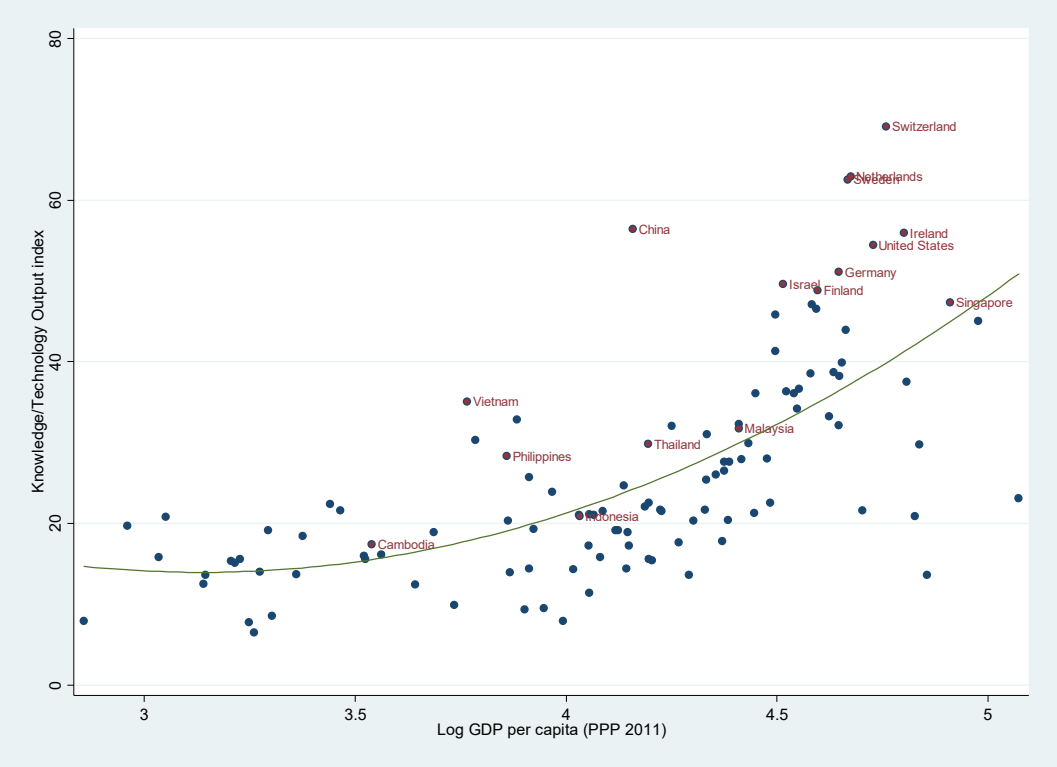


Source: Global Innovation Index (2017)

Figure 5 plots country score values of the innovation output performance index - measured by the *"Knowledge and technology outputs"* sub index[5] - against the latest GDP per capita (2011 PPP adjusted) figure, available for 2016. Results show that innovation output performance increases with income per capita. China is among the top 10 countries, only behind Switzerland, the Netherlands, and Sweden, and above Ireland, the United States, Germany, Israel and Finland. Among other developing East Asian countries covered by the survey, only Indonesia and Cambodia's index values are below the median of the distribution. The same figure suggests that except for Indonesia, all developing East Asian countries covered in the data set present an innovation output performance above what would be expected given its income level. The "gap" size – measured as the difference between the observed innovation output score value and the predicted value given the country's GDP per capita - is displayed in Figure 6. China and Vietnam show the largest positive gaps within the group of countries under study.

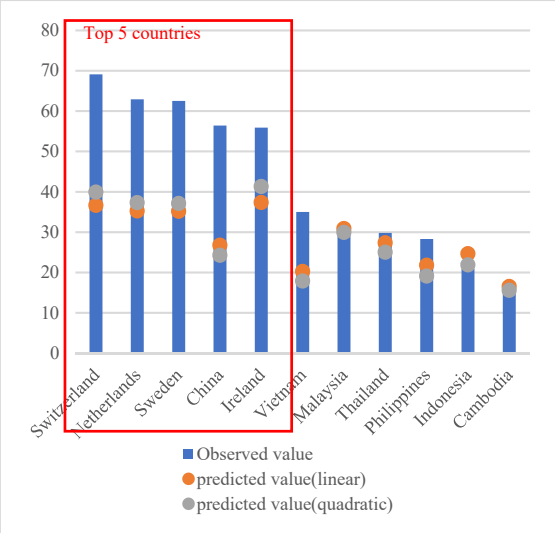
[5] The current analysis does not consider the innovation output performance in terms of creativity, as this pillar encompasses elements of the innovation output process that are less precise in measurement and definition.

Figure 5. 2017 Innovation Output index vs 2016 GDP per capita



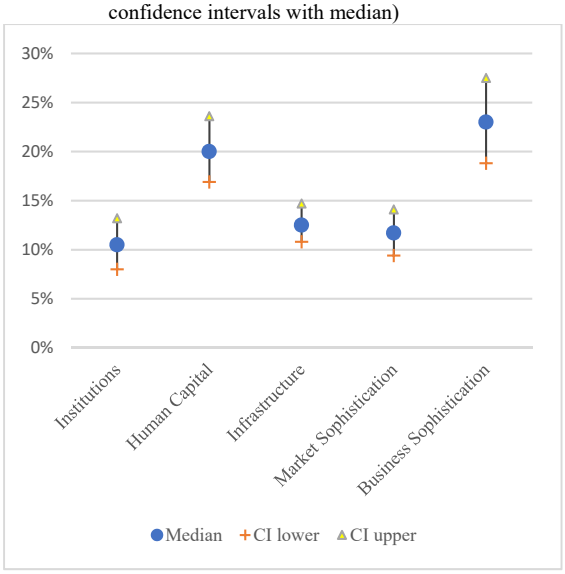
Source: Own elaboration based on data from GII dataset and WDI dataset. Innovation output performance is captured by the "knowledge and technology output pillar.

Figure 6. Actual and benchmarked value of innovation output index: developing East Asian countries and top performers, 2017



Source: Own elaboration based on GII dataset and WDI dataset
Note: Bars show the observed innovation output index value. Dots show the benchmark predicted by a (linear) regression with (the log of) GDP per capita adjusted for (2011) purchasing power parity as the explanatory variable. The regression used all countries available in the GII and WDI dataset.

Figure 7. Relative importance of enabling factors to explain innovation output index across all countries
(absolute contributions to R-squared; 90percent percentile confidence intervals with median)



Source: Own elaboration based on GII dataset and WDI dataset
Note: Bars show the share of total explained variance of innovation output index by individual regressor variables (GDP per capita, and all sub components grouped under each enabling factor: Institutions, Human capital and research, Infrastructure, Market sophistication, and Business sophistication). The percentage contributions are calculated as Owen values for each group of enabling factor. While the goodness of fit (R2) decomposition does not have standard errors, bootstrapping is applied to help attach greater reliability to comparisons of importance. The analysis used all countries available in GII and WDI dataset

Which enabling factors are more important to explain innovation output performance across all countries? To answer this question, a cross-country model is estimated where the innovation output index is regressed against GDP per capita and all innovation input sub components (as displayed in Figure 4) grouped under each enabling factor/pillar: *Institutions*; *Human capital and research; Infrastructure; Market sophistication; and Business sophistication*.[6] Then, in order to identify which group of covariates presents higher importance to explain the variance of the innovation output index across countries, the estimated model's goodness of fit (R2)[7] is decomposed according to the Owen values of each (exogenous) group of explanatory variables. Figure 7 displays the 90 percent bootstrap confidence intervals for the absolute Owen values for each set of variables, grouped under each enabling factor.[8] Not surprisingly, the "usual suspects" *Human capital and research* and *Business sophistication* stand out as key factors explaining the variation of innovation output performance across countries; results suggest that the supply of

[6] Precisely, the following variables, besides GDP per capita, are included in the regression analysis: political environment, regulatory environment and business environment (under Institutions); education, tertiary education and research and development (under Human Capital); ICTs, general infrastructure and ecological sustainability (under Infrastructure); credit, investment and trade, competition and market scale (under Market sophistication); and knowledge workers, innovation linkages and knowledge absorption (under Business sophistication).
[7] Which turned out to be around 85 percent.
[8] For a brief discussion about the Owen and Shapley decompositions, see Huettner and Sunder (2012).

human capital and the capacity of firms to absorb technology account for 23 percent and 20 percent, respectively, of the model's goodness of fit.

More interestingly, however, is the fact that horizontal factors that in principle affect overall firm performance and the accumulation of any type of capital (not only knowledge capital) also matter as determinants of innovation performance: results from Figure 7 suggest that *Institutions, Infrastructure* and *Market Sophistication* pillars account, together, for a substantial part (34.7 percent) of the explained variance of the model.[9] This reinforces the idea presented by Cirera and Maloney (2017) that complementary factors of the business environment - that go beyond specific barriers to innovation - are key to improve the performance and returns to innovation. These factors are normally neglected in the advanced country literature because markets in high-income countries function normally well, but this is not necessarily the case in middle- and low-income countries.

Table 1 below displays how developing East Asian countries covered by the GII data set perform in terms of all enabling factors. The country's performance in each pillar is measured relative to the pillar's median value in the global sample (of the GII data) and the expected level of the country's performance in that pillar given its income level (measured in GDP per capita). Countries whose observed values of pillars are below both the median and the predicted value are marked as one. The enabling factor where this set of countries mostly underperform is *Institutions*; of the seven developing East Asian countries included in the above-mentioned data set, six underperform in this domain; the exception is Malaysia.[10] After *Institutions*, *Business Sophistication* and *Human Capital* stand as the worst performing pillars: four of the seven developing East Asian countries covered by the GII data set present a deficit in these two domains.

