Structural Transformation in Thailand: A Perspective Through Product Innovation

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Abstract

This paper examines Thailand's economic development through the perspective of structural transformation. Building on the insight that the products that a country exports tells much about the country's underlying capabilities, we study Thailand's evolving product structure both at the aggregate country level as well as at the firm level. We show that over the last 30 years, the diversification of Thailand's product structure has been impressive, with important footholds being established in many well-connected and increasingly sophisticated products. This positive overall picture, however, masks potentially serious distributional problems. The number of firms and the number of provinces that are actively engaged in and contributing materially to Thailand's product upgrading are highly concentrated. This may be limiting the gains to the economy more broadly. We confirm the importance of existing product structures at the country, regional, and firm levels for the evolution of firms' product structure over time. That is, the current basket of goods produced by firms, regions, and the country affect firms' decision over which products to introduce and which ones to drop. This path-dependent nature of product innovation has important implications for policy.

JEL classification: O11, O12, O25, O30, F10

Keywords: Innovation, Structural transformation, Economic complexity, Product churning, International trade, Export firms, Thailand.

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Introduction

What determines a country's ability to grow in the long run? Economists have long identified the critical role of productivity growth in explaining large differences in income levels across countries. As Paul Krugman succinctly noted: "Productivity isn't everything, but in the long run it is almost everything." With respect to the drivers of productivity growth, recent growth theories have focused on the role of knowledge and capabilities, both in terms of their generation as well as diffusion. But in order to understand the role of knowledge and capabilities in driving economic development, we need to measure it. How can this be done?

Recently Hidalgo and Hausmann (2009, 2011) have proposed a practical way to proxy the amount of productive knowledge an economy holds by examining the products that it can produce and export with relative comparative advantage. The basic insight is to view products as the embodiment of a complex set of technological know-how and capabilities that differ greatly across countries. More sophisticated and complex products require special and correspondingly more advanced capabilities that only certain countries possess. Thus, the products that countries are able to make reflect their underlying capabilities, defined broadly to include both tangible factors, such as infrastructure, as well as intangible ones, such as the quality of economic institutions. Changes in the product mix that countries make therefore informs on the evolution of countries' underlying capabilities. These measures have enabled numerous studies on various aspects of knowledge and its diffusion, both at the aggregate and more granular levels.

This strand of the literature puts structural transformation at the forefront of the understanding of economic growth. Differences in countries' ability to upgrade their product structure and diversify into more complex goods explain why some countries attain higher income levels while others remain poor. This process of product migration relies on underlying capabilities, much of which are tacit and not easily transferable, and also specific to particular products or industries. The evolution of countries' production structure is thus path dependent. What you do today determines where you go tomorrow. The specific skills and capabilities that a country has at any point in time, as reflected in its current industrial structure, determine the set of 'nearby' products, industries, and activities that the country will diversify into.

But it is not enough to simply move into new products. For there to be a meaningful contribution to economic growth at the aggregate level, the new industries must attract resources into them in substantial enough quantities. Participation must be sufficiently broad. As emphasized by McMillan and Rodrik (2011), structural transformation depends on two key dynamics: the rise of new industries (i.e. economic diversification) and the movement of resources from traditional industries to these new higher productivity industries. Without the first, there is little that propels the economy forward. Without the second, productivity gains don't diffuse to the rest of the economy.

This paper examines Thailand's economic development through the perspective of structural transformation. Building on the insight that the products that a country exports tells much about the country's underlying capabilities, we study Thailand's evolving export product structure both at the aggregate country level as well as at the firm level. In doing so, we exploit a rich dataset on international trade transactions made available by the Thai Customs Department and supplemented by balance sheet information from all registered firms.

Utilizing the measures of product sophistication and relatedness proposed by Hidalgo and Hausmann (2009, 2011), we investigate the determinants of the product mix that a country or firm chooses and look for the existence of path dependencies. In particular, we test whether product innovation is related to pre-existing productive capabilities at the firm, regional, or country levels. We also examine how widespread the gains from product innovation has been by looking at the distribution across firms and across provinces of various products. This informs us on the extent to which product innovation has led to structural transformation at the economy-wide level.

To our knowledge, this is the first systematic study of how the product mix of Thai firms has evolved over time. Existing analysis of Thai exports have focused on broad sectors and those that examine disaggregated product-level dynamics do not do so from a firm-level perspective. Understanding product evolution at the firm level is crucial to gaining insights into broader sectoral or economy-wide trends because it is at the firm level that critical decisions about the mix of products are taken in practice. This is in line with the new trade literature that focuses on firm as the decision making unit utilizing rich firm level data (see Bernard et al (2009) and Bernard et al (2007a,b) for a review).

We find that product innovation and churning is a critical part of firm activity. In our sample of export manufacturing firms, almost 90 percent alter their product mix over a 5-year period and new products on average account for 25 percent of individual firms' total export value. Firm product innovation also exerts considerable influence on aggregate export values with the average contribution from firms adding product amounting to roughly half of each products' export value. Firms also have broad reach. Among manufacturing firms, over 72 percent export more than 1 product, and over half operate across industries and/or sectors accounting for an astonishing 90 percent of all manufacturing exports. That said, firms specialize, with the primary product of multi-product firms typically accounting for between 70-80 percent of their exports.

We also confirm the importance of pre-existing product structures at the country, regional, and firm levels, for the evolution of firms' product structure over time. That is, the current basket of goods produced by firms, region and the country affect firms' decision over which products to introduce and which ones to drop. They also determine the survival probability of new products, with those that are more aligned with existing production structures more likely to survive. These effects are all larger for more sophisticated products.

The importance of existing production structure is a two-edged sword: on the one hand, it suggests the existence of positive spillovers across firms and complementary network synergy effects that help to ease firms' product innovation in certain industries; on the other hand, the existing production structure may constrain firms' ability to "leap" into new and far away products. Either way, it sheds new light into the process of structural change. The importance of pre-existing local product structure for subsequent product innovation helps in understanding how product clusters emerge within countries. Path dependencies in product migration, in particular, implies path dependence in the geographic evolution of production within countries, offering new insights into regional agglomeration and development. They also imply that what one produces matters for the direction that one should go. Measures to promote new industries should consider the pre-existing capabilities of the economy in order to optimize chances of success and to be cost-effective.

From a country level perspective, the evolution of Thailand's product structure has been impressive. Over the last 30 years, Thailand has significantly diversified and upgraded its product structure from what was predominantly agricultural based to increasingly sophisticated manufacturing goods. It has gained important footholds in well-connected and higher value added industries such as electronics, machinery, and motor vehicles and parts. The economy appears well placed to exploit these key footholds and migrate further into new high value-added products. But this overall positive picture masks potentially serious distributional problems at the disaggregate level. The number of firms and the number of provinces that are actively engaged in and contributing materially to Thailand's product upgrading are highly concentrated. Only a handful of firms in a few key provinces are driving Thailand's product innovation, and their contribution to total output is limited. This is suggestive of inefficient resource allocation.

The overall picture that emerges is one of Two-Thailands: one of leading firms and provinces operating at the frontier, and the other of laggards that make up the bulk of the economy at risk of being left behind. This may have wider repercussions for the economy as a whole. Thai firms are succeeding in expanding into higher value-added products and industries, but there are simply not enough of them and the gains are not filtering substantively enough into the wider economy. Hence the overall economic gains are not very apparent at the aggregate level but concentrated in a few firms and regions. This is reflected in the much diminished contribution of structural change in Thailand's growth over the last 15 years. And it may explain why Thailand's income level is low relative to other countries at similar levels of product structure sophistication. To the extent that the high concentration across firms and provinces in product innovation activity reflects concentration of capabilities in particular firms or regions, reinvigorating aggregate growth requires addressing the disparities in productivity and resource allocation among firms. Misallocation, inequality, and limited diffusion could be constraining growth below potential.