Table 1. How developing East Asian countries perform in terms of overall innovation enabling factors, 2017

Country	Institutions	Human capital	Infrastructure	Market sophistication	Business sophistication
Cambodia	1	1	1	0	1
China	1	0	0	0	0
Indonesia	1	1	1	0	1
Malaysia	0	0	0	0	0
Philippines	1	1	0	1	0
Thailand	1	1	1	0	1
Vietnam	1	0	0	0	1

Source: Own elaboration based on GII dataset and WDI dataset.
Note: a value of 1 indicates a variable where the country is below the median country AND below the level predicted by its GDP per capita. The median value (for each variable) is calculated within the 127 countries covered under the GII survey.

To shed light on more granular aspects that might be driving these results, Table 2 focuses on the components under the *Institutions* pillar: *Political environment*, *Regulatory environment* and *Business environment*. Results suggest that *Regulatory environment* – encompassing regulatory quality, rule of law, and cost of redundancy dismissal - is the key obstacle for innovation across developing East Asian countries covered in the GII data set; all of them have a deficit in this

[9] The remaining 7.5 percent of R2 comes from GDP per capita.
[10] But in this case the country underperforms in relation to the predicted level but not in relation to the median value of all countries.

domain. The second most important factor for which this set of countries underperform is *Business Environment*, which comprises starting a business, resolving insolvency and paying taxes.

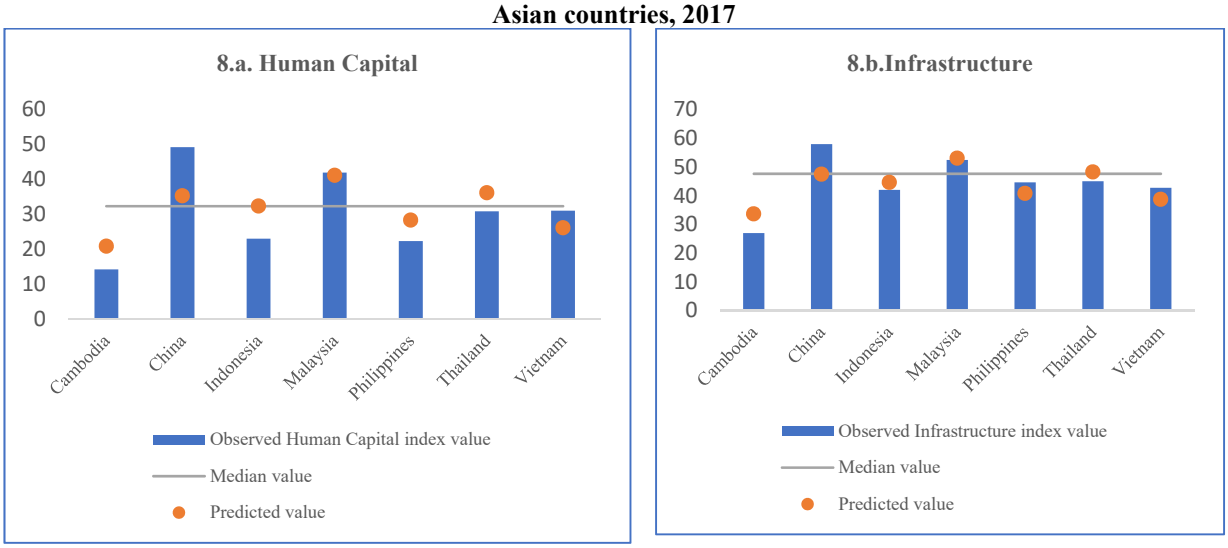
Table 2. How developing East Asian countries perform in terms of institutional factors, 2017

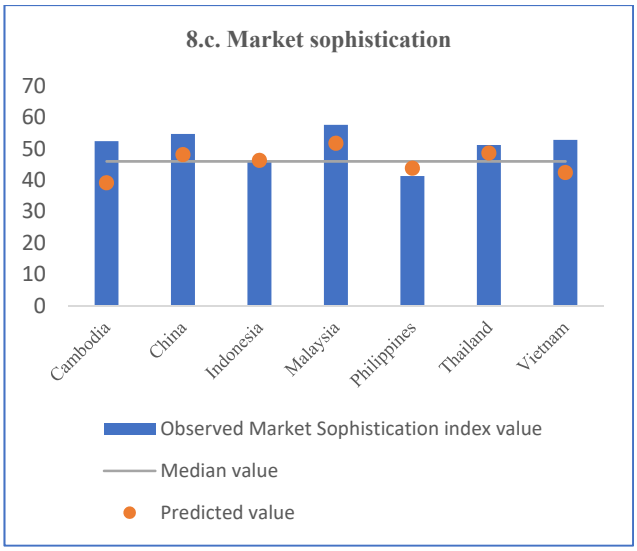
country	Political environment	Regulatory environment	Business environment
Cambodia	0	1	**1**
China	1	1	**1**
Indonesia	1	1	**1**
Malaysia	0	1	**0**
Philippines	1	1	**1**
Thailand	1	1	**0**
Vietnam	0	1	**1**

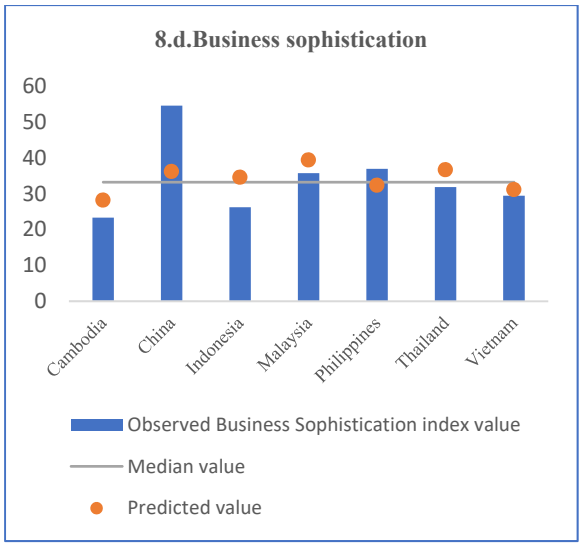
Source: Own elaboration based on GII dataset and WDI dataset.
Note: a value of 1 indicates a variable where the country is below the median country AND below the level predicted by its GDP per capita. The median value (for each variable) is calculated within the 127 countries covered under by the GII dataset.

In this context, how to explain the outstanding performance of China and Vietnam in terms of innovation output performance despite their (low) scores of institutional framework? A potential answer might lie within the remaining enabling factors; results displayed in Table 1 suggest that these two countries outperform in other underlying factors which might compensate for the negative result for the *Institutions* pillar. Precisely, China outperforms in all remaining enabling factors: *Human capital*, *Infrastructure*, *Market Sophistication* and *Business sophistication*. Vietnam outperforms, at least relative to the predicted value, in *Human capital*, *Infrastructure*, and *Market Sophistication*. Figures 8.a to 8.d display these results.

Figure 8. Actual, predicted and median values of innovation input index pillars across developing East Asian countries, 2017







Source: Own elaboration based on GII dataset and WDI dataset
Note: Predicted value dots show the benchmark predicted by a (linear) regression with (the log of) GDP per capita adjusted for purchasing power parity (in 2011) as the explanatory variable; the dependent variable is the enabling innovation factor of interest. The regression used all countries available in the GII and WDI dataset. The median value (for each enabling factor) is calculated within the 127 countries covered by the GII dataset

3. Demand side of innovation: The role of firm characteristics and use of innovation inputs

The analysis of the demand side of innovation draws from the World Bank Enterprise Survey (ES) implemented in 2015-2016 for a selected set of developing East Asian countries, as follows: Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Thailand, and Vietnam. The survey collects substantial balance sheet and other information regarding the investment climate and includes an innovation section (section H) containing questions covering innovation outputs and inputs to the innovation process. Table 3 lists the year the survey was conducted for each country as well as the total number of firms surveyed. The sample for each economy is stratified by industry, firm size, and geographic region. Stratification by industry follows a different level of detail depending on the size of the economy. Stratification by size follows three levels: 5 to 19 (small), 20 to 99 (medium), and 100 or more (large); firms with fewer than five employees are ineligible for the survey. Regional stratification covers the main economic regions in each economy. Through this methodology estimates for the different stratification levels can be calculated on a separate basis and inferences can be made for the non-agricultural private economy.

Table 3. List of developing East Asian countries covered by the Enterprise Survey

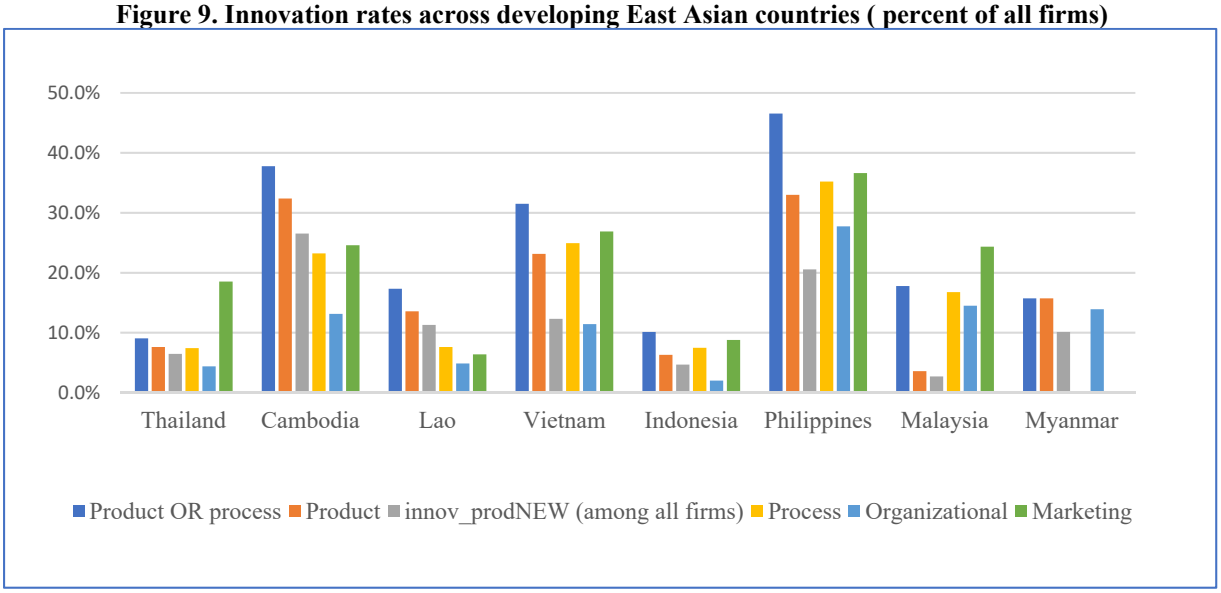
Country	Survey year	# of firms
Cambodia	2016	373
Indonesia	2015	1320
Lao PDR	2016	368
Malaysia	2015	1000
Myanmar	2016	607
Philippines	2015	1335
Thailand	2016	1000
Vietnam	2015	996

Total		6999

Source: Own elaboration based on ES dataset

ES data encompass information on selected dimensions of innovation outputs: product and process innovation, organizational innovation and marketing innovation. Figure 9 plots the (sampling adjusted) share of firms that report innovative activities within the selected set of developing East Asian countries. Results suggest that innovation incidence varies substantially across types of innovation outputs both within and across countries.

Figure 9. Innovation rates across developing East Asian countries (percent of all firms)

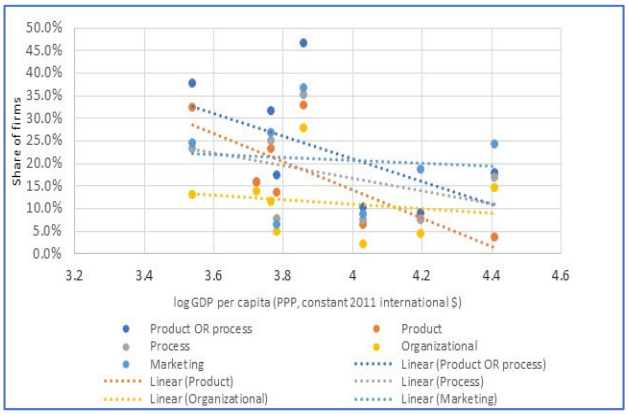


Source: Own elaboration based on ES dataset
Note: tabulations are adjusted by sampling weights

In addition, there seems to be a surprisingly negative association between share of firms reporting innovation activities and income level (Figure 10). This might reflect systematic differences in what is reported as innovation across the income spectrum, which could be explained by the fact that innovation outcomes are likely to be subject to biased interpretations, since firms in lower income countries are likely to report marginal innovation or even imitation as innovation.[11] This negative association seems to disappear after accounting for the novelty of reported innovations; when restricting the sample of firms that report product innovation, data suggest that the proportion of those reporting product innovation that are new to the market is positively correlated with income level (Figure 11).

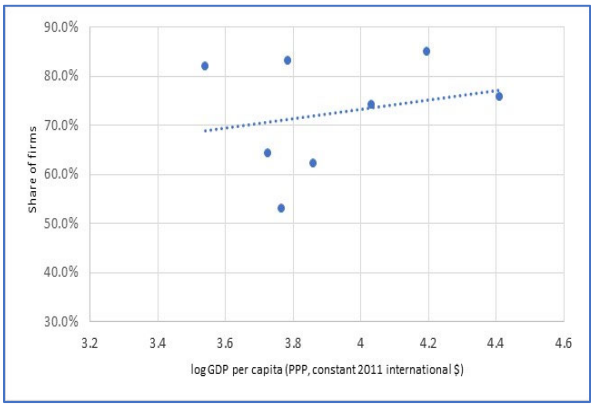
[11] See Cirera and Maloney (2017) as well as Cirera, Lopez-Bassols and Muzi (2016) for further discussion about these measurement issues.

Figure 10. Innovation incidence and GDP per capita across developing East Asian countries



Source: Own elaboration based on ES dataset and WDI dataset
Note: ES tabulations are adjusted by sampling weights

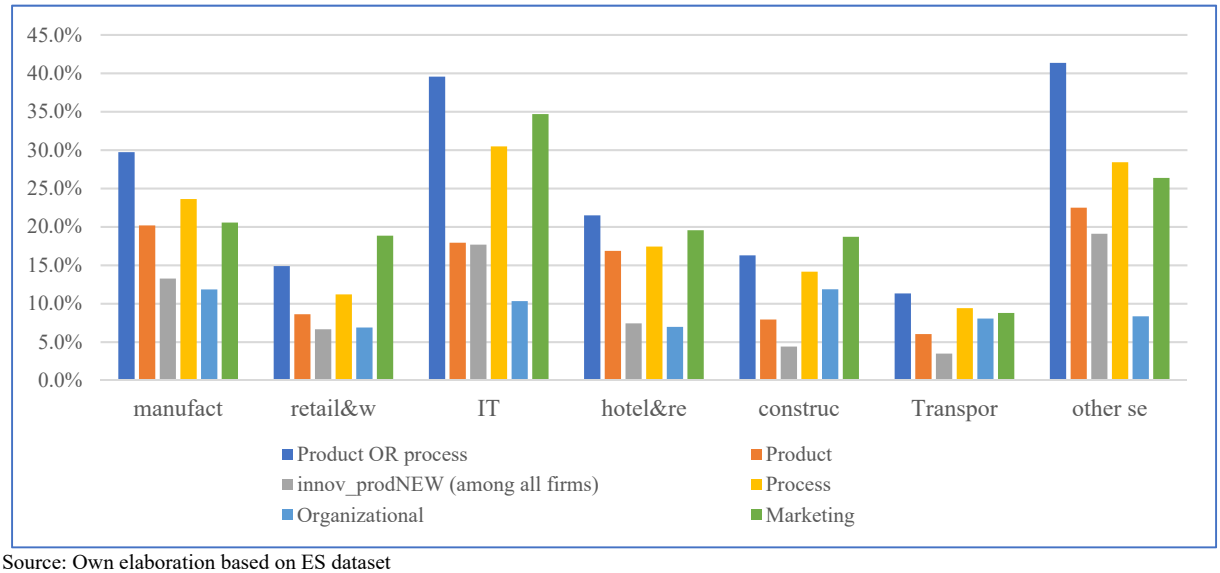
Figure 11. Incidence of product innovation new to the market (percent of firms reporting product innovation) and GDP per capita across developing East Asian countries



Source: Own elaboration based on ES dataset and WDI dataset
Note: ES tabulations are adjusted by sampling weights

Despite these measurement issues, which are typical in innovation surveys, ES data are still illustrative and useful. Data reveal that innovation activities occurs in all sectors, not only in manufacturing. Other service sectors and IT services present the highest innovation rates (Figure 12).

Figure 12. Innovation rates across sectors across developing East Asian countries (percent of all firms)



Source: Own elaboration based on ES dataset
Note: tabulations are adjusted by sampling weights

Box 1. Which firm characteristics are important to explain innovation performance across developing East Asian countries?

To assess how propensity to innovate varies across different firm characteristics (besides sector of operations), a logistic model is estimated where the dependent variable ("innovative company") is a dummy variable that takes the value of one when the firm has introduced innovation and zero when it has not; all types of innovation outputs mapped in the ES data set are modeled. Firm age, size (measured in terms of number of employees), ownership, export status, city size and sector are included as explanatory variables. Parameters are estimated by maximum likelihood using sampling weights, and standard errors are clustered by country.