The rest of the paper is structured as follows. The first section outlines the conceptual framework for analyzing structural transformation through the evolution of countries' product structure, describes the data, and examines Thailand economic evolution through this perspective. The second section investigates product evolution at the firm level focusing particularly on the determinants of product adding, dropping, and survival. Section three examines the distributional aspects of product innovation across firms and regions, linking this back to the overall performance of the economy. The final section concludes.

1. Structural Transformation and Thailand's Product Structure

It has long been established that developing economies are characterized by large productivity gaps between different parts of the economy. Dual economy models have typically emphasized productivity differentials between broad sectors of the economy, such as the traditional (rural) and modern (urban) sectors. More recent research has identified significant differentials within modern, manufacturing activities as well (eg. Hsieh and Klenow (2009) and Restuccia and Rogerson (2017)). Large productivity gaps can exist even among firms and plants within the same industry. These gaps tend to be much larger in developing countries than in advanced economies. They are indicative of the allocative inefficiencies that reduce overall labour productivity.

Given these differences, it is possible to decompose a country's labour productivity growth into two components. The first "within" component reflects productivity growth that occurs within each sector. The second "between" component captures the productivity effect of labour reallocations across different sectors and activities, what McMillan and Rodrik (2011) call the "structural change" term. We focus on this second element of productivity growth, which is driven by two key dynamics: economic diversification through the rise of new industries and the movement of resources from traditional activities to these new higher productivity industries. The first force works to propel the economy forward, while the second acts to spread the productivity gains to the rest of the economy. Both forces are critical to the structural transformation of countries that lift overall productivity levels.

Rodrik and Mcmillan (2011) find that the goods that countries specialize in is an important determinant of whether and the extent to which structural change goes in the right direction and contributes to overall productivity growth. Hausmann and Hidalgo (2009, 2011) take this idea further and developed a framework to quantify the productive knowledge embedded in an economy by examining the products that it exports. By tracking the evolution of countries' product structure, one can then assess the extent to which countries are developing the necessary capabilities to generate structural transformation. We will base our assessment of Thailand's economic evolution through this product-based view of structural transformation. Before doing so, we briefly outline the data used in this paper.

1.1 Data Sources

Three different sources of data are brought together: i) international trade flows from BACI database which is provided by CEPII. The database holds bilateral trade values at 6-digit HS disaggregation; ii) trade transactions of Thai exporters from the Thai Customs Department at the Ministry of Finance; and iii) Company Profile and Financial Statement (CPFS) database from the Department of Business Development at the Ministry of Commerce.

The customs data cover all shipments of goods that crossed into or out of Thailand between 2001 and 2015. The key variables available include firm identification, destination/origin, commodity, value, currency, shipping method, point of entry/exit, as well as tariffs and duties. Apaitan et al (2016) provide detailed discussion of this data. The CPFS database consists of annual financial statements submitted to the department by all registered firms in Thailand. Key available variables include firm identification, balance sheet items (total and sub-items of assets, liabilities, and equities), and income statement items (revenues, expenses, and net income). The data also include information on the type of business and industry in which each firm operates, as well as firm location. Merged with the customs data, CPFS data provides additional information on major characteristics of traders who are registered firms.

We base our analysis on HS2007 classification. The trade transactions of Thai exporters beyond 2012 (which are reported in HS2012 classification) are converted to HS2007. To avoid large fluctuations associated with the global financial crises, our primary focus is on the period 2010-2015. The matched sample contains 36,612 exporting firms in 2015, of which 10,759 are manufacturing firms. We next outline the conceptual framework behind the key measures that we will use to quantify countries' economic capabilities before turning to the dynamics of Thailand's production structure.

1.2 Products and Capabilities: A Measurement Framework

Instead of seeing products as made with machines, raw materials and labour, Hausmann and Hidalgo (2009, 2011) propose a framework that views products as the embodiment of knowledge, know-how, and capabilities. To successfully produce and sell products in significant quantities, an agglomeration of factors have to come together. This includes not only the requisite knowledge of how to make the product, but also enabling factors such as transportation infrastructure, inputs and market institutions. Markets play a key role in harnessing the numerous bits and pieces of know-how distributed among many people to produce a larger variety of more sophisticated products. They allow the knowledge that is held by few to reach many. Thus, specialization at the individual or firm level begets diversity at the national and global level.

The amount of knowledge that is required to make a product can vary enormously from one good to the next. Some goods, like medical equipment or car engines, embed large amounts of knowledge and are the results of very large networks of people and organizations. By contrast, shirts or coffee, embed much less knowledge, and the networks required to support these operations do not need to be as large. Exploiting these variations, one can infer differences in the amount of productive knowledge that countries hold. Complex economies are those that can combine vast quantities of relevant knowledge together, across large networks of people, to generate a diverse mix of knowledge-intensive products.

To quantify complexity, Hausmann and Hidalgo (2009) proposed an innovative use of international trade data to infer the capabilities needed to produce a given product. The basic building block revolves around measuring the "diversity" and "ubiquity" of each product that a country exports with revealed comparative advantage[1]. Diversity refers to the number of products that a country exports, while ubiquity refers to how unique the product is in terms of the number of countries that are able to export it.

The framework then combines diversity and ubiquity to approximate the variety of capabilities available in a country or required by a product. The underlying idea is that a country can export a particular product with RCA if it possesses the necessary capabilities. Thus, a country with more diversified export baskets has more capabilities. Similarly, a product that is less ubiquitous – and hence exported by fewer countries – requires more exclusive capabilities. Using an iterative procedure that considers information on both diversity and ubiquity, quantitative measures of complexity can be derived: the Economic Complexity Index (ECI) for countries and the Product Complexity Index (PCI) for products. Details of the construction of ECI and PCI are contained in Hausmann et al. (2011).[2]

[1] Revealed comparative advantage (RCA) of country *c* in product *p* is defined as

$$RCA_{c,p} = \frac{X_{c,p} / \sum_p X_{c,p}}{\sum_c X_{c,p} / \sum_c \sum_p X_{c,p}}$$

where $X_{c,p}$ denotes the export value of product *p* by country *c*. That is, the RCA is calculated as the share of product *p* in country *c*'s total exports, divided by the share of product *p* in the world exports. A country has a revealed comparative advantage in product *p* if RCA of product *p* is greater than 1.

[2] There are two main limitations to the measures. First, they use data on exports, not production. Second, the dataset includes only goods trade, not services. That said, recent preliminary analysis shows that these measures are robust to the inclusion of services.

The underlying intuition for these measures is well captured by thinking of the various capabilities as Lego pieces. In this analogy, a product is equivalent to a Lego model, and a country is equivalent to a bucket of Legos. Countries will be able to make products for which they have all of the necessary capabilities, just as the Lego models that can be built are constrained by the types of Lego pieces in the bucket. Advanced Lego models require more unique pieces, and the more pieces that one has the more models that one can build. Inferring capabilities from a country's exports can be compared to looking at Lego models and gauging how extensive the bucket that was used to build them were in terms of the number as well as uniqueness of the pieces that it contained.