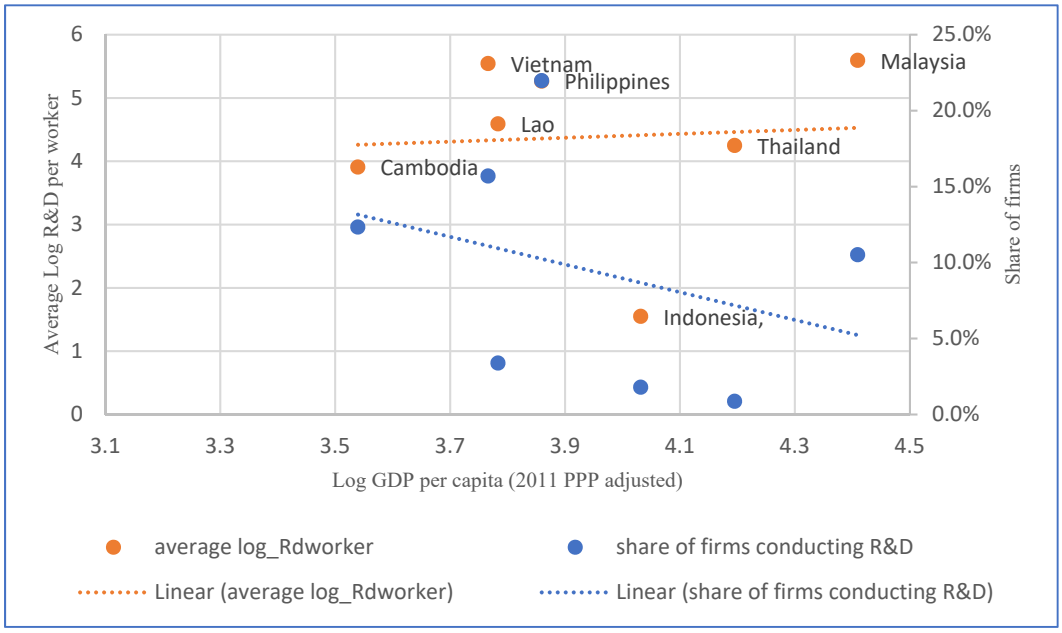
Table A2 in the annex shows – for each type of innovation output - the odds ratio of each firm characteristic. Results suggest that the role played by firm characteristics varies according to type of innovation outputs. The fact that the odds ratio of the firm age variable is less than one suggests that older firms are less prone to innovate; this is valid for all types of innovation. Firm size is an important characteristic regardless of the type of innovation output; in this case, for instance, the odds of introducing product or process innovation is 3.23 times greater for large firms than for micro firms (see column 1). Export status is another firm characteristic to influence innovation performance; the odds of introducing product innovation is 1.46 times higher for exporters than for non-exporter firms (see column 2). However, if the analysis is restricted to firms that report product innovation (see column 3), being an exporter reduces the probability of introducing product innovation that is new to the market. Foreign owned firms are surprisingly less prone to innovate when compared to domestic companies: in the case of process innovation for instance, foreign companies are 31.6 percent less likely to innovate than domestic peers (column 4). Size of locality also plays an important role: being located in large cities increases the probability of innovating; for certain types of innovation activities (precisely for process, organizational and marketing innovation) this association seems to be nonlinear. Sector of activity also matters: all else equal, other service sector companies present the highest probability to introduce a product innovation (2.415 times higher) when compared to the baseline category (wholesale and retail).

Innovation inputs - defined as the set of investments and activities that firms carry out to develop their capabilities to innovate (Cirera, Lopez-Bussols and Muzi, 2016) - represent another relevant dimension to be considered when assessing innovation performance at the firm level. ES data cover a limited set of innovation inputs: R&D activities; purchase and/or licensing of (patented and non-patented) technology; and, formal training for development of innovative products/processes.

R&D activities represent the most commonly discussed innovation input in the literature; see for instance, Mohnen and Hall (2013) for a recent review of studies across OECD countries. ES data for the selected set of developing East Asian countries under analysis show that R&D intensity (measured as the total R&D expenditures per worker) does not vary too much with income level, a result that is driven by Indonesia which presents a low level of (average log) R&D intensity (Figure 13). The linear association (between R&D intensity and GDP per capita) would be strongly positive if Indonesia is excluded. On the other hand, R&D incidence decreases sharply with income level, a result that is robust to the exclusion of Indonesia. When taken together, these results suggest that - at least for this selected set of developing East Asian countries, and when taking Indonesia out of the analysis - a smaller fraction of firms undertake R&D as income level increases, while R&D expenditures (among these firms conducting R&D) increases across the income span. Overall, this result is consistent with findings from Cirera and Maloney (2017) using

ES data for several countries around the world[12] and suggests that policy needs to expand the spectrum of firms that conduct R&D as a way to increase the national R&D intensity.

Figure 13. R&D intensity, R&D incidence and GDP per capita across developing East Asian countries



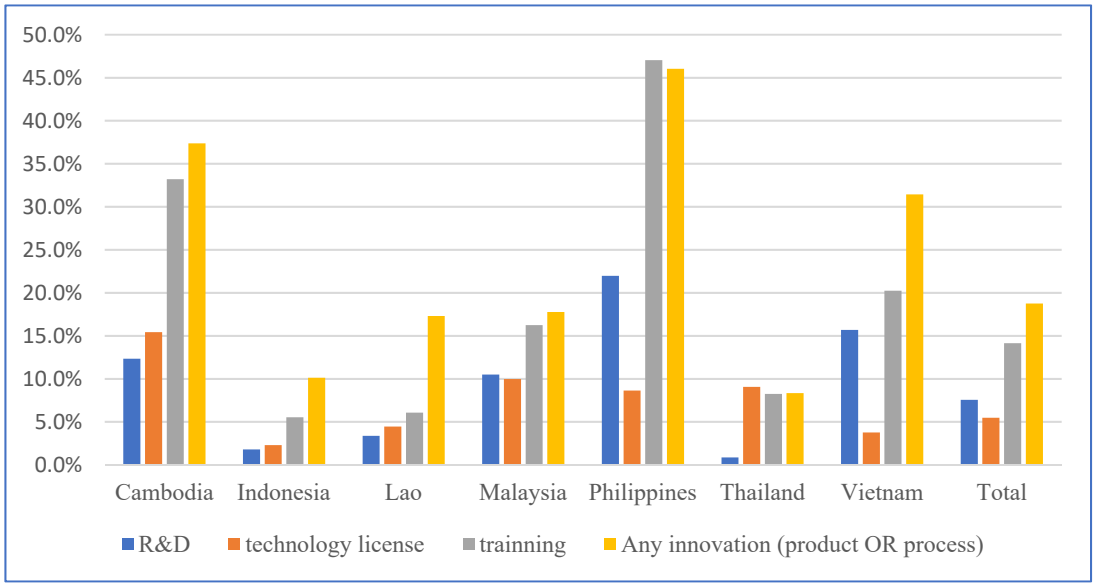
Source: Own elaboration based on ES data and WDI dataset

Note: R&D intensity is computed as the average logarithm of R&D per worker in US$, adjusted by sampling weights; R&D incidence is computed as the share of firms doing R&D using sampling weights.

ES data suggest that other innovation inputs, besides R&D, also play a relevant role in the innovation process. Results show that the proportion of firms that report innovation (of product or process) is much larger than reported formal R&D activities; in other words, a large fraction of firms that introduce innovation do not report formal R&D. This outcome is suggestive that other innovation inputs, besides R&D activities, are at play and could be seen as complementary factors of production in the innovation process, as highlighted in Cirera and Maloney (2017). Formal training for development of innovative products/processes is the most frequently used innovation input across the developing East Asian countries under analysis (Figure 14). On average, R&D inputs stands out as the second most frequently used input; a result that is probably driven by the Philippines and Vietnam as these countries present the top two highest R&D incidences (22 percent and 15.7, respectively) within the selected set of countries. Purchase of technology license is the third most frequently used innovation input. Overall, this result suggests that policies to boost innovation in this selected set of developing East Asian countries need to go beyond supporting R&D and encompass also other complementary inputs.

[12] Drawing from ES data for several countries around the world, Cirera and Maloney (2017) find evidence that investment in R&D increases with GDP per capita and a large part of this increase is due to increased spending among the few firms doing R&D.

Figure 14. Use of innovation inputs vs innovation rates across developing East Asian countries (percent of all firms)



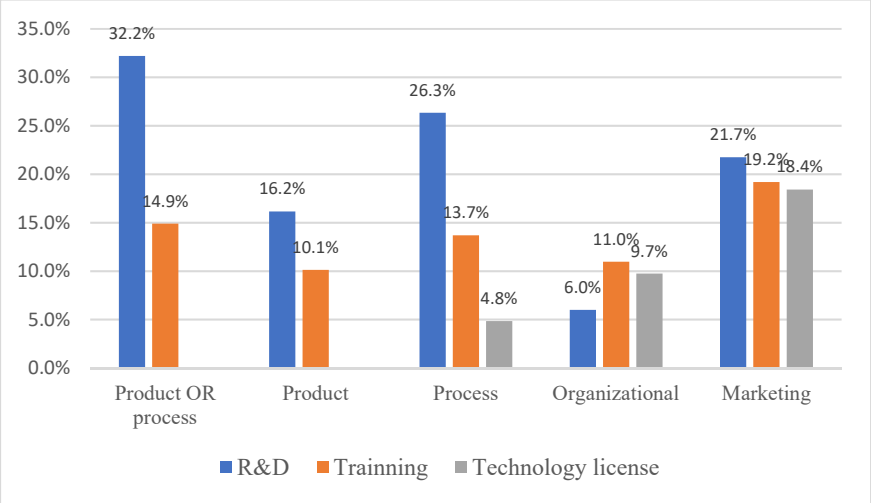
Source: Own elaboration based on ES data
Note: tabulations are adjusted by sampling weights

Box 2. How R&D activities, training activities and acquisition of technology licenses affect the probability to innovate across developing East Asian countries

To assess how the overall probability to innovate is influenced by innovation inputs, the logit model applied in Box 1 is estimated again, now with R&D, technology license and training activities as additional (dummy) explanatory variables. Again, parameters are estimated by maximum likelihood using sampling weights and standard errors are clustered by country. Table A3 in the Annex presents – for each type of innovation output - the odds ratio of each innovation input. Firms that perform R&D activities are more likely to innovate when compared with those that do not perform; the probability of introducing product or process innovation among firms that perform R&D activities is 7 times higher when compared with those that do not perform, and this applies to all types of innovation activities except for firms that have introduced an innovation product that is new to the market. Training activities for innovation is another relevant innovation input: firms that provide formal training for the development of new products and processes are almost 3 times more likely to innovate (in product or process) than those firms that do not offer the same type of training. This positive association holds for other types of innovation outputs: organizational and marketing innovation, and also for those firms that have introduced innovative products that are new to the market. Purchasing or licensing technology also increases the probability to innovate, but in this case the positive association applies only to process, organizational or marketing innovation.