It is worth noting the contrast between this view and the strand of the growth literature that stresses the role of core productive factors such as capital, labour, institutions, and technology (eg. Aghion and Howitt (1992), Aghio et al (2014)). In that approach, particular products are ignored and the focus is more on generic factors that drive long run growth. While the focus on capabilities does include the role of these factors implicitly, they also encompass broader and more specific elements of skills and know-how. Because it is hard to transfer and acquire, such tacit knowledge makes the accumulation of productive knowledge difficult, limiting its diffusion, and ultimately constraining the process of growth and development.[3] It also creates important path dependencies in countries' industrial development process. Because acquiring the requisite know-how to successfully produce goods in brand new unfamiliar industries is difficult, countries tend to move into industries that mostly reuse what they already know, since these industries require adding modest amounts of productive knowledge. For example, it is easier to move from shirts to blazers than it is to move from shirts to engines. Economies thus diversify by moving from the products they already produce to others that require a similar set of embedded knowledge and capabilities.

A key aspect of understanding countries' development process, and the underlying evolution of economic capabilities, therefore lies in understanding the similarities in the capability requirements of different products. Hidalgo et al. (2007) proposed a measure of proximity or relatedness between products based on a simple insight. If a country can export two products simultaneously, then those two products are likely to have similar requirements in terms of institutions, infrastructure, resources, technology, or some combination thereof. For example, if shirts require knowledge that is similar to that required by blazers, but different from that required by engines, then the probability that a country exporting shirts will also export blazers will be higher than the probability that it will also export engines. So the probability that a pair of products is co-exported carries information about how similar these products are.

More specifically, one can define the proximity between product *p* and *p'* as

$$\phi_{pp'} = min\{Pr(p|p'), P(p'|p)\} \quad (1)$$

where $Pr(p|p')$ is the probability that a country has RCA>1 in product *p* given that it has RCA>1 in product *p'*. That is, $Pr(p|p')$ is the ratio of the number of countries with RCA in both *p* and *p'* over the number of countries with RCA in *p*. $Pr(p'|p)$ is the ratio of the number of countries with RCA in both *p* and *p'* over the number of countries with RCA in *p'*. By using the minimum of these two

[3] One prominent example of tacit knowledge is learning-by-doing. This has long been recognized as a key dimension in driving firm productivity. Recent studies based on micro-level production data has provided more detail on this process (eg Benkard (2000) and Kellogg (2011)).

pairwise conditional probabilities, we circumvent the problem when a country is a sole exporter of one good and also make the measure more stringent. Proximity is thus calculated as

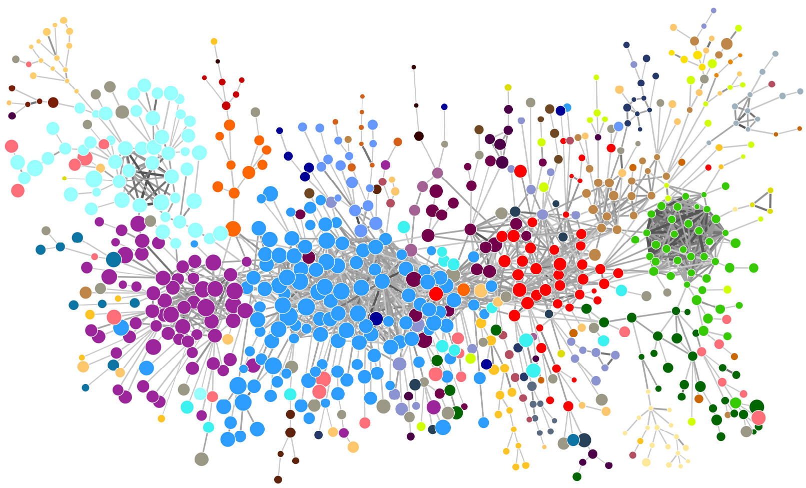
$$\phi_{pp'} = \frac{\sum_c M_{cp} M_{cp'}}{\max\left(k_{p,c}, k_{p',c}\right)} \qquad (2)$$

where M_{cp} = 1 if country c exports product p with RCA>1 and 0 otherwise, and $k_{p,c} = \sum_c M_{cp}$.

This measure can be used to calculate the proximity between all pairs of products in our dataset. The collection of all proximities is a network connecting pairs of products that are significantly likely to be co-exported by many countries and, hence, require a degree of similarity in terms of input and capabilities. Hausmann et al. (2011) refer to this network as the "product space" and use it to study the productive structure of countries.

To the extent that products embody knowledge that are tacit in nature and producing new products require additional know-how, it follows that developing these new capabilities will be easier if they can leverage on those that already exist. This reduces the need to coordinate the accumulation of several new capabilities simultaneously. The product space can then be seen as a description of the varied routes and possibilities that countries may take in diversifying production across products or industries. Depending on the starting point, some routes will be easier to attain than others. This makes the development process path dependent.

Figure 1: The Product Space



Source: Hausmann et al. (2011).

Figure 1 shows the product space as depicted by Hausmann et al. (2011). The size of nodes reflects products' PCI score and the colour denotes industry clusters. Clearly, products in the same industry tend to cluster together and complex products tend to lie in dense and highly-connected middle part of the network reflecting the existence of a large number of neighbouring products that use a similar set of capabilities. High density of links between products enables agglomeration externalities and synergies of various kinds. Network proximity allows "leaps" across the product space to new products. Countries that already have what it takes to make one product will find it relatively easy to move to the nearby ones. A highly connected product space, therefore, makes the problem of growing the complexity of an economy easier. Conversely, a sparsely connected product space makes it harder.

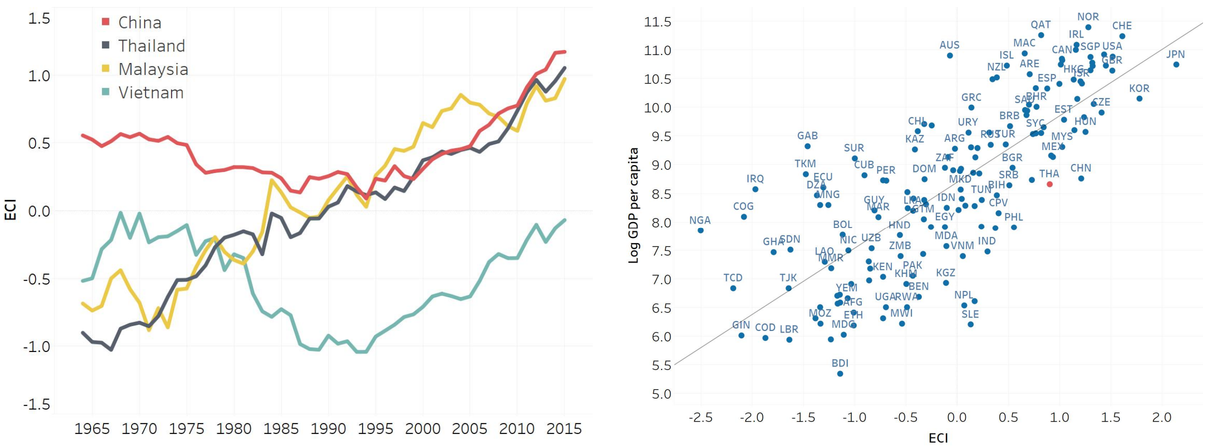
1.3 Thailand's Economic Evolution through the Lens of Product Migration

We begin by examining Thailand's economic development through the view of economic complexity. The left-hand panel of Figure 2 shows that Thailand's economic complexity has risen steadily over the last 30 years. This reflects the continued success of Thailand in gaining footholds in new products and industries. Starting from import substitution to export orientation in the 1970s, Thailand's manufacturing base expanded rapidly during 1980-1995 and continued to consolidate in the subsequent period of export orientation. The relative high diversity of Thai exports is reflected in an ECI score that ranks 24th in the world in 2015, on par with Malaysia and above many OECD countries. This is rather striking given Thailand's relative income level.