The figure below displays the average marginal effect of using each innovation input on the probability to introduce innovation across its different formats. Results show that, on average, firms that perform R&D activities are 32 percent more likely to introduce product or process innovation than firms that do not perform R&D. Offering training for innovative activities increases the probability to innovate products and processes by almost 15 percent when compared to firms that do not offer this type of training. For marketing innovation, the acquisition or licensing of technology increases the probability to innovate by 18.4 percent when compared to firms that do not purchase or license technology.

Figure B2.1. Average marginal probability to innovate given the use of innovation inputs across developing East Asian countries



Source: Own elaboration using ES data

Note: average marginal effect results from a probit model estimating the probability of introducing all types of innovation (product or process; product; process; organizational; and marketing) conditional on whether the firm: perform R&D activities, offer training for innovative activities, and acquire technology license (all of them introduced simultaneously in the regression). Controls for firm age, size, sector, ownership, export status, city size plus country fixed effects are also included as regressors. The graph shows only the coefficients/effects that are statistically significant. For innovation of product or process, and product innovation, the effect of technology license was not statistically significant.

3.1. Managerial capabilities as a (complementary, but key) innovation input

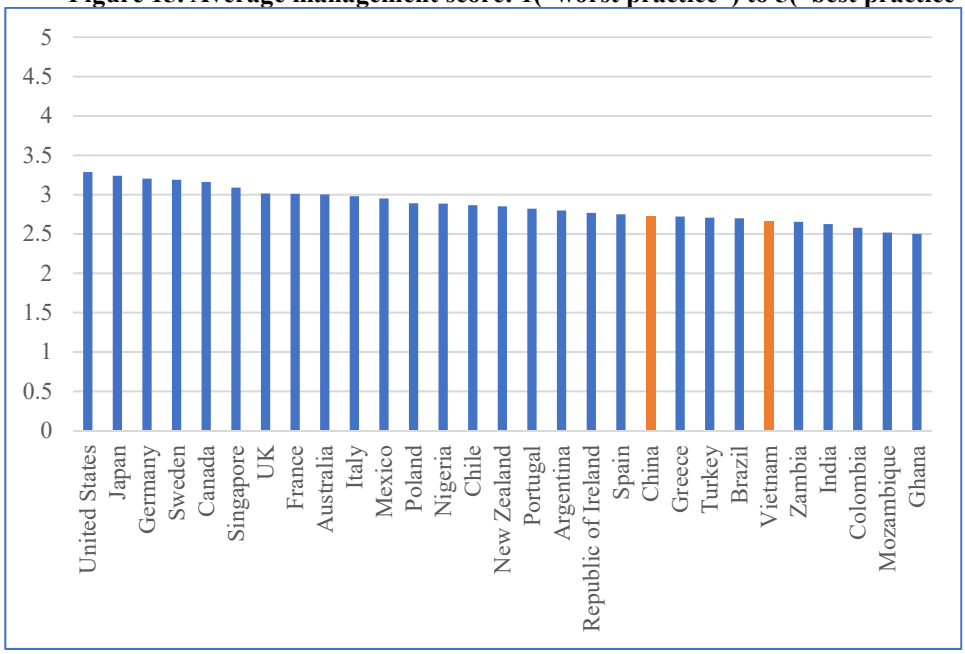
Besides R&D, training activities and acquisition of technology license, managerial and organizational capabilities represent another key innovation input. As highlighted in Cirera and Maloney (2017), these capabilities are part of core competences and critical inputs for innovation as they determine the way in which knowledge is employed and accumulated, especially for firms that are far from the technological frontier. In this regard, low managerial capabilities are one of the key reasons why firms do not invest more in innovation, since they prevent firms from identifying productive opportunities, evaluating their feasibility, managing their risk, and allocating human resources effectively. Therefore, they should be understood as an innovation input that needs to be accumulated and combined with other complementary inputs to yield innovation outcomes. Recent empirical evidence shows that managerial capabilities is positively correlated with productivity and innovation. Drawing from a broad range of middle-income and developing countries, Bloom and Van Reenen (2010) show average management scores to be highly correlated with aggregate labor productivity. More recently, Cirera (2017) finds evidence that good management practices have a dual positive effect on productivity: it enables more efficient use of resources and increases the probability to innovate. Using Mexican micro data, Iacovone and Pereira-Lopez (2017) provide micro-level evidence on the complementarity between managerial practices and R&D efforts in Mexico by showing that better managerial practices increase the impact of R&D activities leading to innovation activities.

The World Management Survey (WMS) is used to assess the status of managerial practices in developing East Asia; only two developing East Asian countries are included in the survey: China and Vietnam. The WMS is a globally comparable survey of management practices that permits benchmarking countries by management practices. As per the methodology presented originally

by Bloom and Van Reenen (2007), the survey uses an interview-based evaluation tool that defines and scores from 1 ("worst practice") to 5 ("best practice") across 18 management practices that are grouped along four key areas. They are: i) operations management techniques - measuring the degree to which the firm acted upon encountering a problem in the production process; ii) systematic performance monitoring – capturing the extent to which the firm monitored production performance indicators and how many indicators; iii) appropriate target setting – measuring the time horizon of production targets (short versus long term); and iv) talent management (incentives) – measuring whether managers are offered performance bonuses. The sample of interviewed firms is restricted to the manufacturing sector and encompasses firms with 50 to 5,000 employees. The data set employed for the current analysis encompasses 11,930 manufacturing firms surveyed between 2006 and 2014. Table A4 in the Annex presents the summary statistics of overall management score by country.

Figure 15 presents the average managerial score of firms across countries. The United States has the highest average followed by Japan, Germany and Sweden. China and Vietnam show up in the second half of the distribution (Figure 13), ranked respectively at 20th and 24th, among 29 countries. The (average) ranking varies depending on the subcomponents of the overall management quality score: operations, monitoring, targets and incentives. Japan is the top 1 in target management, while the United States has the highest mean score in operations and target incentives (see Figure A1 in the Annex for ranking figures of all subcomponents).[13]

Figure 15. Average management score: 1("worst practice") to 5("best practice")



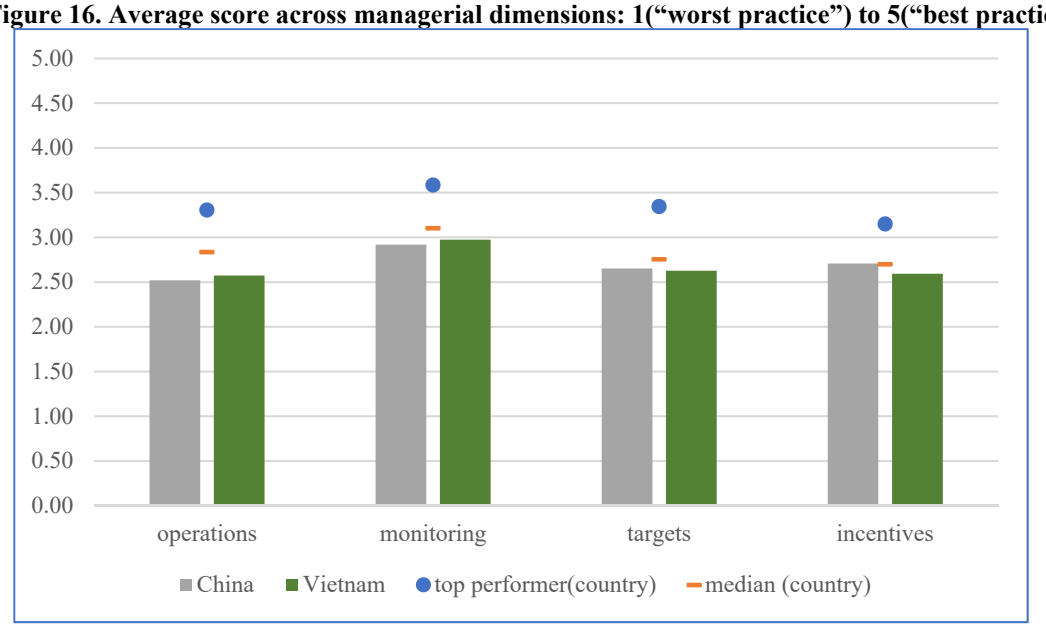
Source: Own elaboration based on WMS dataset.
Note: The country score is calculated as a simple average across firms, for each country

Some of these subcomponents of overall management quality are especially relevant to innovation. In principle, innovation activities are, by definition, long term and highly uncertain. In

[13] In a separate analysis - also drawing from WMS data, Malaysia is benchmarked against a quite similar set of countries and its average management practices is also ranked below the United States and Japan, but in line with large Australasian countries and Southern Europe. For further details, see World Bank (2017) chapter 4.

this regard, target setting, and monitoring are key elements for innovation. Data suggest that Chinese firms are, on average, stronger in monitoring, followed by the development of human resources policies (incentives); the capacity to set long-term targets emerges only as the third performing area (Figure 16). Vietnamese firms are also stronger in monitoring, and in this case with a superior performance in comparison to China; the capacity to set long-term targets is the second highest performing area. When taken together, these results suggest that the performances of both China and Vietnam are below the median countries in all domains (except for incentives, in the case of China), which points to a potential scope for improvement.[14]

Figure 16. Average score across managerial dimensions: 1("worst practice") to 5("best practice")



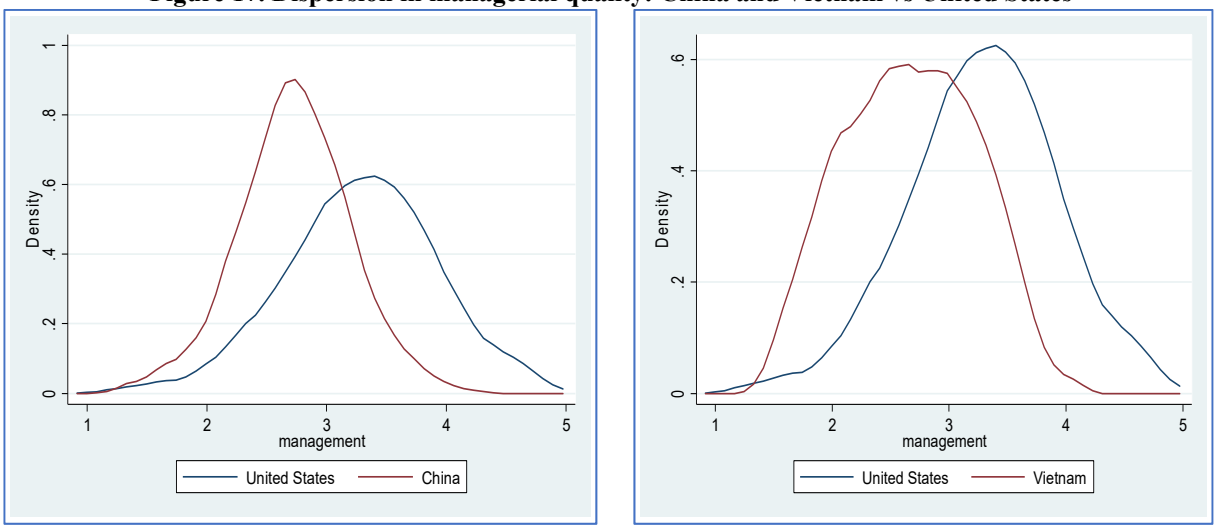
Source: Own elaboration based on WMS dataset.
Note: The country score is calculated as a simple average across firms, for each country

Moving the focus of the analysis from the average to the entire distribution of management quality score, Figure 17 plots the kernel density functions of China and Vietnam against the United States, the top performing country in the survey. The Kolmogorov-Smirnoff test (for which the null hypothesis is the equivalence of compared distributions) is also reported; in both cases, there is evidence to reject the hypothesis. Overall, data show a wide variation in all three countries, but a distinguishing feature for the United States is that the mean of its distribution is more skewed to the right when compared to China and Vietnam. In addition, the tail of poorly-run firms (here defined as those with management score lower than 2) is much fatter in China and Vietnam when compared to the United States. Almost 13 percent of Vietnamese firms were classified as poorly managed; six and half times more than in the United States. In China, the proportion of firms classified as poorly managed is 5 percent. Even the best Chinese performer (with a score of 4.22) would need to improve its performance to meet the level of the 95th percentile firms in the United

[14] In a separate analysis – see World Bank (2017) - Malaysian firms are shown to present stronger performance in monitoring, followed by talent management (incentives).

States (score of 4.33).[15] Also, results from quantile regression show that the score of the United States is consistently higher than China and Vietnam at all relevant deciles; more specifically, the (negative) difference in managerial quality in relation to the United States appears greatest among the better managed (higher deciles) firms for both Vietnam and China (Figure 18).

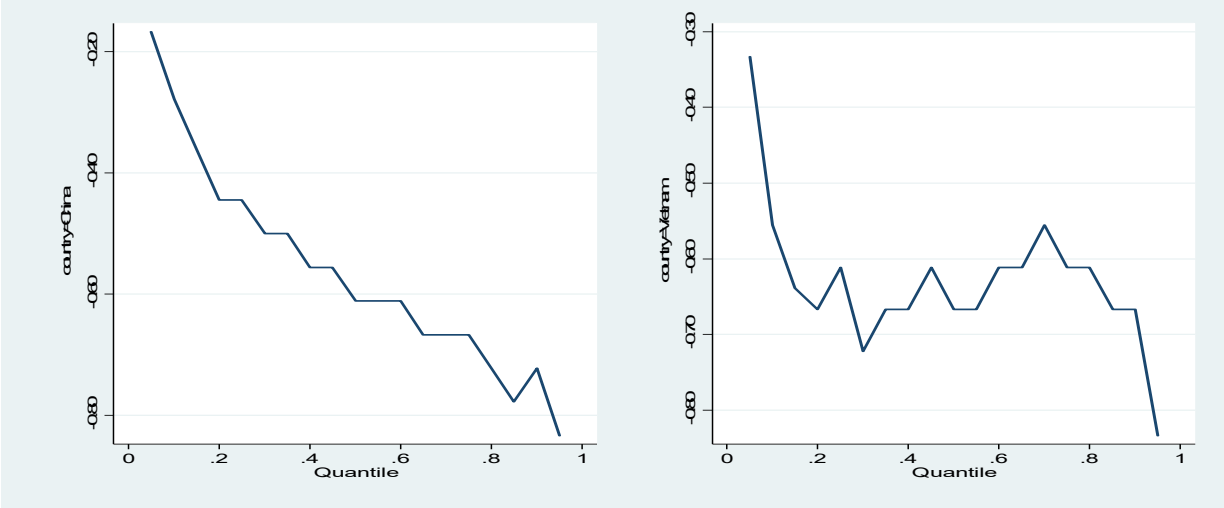
Figure 17. Dispersion in managerial quality: China and Vietnam vs United States



Combined K-S tests: p value= 0.000 | Combined K-S tests: p value= 0.000

Source: Own elaboration based on WMS data

Figure 18. Coefficients of quantile regression (China and Vietnam against United States) across deciles



Source: Own elaboration based on WMS data

[15] According to World Bank (2017), Malaysian firms drawing from different waves of WMS data showed that the spread of management practices within Malaysia is wide, with a smaller tail of badly managed firms than China.

Several factors could in principle drive these differences is managerial quality across firms and then countries. Bloom and Van Reenem (2007) focus on four developed countries (the United States, Germany, the United Kingdom and France) and find evidence that, on average, poor management practices are more prevalent when product market competition is weak and/or when family-owned firms pass management control down to the eldest sons (primogeniture). More recently, Maloney and Sarrias (2017) revisit this issue but using a global sample of countries and focusing on the entire distribution of management quality, not only the mean, as a way to identify which factors are correlated with managerial practices across the convergence path (towards the frontier country, the United States). They find evidence that confirms Bloom and Van Reenem's result on the importance of ownership as a correlate to explain variation of managerial quality, particularly among less well-managed countries. As a new result, the authors find that human capital of the managers is a key factor driving differences in managerial quality across the whole distribution, particularly among better-managed countries. Overall, these two empirical regularities suggest there might be several distinct dynamics at work across the managerial quality convergence process. In this regard, evidence presented by Maloney and Sarrias (2017) shows that China has substantial space to improve in these two fronts: among Chinese surveyed firms used in their analysis, 54 percent have managers with a degree, against 86.3 percent in the United States and 96.2 percent in Japan; in addition, only 25 percent of the Chinese surveyed firms have a diffused ownership structure (with many shareholders) against 45.7 percent in the United States and 53 percent in Japan.

4. Concluding remarks

The current paper followed the comprehensive approach about national innovation systems presented at Cirera and Maloney (2017) and shed light on key innovation patterns and constraints within a selected group of developing East Asian countries (Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Thailand and Vietnam). The paper presented two sets of empirical exercises drawing from different data sets, at the country and firm levels. Some illustrative results are noteworthy.

First, a simple country benchmarking exercise, drawing from the GII data set, was conducted to identify which innovation enabling factors matter the most to explain innovation output performance across countries. The following developing East Asian countries were covered in the data set: Cambodia, China, Indonesia, Malaysia, the Philippines, Thailand and Vietnam. Results suggest that horizontal factors that in principle impact overall firm performance and accumulation of any type of capital (not only knowledge capital) also matter as determinants of innovation performance: almost 35 percent of variation of innovation output performance across all countries covered by the GII data set is explained by the *Institutions*, *Infrastructure* and *Market Sophistication* pillars. Among these enabling factors, the one where the developing East Asian countries covered by the data set mostly underperform is *Institutions*; precisely in terms of regulatory environment and business environment. These results reinforce the idea presented in Cirera and Maloney (2017) that complementary factors of the business environment - that go beyond specific barriers to innovation - are critical to improve the performance and returns to innovation. Therefore, boosting the regulatory environment and business environment is key to improve the innovation output performance of this selected set of countries.

Second, a firm-level analysis drawing from ES data was undertaken to assess the diversity of innovation activities; the following developing East Asian countries were covered in the data set: Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Thailand and Vietnam. Results show that product innovation and marketing innovation are the prevalent forms of innovation within this group of countries. Data also suggest that innovation activities occur in all sectors, not only in manufacturing; other service sectors and IT services present the highest innovation rates. In addition, once the novelty of reported innovations is accounted for, the proportion of firms reporting product innovations that are new to the market is positively correlated with income level. This corrects for firms in lower income countries being more likely to report marginal innovation or even imitation as innovation. When it comes to the use of innovation inputs, there is evidence that a smaller fraction of firms undertakes R&D as income level increases, while the spending among these firms doing R&D increases across the income span (when taking Indonesia out of the analysis). The analysis also showed that other innovation inputs, besides R&D, matter to innovation activities: the probability to innovate increases when firms run R&D activities, offer formal training to develop innovative products or processes, and acquire or licenses new technologies, even when controlling for key firm characteristics (such as size, age, ownership, export status) as well as sector and size of the city where the firm operates.