To put this in a broader context, the right-hand panel of Figure 2 plots countries' economic complexity index (ECI) against real GDP per capita. There is a clear positive relationship between economic complexity and income levels. This echoes Hausmann et al. (2007, 2011) finding that the ECI explains differences in per capita income well and also helps to predict economic growth. The figure shows that relative to its income level, Thailand places high in terms of its level of complexity. On the one hand, this can be viewed as indicative of Thailand's potential to grow quickly in the future to reap the full benefits of the capabilities it already possesses. On the other, it indicates that Thailand is punching below its weight, with some underlying frictions preventing it from realizing its full economic potential. We provide some suggestive evidence of such frictions below when we turn to the firm level analysis.

Figure 2: Economic Complexity

Economic Complexity by Country, 1964-2015 | Economic Complexity Index vs GDP per Capita, 2015

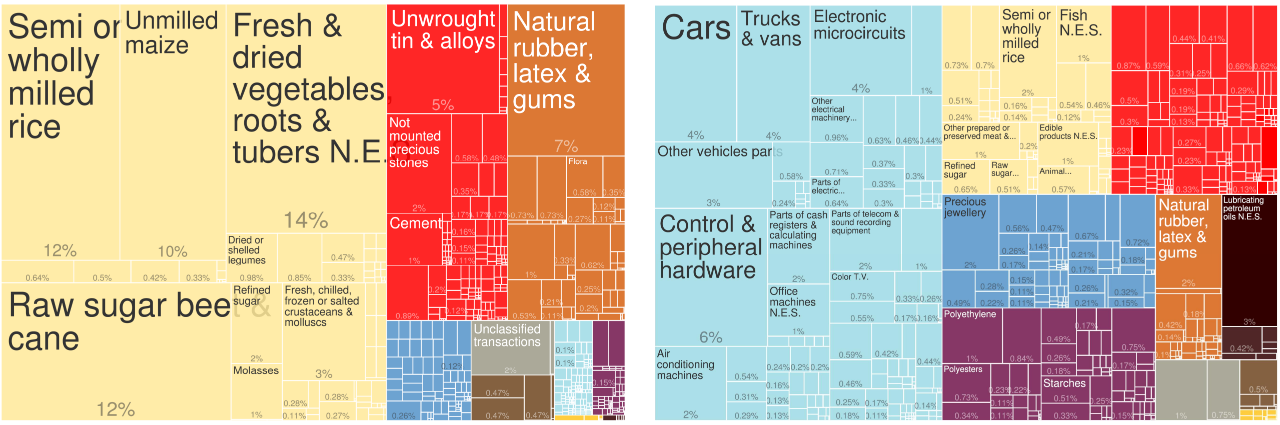


Source: Hausmann et al. (2011) and authors' calculation. The Atlas of Economic Complexity (HS 4-digit) and World Development Indicators. Note: The right panel includes 159 countries, excluding countries with GDP less than 1 billion USD.

Turning to Thailand's evolving product structure, Figure 3 provides two snap shots of Thailand's export composition. Comparing 1975 and 2015, one can clearly see the transformation of Thailand's export basket from one that was largely agricultural based to a much more manufacturing oriented product mix. The rise of electronics, machinery and motor-vehicles-related goods have been particularly dramatic. These now account for 46 percent of total exports while agricultural goods make up only 12 percent.

Figure 3: Thailand's Evolving Export Basket

Thailand's Exports in 1975 | Thailand's Exports in 2015



Source: The Atlas of Economic Complexity.

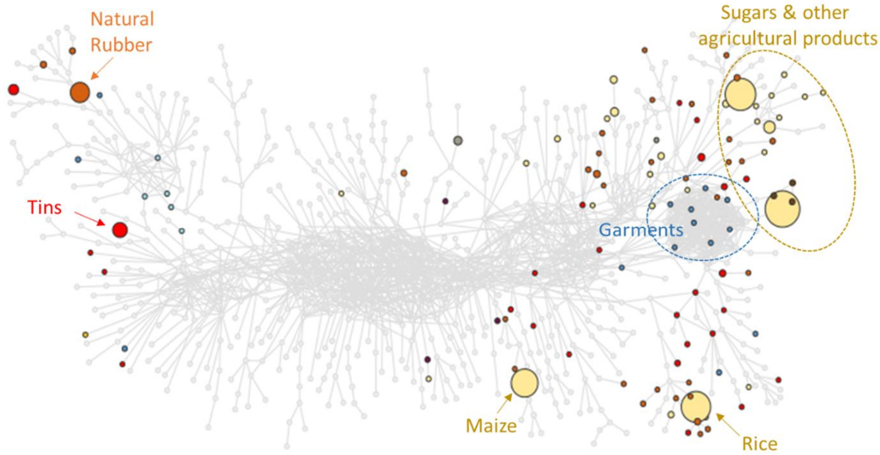
A better sense of Thailand's evolving capabilities can be obtained by examining Thailand's development through the product space. Figure 4 shows that back in 1975, Thailand occupied the sparse regions of the product space specializing mainly in agricultural commodities but with a few products also in garments as well as natural rubber. By 1995, those initial footholds in garments and natural rubber had expanded substantially along with the impressive rise of an electronics cluster – particularly in the hard disc drive industry. A degree of migration towards the middle part of the product space can also be seen, primarily in automotive electrical parts and tires.

These initial footholds again set the foundation for significant subsequent expansion in this dense part the product space, so that by 2015 we see important gains in vehicles and parts as well as plastics, chemicals and rubber products. We also see the much diminished importance of the garments industry as well as agricultural products. Thailand's current position in the highly connected central regions of the product space, along with the emergence of new clusters such as chemical products, suggests strong potential for future diversification. But as we already noted, there may also be important constraints to reaping the full benefits of such diversification.

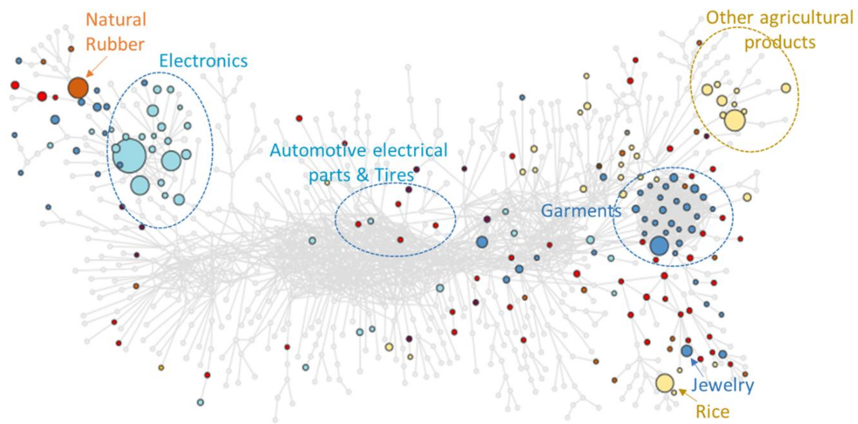
Overall, Thailand's migration leftward and inward through the product space reflects the impressive transformation of the Thai economy from mainly agricultural to a manufacturing powerhouse. This played a critical role in supporting higher income levels and is reflected in the steady increase in Thailand's overall ECI score. Indeed, if one decomposes Thailand's export value according to each products' complexity score (PCI), the rising importance of relatively high complexity products can be clearly seen (Figure 5). Over the last 20 years, the share of the least complex products – defined as products in the lowest PCI quintile – in Thai exports has steadily declined, while those in the top two quintiles generally increased before tapering off since 2007. For comparison, Figure 5 also shows the decomposition for Vietnam and China. The rapid transformation of both countries is striking, with Vietnam now reaching a similar state where Thailand was in 1995 while the share of complex products in China's exports has surpassed those of Thailand by some margin.

Figure 4: Thailand's Migration Through the Product Space

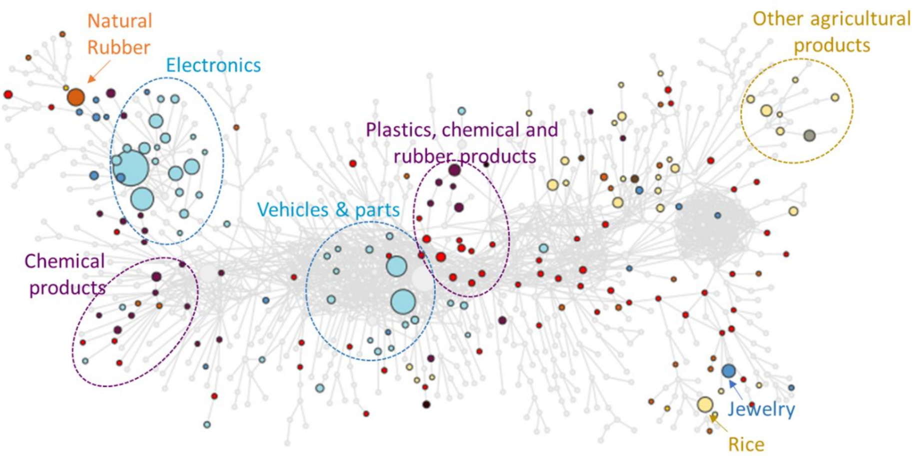
Thailand's Product Space in 1975



Thailand's Product Space in 1995

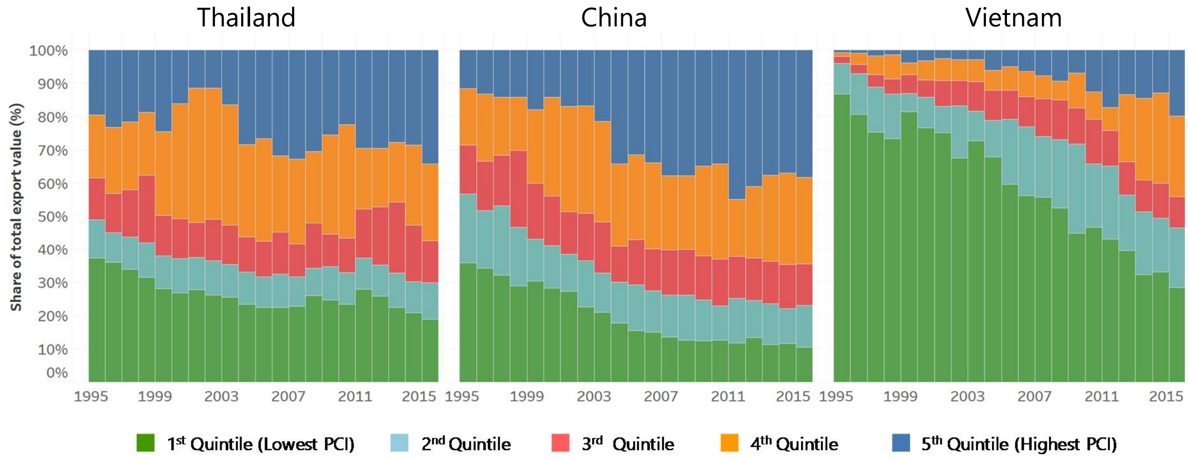


Thailand's Product Space in 2015



Source: The Atlas of Economic Complexity (based on SITC 4-digit) and authors' calculations. Note: Node size represents the share of Thailand's export value.

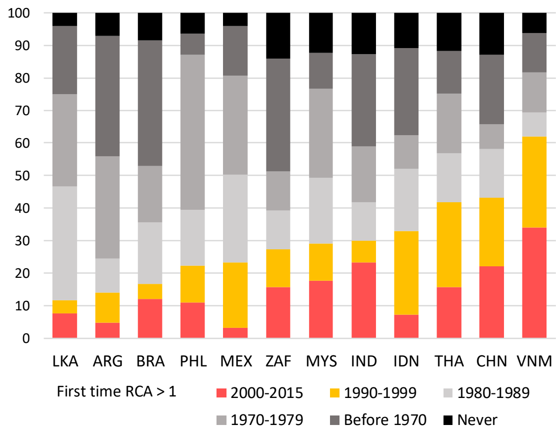
Figure 5: Composition of Export by Complexity



Source: BACI database and authors' calculation.

To get a sense of the dynamism of product innovation, Figure 6 shows the composition of exports in terms of the date which products first attained RCA>1, so that they were exported in significant volumes, for selected emerging market countries. In Vietnam, for example, over half of its exports are made up of products that gained RCA over the last 25 years, whereas for Sri Lanka and Argentina, recent RCA successes make up less than 10 percent of total exports. This reflects the contrasting dynamism between these countries, with Vietnam being clearly more vibrant. Thailand also scores relatively well on this front, with around 40 percent of exports coming from recent vintages of RCA attainment, indicating continued success in breaking into new products and industries.

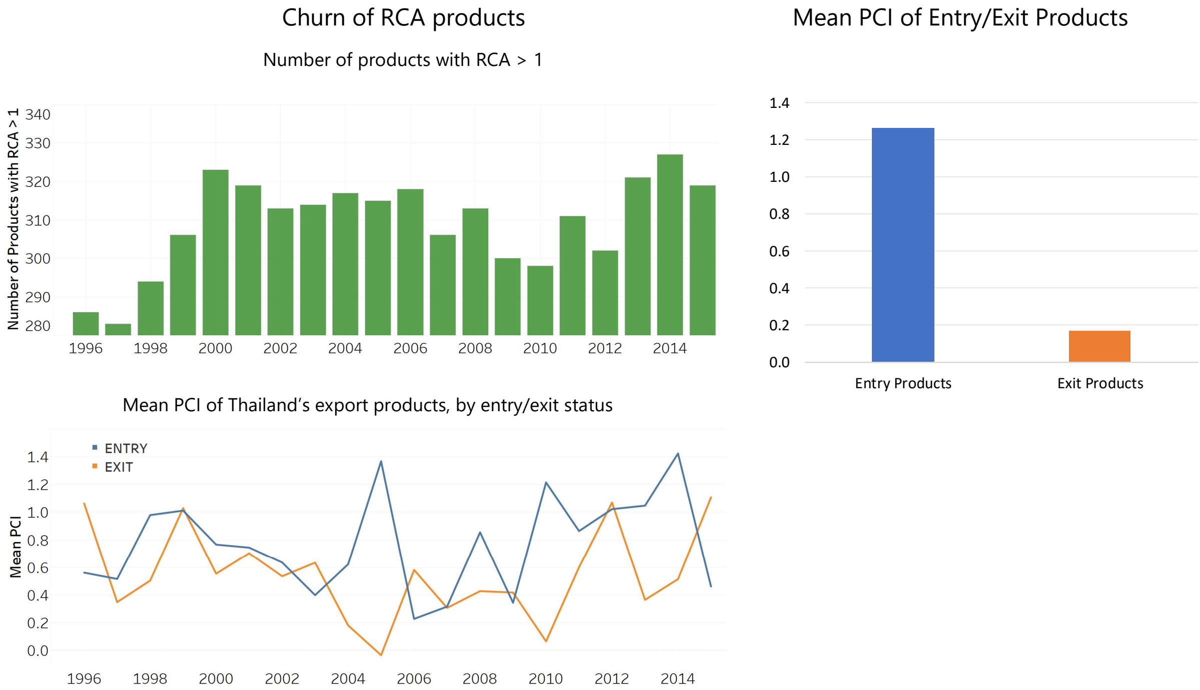
Figure 6: Composition of Export by RCA Vintage



Source: The Observatory of Economic Complexity, UN Comtrade and authors' calculations.