Third, a firm-level assessment drawing from WMS was conducted to shed light on managerial capabilities, a critical innovation input. Results showed that the average managerial quality of China and Vietnam, the only two developing East Asian countries covered by the survey, are ranked respectively at 20th and 24th, among 29 countries. Results also showed that the tail of poorly-run firms is much fatter in China and Vietnam when compared to the United States. In addition, results from quantile regression showed that the score of the United States is consistently higher than China and Vietnam at all relevant deciles. Finally, when it comes to factors that drive the accumulation of managerial capabilities, results presented by Maloney and Sarrias (2017) point to ownership structure and human capital of the management level as key drivers of the managerial convergence path.

The analysis presented in this paper did not intend to assess the specificities of how governments can support the development of innovation capabilities and the optimization of returns to innovation, even less the capabilities needed at the government level to develop an effective innovation policy. However, the results presented here pointed to some key areas that could help strengthening the design and development of innovation policies across developing East Asia. First, it is key to adopt a broad view of innovation policy and invest in missing complementary factors. In this regard, policies to promote innovation should not be restricted to a science and technology ministry; supporting the development of business and regulatory environments that are conducive to overall firm performance and the accumulation of any type of capital (not only knowledge capital) is also expected to improve innovation returns. In addition, boosting innovation performance goes beyond the promotion of R&D; other complementary inputs should be taken into consideration, such as training for innovative activities, acquisition/licensing of technology and managerial practices. The latter deserves special attention. As highlighted by Cirera and Maloney (2017), low managerial capabilities exert direct influence on innovation activities, as they prevent firms from identifying productive opportunities, evaluating their feasibility, managing their risk, and allocating human resources. In this turn, policies designed to promote the upgrade of organization and managerial practices (as management extension

programs, for instance) should be included at the core of innovation policies, particularly for countries far from the frontier.

5. References

Bloom, N., and J. Van Reenen. 2010. "Why Do Management Practices Differ across Firms and Countries?" *Journal of Economic Perspectives* 24 (1): 203–24.

Bloom, N., and J. Van Reenen. 2007. "Measuring and Explaining Management Practices Across Firms and Countries." *Quarterly Journal of Economics* 122 (4): 1351–1408.

Cirera, X., V. López-Bassols, and S. Muzi. 2017. "Measuring Firm Innovation: A Review of Existing Approaches." Unpublished paper, World Bank, Washington, DC.

Cirera, X. and W. Maloney, 2017 "The Innovation Paradox: Developing-Country Capabilities and the Unrealized Promise of Technological Catch-Up" World Bank, Washington, DC

Cirera, X.. 2017. "Management Practices as an Input for Innovation and Productivity in Developing Countries." Unpublished paper, World Bank, Washington, DC.

Huettner, F. and M. Sunder. 2012. "Axiomatic arguments for decomposing goodness of fit according to Shapley and Owen values" *Electronic Journal of Statistics* (6):1239-1250

Iacovone, L., and M. Pereira-Lopez. 2017. "Management Practices as Drivers of Innovation: New Evidence from Mexico." Unpublished report, World Bank, Washington, DC.

Mason, A. and S. Shetty. 2018. "A Resurgent East Asia: Navigating a Changing World" World Bank, Washington, DC

Mohnen, P., and B. H. Hall. 2013. "Innovation and Productivity: An Update." *Eurasian Business Review* 3 (1): 47–65.

Maloney, William F., and Mauricio Sarrias. 2017. "Convergence to the Managerial Frontier." *Journal of Economic Behavior & Organization* 134 (C): 284–306.

World Bank. 2017 "Study on the Effectiveness of the Human Resources Development Fund" Unpublished Memo

Annex

Table A.1. Explaining Innovation Output Performance Index, 2017
(Decomposition of the goodness of fit according to Owen values)

Group	Regressor	Median	CI lower	upper	Median	CI lower	Upper
1	log_GDPpc_PPP11	0.075	0.058	0.095	**0.075**	**0.058**	**0.095**
2 (*Institutions*)	Political environment	0.036	0.026	0.052	**0.105**	**0.08**	**0.132**
	Regulatory environment	0.029	0.019	0.041			
	Business environment	0.037	0.025	0.056			
3 (*Human capital and research*)	Education	0.023	0.013	0.039	**0.2**	**0.169**	**0.236**
	Tertiary education	0.023	0.015	0.036			
	R&D	0.152	0.117	0.191			
4 (*Infrastructure*)	ICT	0.057	0.042	0.077	**0.125**	**0.108**	**0.147**
	General infrastructure	0.038	0.019	0.065			
	Ecological sustainability	0.027	0.017	0.045			
5 (*Market sophistication*)	Credit	0.034	0.019	0.057	**0.117**	**0.094**	**0.141**
	Investment	0.024	0.01	0.044			
	Trade, competition& Market scale	0.056	0.04	0.078			
6 (*Business sophistication*)	Knowledge workers	0.062	0.042	0.088	**0.23**	**0.188**	**0.275**
	Innovation linkages	0.031	0.015	0.061			
	Knowledge absorption	0.132	0.096	0.175			

Source: own elaboration based on GII and WDI datasets. Note: The regression used all countries available in the GII and WDI dataset

Table A.2 Determinants of firm innovation performance across developing East Asian countries: basic firm characteristics (odds ratio)

Control variables	Product OR process	Product	Product_new (among firms reporting product innovation)	Process	Organizational	Marketing
	(1)	(2)	(3)	(4)	(5)	(6)
age	0.988*	0.974**	1.000	0.989**	0.980**	0.973**
Size (micro=reference)						
Small	1.04	0.630**	0.111*	0.820*	1.992	1.262*
Medium	1.758**	1.555*	0.161	1.269	4.611	2.580**
Large	3.228**	2.804**	0.247	2.100**	14.007*	4.249**
Export status						
Exporter	1.409	1.465**	0.434**	1.442*	1.818*	1.460+
Ownership						
Foreign	0.725*	0.744*	0.711	0.684+	0.440**	0.71
City size (less than 50k=reference)						
City with population>1 million	6.181**	7.784**	1.478	5.935**	7.136**	4.591**
Over 250.000 to 1 million	3.843**	3.608**	2.435*	4.081*	4.789**	3.539*
50.000 to 250.000	4.415*	2.200**	2.495**	5.161*	7.368**	3.831*
Sector (retail/wholesale=reference)						
manufacturing	1.799**	1.609*	0.505*	1.901**	0.832	0.724
IT	0.812	0.867	16.676**	0.647	0.471	0.434*
hotel&restaurants	1.493	1.700+	0.166*	1.779	0.778	1.08
construction	0.803+	0.523*	0.339**	1.016	1.271	0.693
Transport	0.702	0.662+	0.327**	0.792	0.856	0.217**
other services	4.212**	2.415**	0.98	3.446**	0.962	1.468+
Constant	0.012**	0.016**	67.324**	0.012**	0.003**	0.041**
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Source: own elaboration based on ES dataset. Note: logit regression applies sampling weights. The following countries were included in the analysis: Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Thailand, and Vietnam

+ p<0.10, * p<0.05, ** p<0.01

Table A3. Determinants of firm innovation performance across developing East Asian countries: basic firm characteristics and use of innovation inputs (odds ratio)

Control variables	Product OR process	Product	Product_new (among firms reporting product innovation)	Process	Organizational	Marketing
	(1)	(2)	(3)	(4)	(5)	(6)
R&D activities						
Yes	7.055**	4.458**	0.813	6.161**	2.362*	4.424**
Training activities						
Yes	2.958**	2.939**	1.791*	3.144**	4.219**	3.921**
Tech license						
Yes	1.468	1.332	1.404	1.606*	3.514*	3.754**
age	0.989*	0.971**	0.997	0.990+	0.979**	0.973**
Size (micro=reference)						
Small	1.044	0.592**	0.476**	0.692**	0.277**	1.073
Medium	1.369	1.224	0.621	0.78	0.494+	1.621**
Large	1.690**	1.512*	1.000	0.778	1.000	1.303
Export status						
exporter	0.994	1.22	0.395**	1.033	1.207	0.971
Ownership						
foreign	0.692**	0.663*	0.782	0.640*	0.524**	0.787
City size (less than 50k=reference)						
City with population>1 million	5.096**	6.141**	1.57	4.636**	5.592**	3.361**
Over 250.000 to 1 million	2.904*	2.513**	2.506*	3.030*	3.069**	2.391
50.000 to 250.000	3.686+	1.505	2.253**	4.320*	5.329*	2.711+
Sector (retail/wholesale=reference)						
manufacturing	2.247**	2.078*	0.486**	2.447**	0.960	0.77
IT	0.718	0.988	15.013**	0.534	0.342	0.262**
hotel&restaurants	1.758	2.123*	0.136*	2.108	0.878	1.195
construction	0.932	0.660+	0.324*	1.234	1.357	0.764
Transport	0.679	0.727	0.332**	0.834	1.01	0.177**
other services	4.790*	1.905	5.145	4.307**	0.812	1.513
Constant	0.010**	0.017**	24.531**	0.013**	0.022**	0.050**
Country Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Source: own elaboration based on ES dataset. Note: logit regression applies sampling weights. The following countries were included in the analysis: Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Thailand, and Vietnam