In addition to looking at export values, it is also instructive to examine the *number of products* that Thailand exports with RCA>1 to gauge how its economic diversity has developed over time. Figure 7 shows that Thailand's export diversity increased sharply around 2000 and again in 2013 with a period in between where diversity trended down. Underlying this overall picture has been considerable churn in the flow of products whose export value expanded enough to cross the RCA>1 threshold ("entry" products) and products that lose their revealed comparative advantage status ("exit" products), as well as considerable heterogeneity in the sophistication of these products. The left-hand panel of Figure 7 shows that entry products on average tend to be more complex than those that exit. Indeed, looking at the most recent 5-year period, the average PCI of entry products far exceeds that of exit products (right-hand panel of Figure 7).

Figure 7: Dynamics of Products Exported with Revealed Comparative Advantage

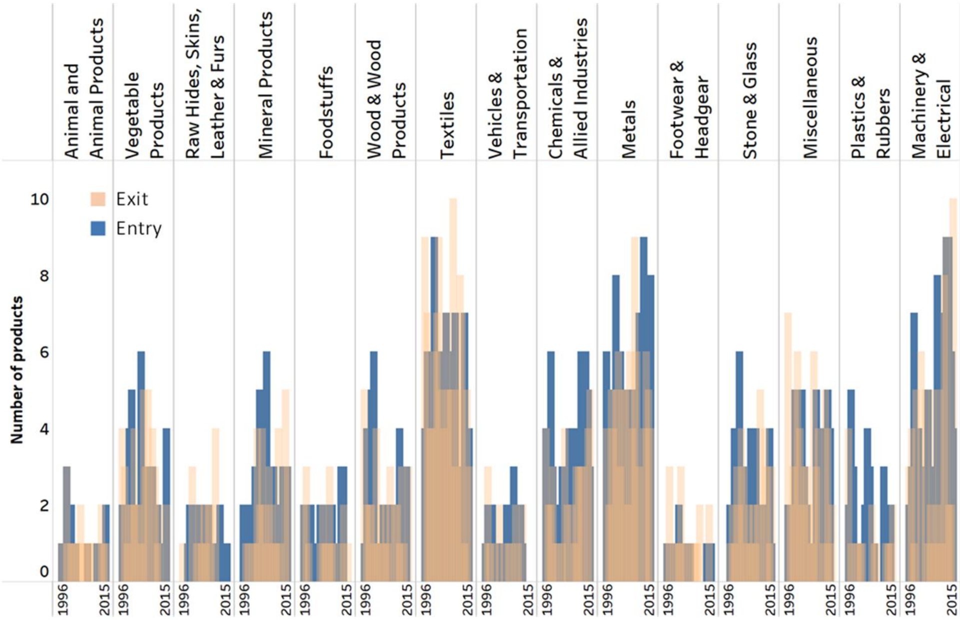


Source: The Atlas of Economic Complexity (based on SITC 4-digit) and authors' calculations. Note: 'Entry' refers to products with RCA<1 in the former period and RCA>1 in the latter period, and vice versa for the 'exit' products. In the left-hand panel, exit and entry status is determined on a year-by-year basis. In the right panel, exit and entry is determined by considering the product's average RCA during 2011-2015 compared with their RCA during 1995-1999.

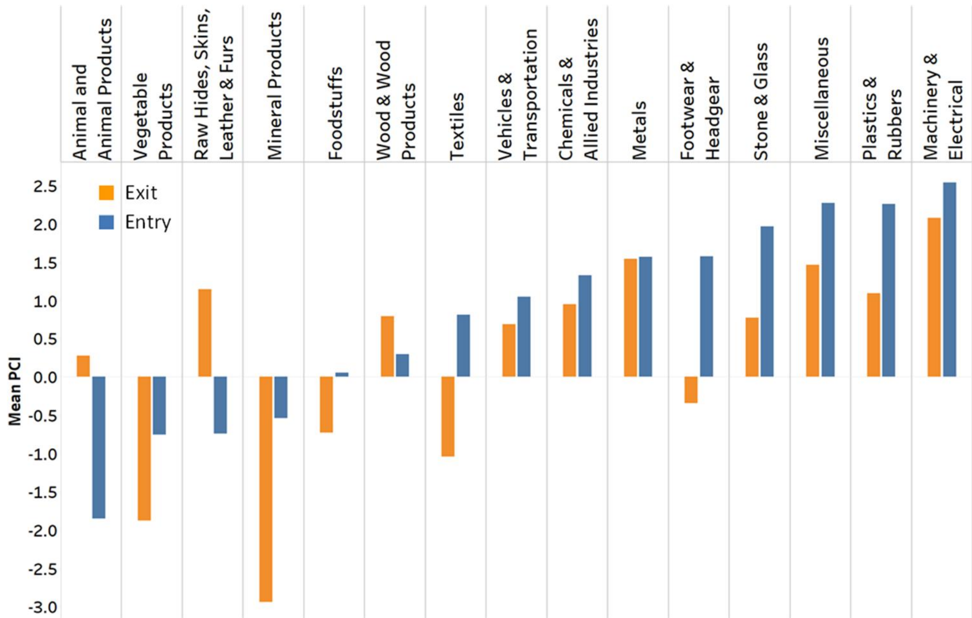
Figure 8 breaks this down across industry sectors. The top panel shows the number of entry and exit products. We see a significant amount of churn across all sectors, particularly in textiles, metals, and machinery and electrical products. Considering the mean sophistication of entries and exits, as measured by the PCI, the bottom panel shows that most sectors, especially high complexity ones such as machinery and electrical products as well as plastics and rubbers, have seen product migration on net towards higher complexity products, while a few lower complexity sectors, such as animal products, have experienced the opposite. Overall, Thailand's upward ECI trend overall is characterized by net product upgrading but with substantial differences across sectors.

Figure 8: Product Churning By Sector

Number of entry and exit products, year by year



Mean PCI of exit and entry products during 1995-2015, by product category



Source: The Atlas of Economic Complexity (based on SITC 4-digit) and authors' calculations. Note: Top panel shows yearly entry and exit products (RCA>1 as threshold). In bottom panel, average PCI of exit products and entry products over 1995-2015 are shown by category.

Finally, it is informative to examine the similarity of Thailand's export structure – and hence its underlying capabilities – to those of other countries. To do so, we construct a "country space" analogue to that of the product space. We base our assessment of closeness between any pair of countries on how similar their product structures are on the basis of the product space. This is done by constructing a measure of relatedness between a country's export basket and the universe of products available and then relating countries to each other based on this measure. Thus two countries don't need to export the same products to be similar but their relation reflects how similar their place in the product space is.

Specifically, we define a country's i relatedness of product p as

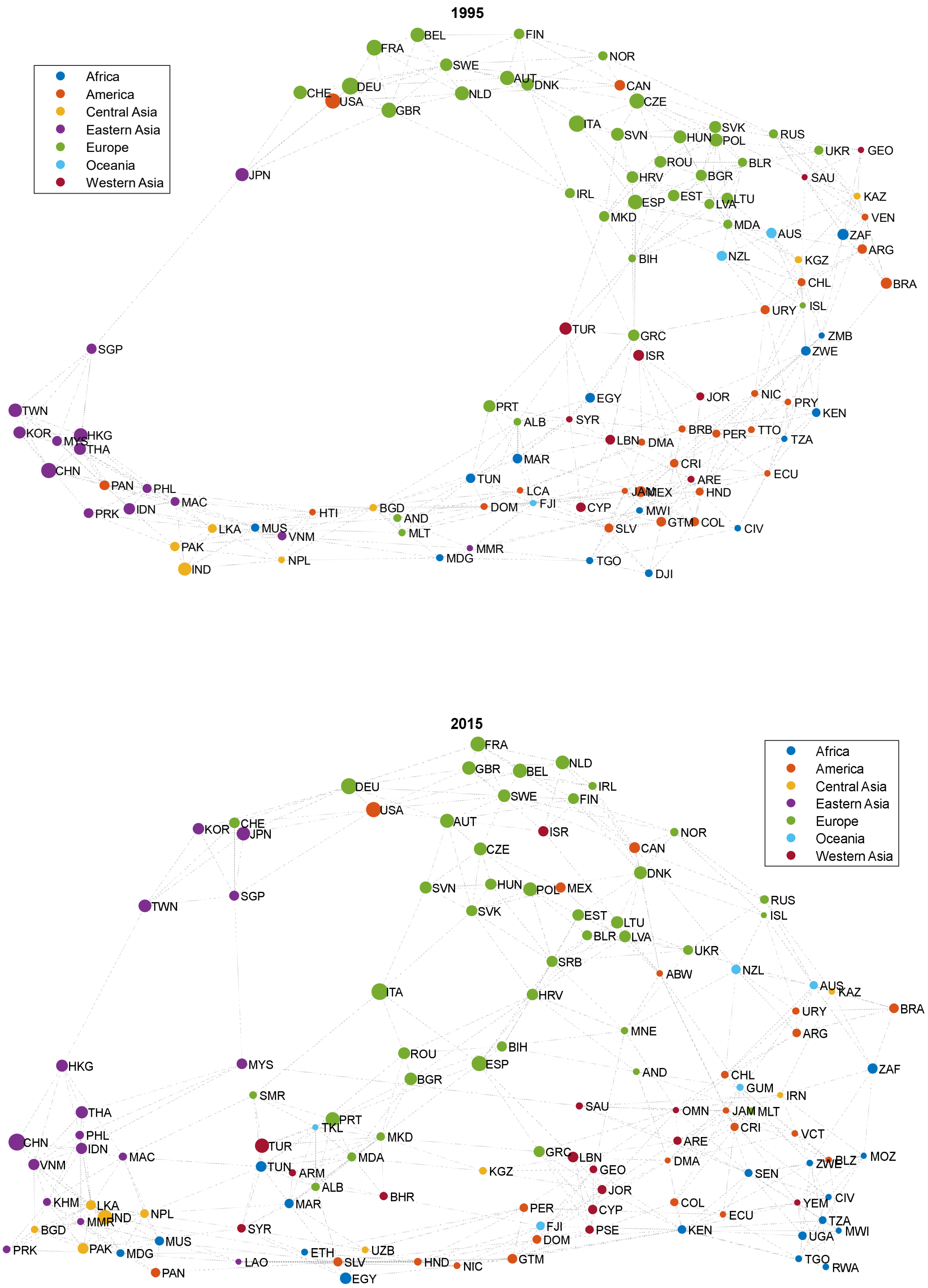
$$Relatedness_{cp} = \frac{\sum_{p'} M_{cp'} * \phi_{pp'}}{\sum_{p'} \phi_{pp'}} \quad (3)$$

whereM_{cp}= 1 if country i exports product p with RCA>1 and 0 otherwise. For each country, we then construct the vector of relatedness ($\overrightarrow{R_c}$) where its elements are $Relatedness_{cp}$. The degree of similarity between a given pair of countries is then simply the correlation between their respective relatedness vectors. This correlation matrix allows us to build the country space using similar steps taken in constructing the product space. Figure 9 depicts the country space for 1995 and 2015 where the node size reflects number of products that the country exports with RCA>1 and the colour code is assigned by region. To avoid cluttering, we only keep the top 5 strongest links for each node and exclude countries that export fewer than 200 products with revealed comparative advantage.

As can be seen in Figure 9, the country space exhibits significant geographical clustering. For example, developing Asia is clustered in the lower left while more advanced economies in Europe and North America are located in the upper right of the country space. Geographical proximity clearly has a bearing on the degree of similarity between countries' product structure. This is consistent with the literature on knowledge diffusion which shows knowledge decays strongly with distance. In closely related work, Bahar et al. (2014), for example, show that the probability that a product is added to a country's export basket is significantly higher if a neighboring country is a successful exporter of that same product.

Comparing the evolution of the country space between 1995 and 2015 reveals some significant changes. Italy, Spain, and Greece, for example, fell markedly away from their European peers while Israel and Mexico moved up substantially to be closer to the European cluster – the former reflecting the rapid rise of high-technology sector and the latter the rapid expansion in manufacturing related to NAFTA). Among Asian countries, Korea, Singapore and Taiwan moved substantially away from their counterparts and now reside closer to the United States and European nations. As for Thailand, it remains relatively close to the Asia cluster which has seen the continued rise of China as well as recent emergence of Vietnam.

Figure 9: Country Space



Source: BACI database; Authors' calculation.

2. Product Innovation

Given the close link between a country's product structure and its development path, it is important to understand the determinants of product innovation. The perspective of growth and transformation that we have outlined so far has stressed the cumulative nature of knowledge, with one discovery setting the foundation for the next discovery, resulting in important spillovers and path dependence. Much of knowledge is also tacit, acquired only through experience and passed on primarily through direct human interaction. This acts to limit their diffusion to localized areas. Thus the two key dimensions of product innovation are localized spillover effects and path-dependency. Success in one area may engender success in other areas and the probability of success in a given area is not random but depends on the extent of pre-existing capabilities in similar areas. These forces may operate not only at the national level but also at the regional scale (eg. Neffke et al (2011). In this section, we investigate the role of such spillovers and path-dependency in the process of product innovation. We begin our assessment by looking across countries to evaluate whether these mechanisms operate generally at the country level.

2.1 Product Innovation: A Cross-Country Perspective

Our analysis on the determinants of product innovation at the country level emphasizes the extensive margins of exports, exploring whether a country's starting point in the product space matters in affecting its ability to become productive enough to export a product for the first time.[4] Specifically, we examine how countries' existing product structures are related to the probability of them making "jumps" to new products. We conduct our analysis on a panel of 99 countries over 1995-2015. After dropping products whose total export value over this period is less than 1 billion USD, we are left with a universe of 1241 products. Following Bahar et al. (2014), the dependent variable "jump" is defined as a tenfold or more increase in the RCA (from RCA<= 0.1 to RCA>= 1) of country *c* in product *p* within a 10-year or 5-year period. Given our sample, the former gives us 2 periods (of 10-year jumps), and the latter 4 periods (of 5-year jumps).