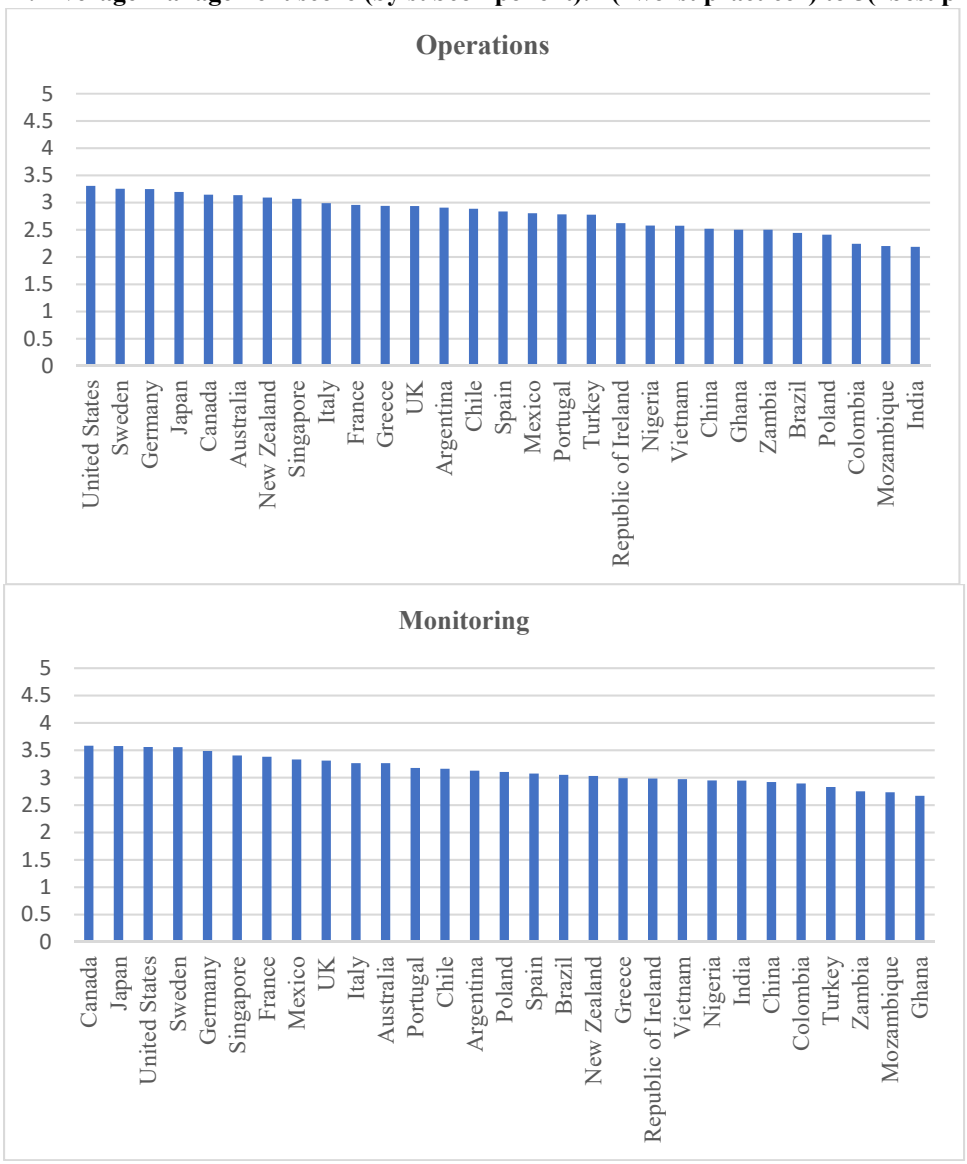
+ p<0.10, * p<0.05, ** p<0.01

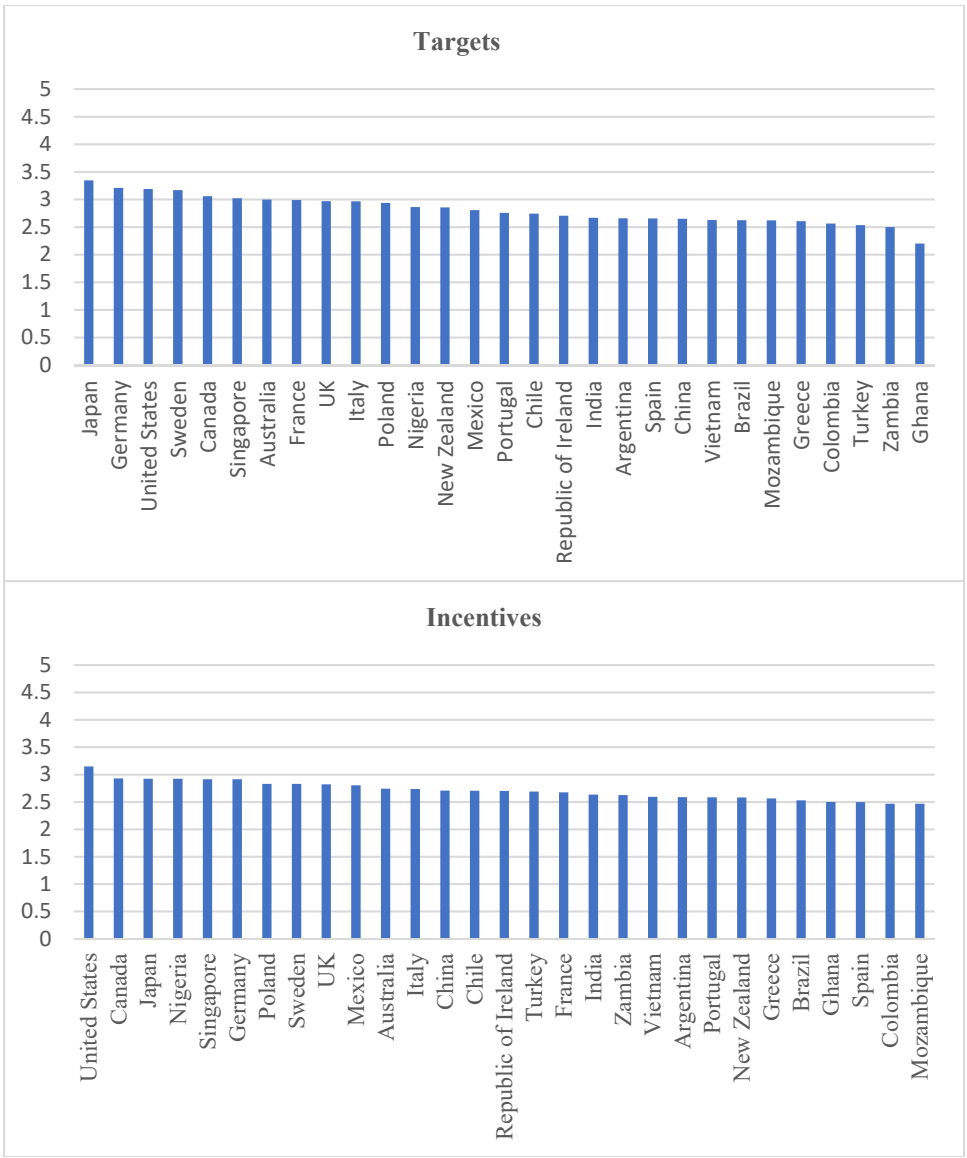
Table A4. Summary statistics of overall management score by country

country	N of firms	mean	sd	min	max
Argentina	450	2.797	0.615	1.167	4.778
Australia	439	3.001	0.581	1.111	4.444
Brazil	1076	2.697	0.648	1.056	4.722
Canada	396	3.160	0.619	1.444	4.556
Chile	360	2.865	0.545	1.222	4.167
China	680	2.729	0.469	1.278	4.222
Colombia	170	2.578	0.544	1.167	3.944
France	590	3.010	0.551	1.500	4.556
Germany	496	3.202	0.560	1.588	4.722
Ghana	1	2.500	.	2.500	2.500
Greece	585	2.720	0.703	1.111	4.833
India	709	2.625	0.717	1.000	4.833
Italy	622	2.979	0.587	1.333	4.500
Japan	168	3.238	0.614	1.444	4.778
Mexico	477	2.949	0.643	1.278	4.611
Mozambique	10	2.517	0.506	1.778	3.389
New Zealand	136	2.851	0.559	1.111	4.056
Nigeria	13	2.885	0.674	1.722	4.500
Poland	362	2.890	0.642	1.056	4.556
Portugal	410	2.821	0.620	1.133	4.444
Republic of Ireland	161	2.766	0.769	1.278	4.889
Singapore	242	3.088	0.669	1.222	4.778
Spain	214	2.748	0.616	1.278	4.389
Sweden	377	3.187	0.553	1.389	4.722
Turkey	332	2.706	0.400	1.722	4.056
United Kingdom	1437	3.014	0.625	1.111	4.889
United States	938	3.285	0.639	1.222	4.889
Vietnam	75	2.667	0.541	1.667	3.824
Zambia	4	2.653	0.661	1.722	3.222
Total	11930	2.920	0.644	1.000	4.889

Source: own elaboration based on WMS dataset.

Figure A1: Average management score (by subcomponent): 1("worst practice") to 5("best practice")





Source: own elaboration based on WMS dataset.