We estimate the following country-product-year panel regressions

$$\begin{aligned} Jump_{c,p,t\rightarrow T} = \alpha + \beta_1 Relatedness_{c,p,t} + \beta_2 PCI_{p,T} + \beta_3 Relatedness_{c,p,t} * PCI_{p,T} + \beta_4 ECI_{c,t} \\ + \beta_5 Relatedness_{c,p,t} ECI_{c,t} + \beta_5 RCA^0_{c,p,t} + \varepsilon_{c,p,t} \end{aligned} \quad (4)$$

where $Jump_{c,p,t\rightarrow T}$ is equal to 1 for products that attained RCA>1 during the time window, $Relatedness_{c,p,t}$ measures how close product *p* is in relation to the country *c*'s mix of exports in the initial year (calculated as in (3)), $PCI_{p,T}$ denotes the end-of-period *T* complexity measure of the new product, and $ECI_{c,t}$ is country *c*'s level of productive capacity (ECI index) at the initial year. $RCA^0_{c,p,t}$ is a dummy variable indicating whether products have RCA=0 at the beginning of the period and serves to absorb any non-linear effect for products that the country never exported before. Finally, the interaction terms between relatedness and PCI and ECI account for changes in the importance

[4] The extensive margin has been shown to account for a significant fraction of the growth of global trade in the last decades (Kehoe and Ruhl (2013))

of relatedness across different complexity levels of the new products as well as across different initial productive capacity levels of the country.

The underlying hypothesis here is that countries' ability to make successful jumps to new products depends on their capabilities. These may refer to very different domains, including tangible inputs, such as infrastructure, and intangible ones, such as knowledge and institutions. While some capabilities are important only for specific products (eg. specific technological knowledge), there are also general purpose capabilities that are relevant for all products in a given country (eg. infrastructure and institutions). We investigate both dimensions. The relatedness variable captures the effect of product specific knowledge, while the ECI captures capabilities which are common to all products in a given country. The latter tells us whether countries characterized by stronger general-purpose capabilities find easier to jump to new products, therefore mitigating the importance of product relatedness.

We include only products that are 'eligible' to jump, that is, all observations in our dataset for which $RCA_{c,p,t} \leq 0.1$ at the beginning of the period. For the 10-year span, the unconditional probability of a successful jump is 0.8 percent, while for the 5-year window this probability is 0.5 percent. For robustness checks, we add country fixed effects, time fixed effects, and product-year fixed effects in the alternative specifications. Time fixed effects control for global trends such as the intensity of trade or technology globalization that may affect jump probability across periods, while product-year fixed effects control for any time-varying product-specific characteristic such as global demand, productivity shocks, or price shocks that may affect the probability of jumps in a similar way across countries. Standard errors are clustered at the country level. The baseline specifications are shown in Column (1) and (5) of Table 1 for the 10-year and 5-year windows, respectively.

Table 1: Product Jumping at Country Level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	**10-year Jump** (from RCA <=0.1 to RCA >= 1)				**5-year Jump** (from RCA <=0.1 to RCA >= 1)			
Dummy RCA=0	-0.002**	-0.001*	-0.002**	-0.003***	-0.002***	-0.001***	-0.001***	-0.003***
	(-2.075)	(-1.757)	(-1.987)	(-3.802)	(-3.873)	(-2.715)	(-2.774)	(-6.017)
PCI	-0.003***	-0.002***	-0.002***		-0.002***	-0.001***	-0.001***	
	(-7.418)	(-5.733)	(-5.786)		(-7.301)	(-6.280)	(-6.396)	
ECI	0.001	-0.002	-0.002	0.001*	0.000	-0.001	-0.001	0.001*
	(1.018)	(-0.974)	(-1.215)	(1.762)	(0.931)	(-1.104)	(-1.311)	(1.870)
Relatedness	0.097***	0.095***	0.123***	0.066***	0.053***	0.049***	0.055***	0.028***
	(6.971)	(3.407)	(4.015)	(6.007)	(7.099)	(4.684)	(5.198)	(5.771)
Relatedness * PCI	0.006***	0.005***	0.005***	0.004***	0.005***	0.003***	0.003***	0.002***
	(5.593)	(5.244)	(5.225)	(4.225)	(6.509)	(6.182)	(6.279)	(4.946)
Relatedness * ECI	-0.064***	-0.032*	-0.047**	-0.047***	-0.036***	-0.024***	-0.028***	-0.022***
	(-7.581)	(-1.908)	(-2.495)	(-7.120)	(-8.417)	(-3.927)	(-4.170)	(-7.546)
Constant	0.006***				0.005***			
	(4.018)				(5.218)			
Observations	130,883	130,883	130,883	130,883	259,121	259,121	259,121	259,121
Fixed Effects		Country	Country, Year	Product-Year		Country	Country, Year	Product-Year
R-squared	0.005	0.009	0.009	0.029	0.002	0.004	0.004	0.025

Robust z-statistics in parentheses. Standard errors clustered at the country level.
*** p<0.01, ** p<0.05, * p<0.1

We can see that across all specifications, the relatedness variable is positive and significant indicating that the probability of countries making jumps into new products is higher if those products are closer to each country's initial product structure. To assess economic significance, we examine sensitivity in terms of one standard deviation changes in the explanatory variables. For the 10-year baseline specification, a one standard-deviation increase in relatedness of the new product is associated with a 1.6 percentage point increase in the likelihood of a successful jump.[5] This is twice as large as the unconditional probability of jumps (0.8 percent). The first interaction term shows that relatedness matters more for more complex products. A one standard-deviation increase in PCI would increase the importance of relatedness by about 10 percent. However, for countries with higher general capacity (higher ECI), relatedness matters *less* for probability of jumps: a one standard-deviation increase in ECI reducing the importance of relatedness by as much as 70 percent.

Overall, the probability that a country will jump into a new product is strongly related to how close that product is to other products the country already makes. Thus, the location of a country in the product space captures information regarding both the productive knowledge that it possesses and the capacity to expand that knowledge by moving into nearby products. The development process is path-dependent.[6] At the same time, this dependence seems to matter less the more advanced the economy is. One interpretation is that as economic complexity rises (higher ECI), countries attain greater "general purpose" capabilities that are not specific to particular products. This makes it easier of for sophisticated countries to jump to new products even if those products are far away from their initial product mix.

2.2 Product Evolution of Thai Export Firms

We now shift our focus to firms where decisions about which products to add and drop are actually taken. Product churning within firms has traditionally been overlooked as theoretical models have mainly relied on the simplifying assumption of mono-product firms. In the international trade literature, for example, both the classic theory of comparative advantage and the new trade theory focus on mono-product firms. Recent empirical evidence, however, indicate intense product churning at the firm level and its importance in contribution to growth of aggregate output (eg. Bernard et al. (2010) and Cilem et al. (2017)).[7] Hence understanding the factors that drive changes in the range of products that a firm exports helps in understanding broader trends in output and productivity at the aggregate level.

[5] One standard deviation of relatedness is equal to 0.163. Given the coefficient for relatedness from the baseline 10-year jump regression is 0.97, a one standard deviation increase in relatedness is thus associated with 0.163 x 0.97 = 0.0158 (or 1.58 percentage point) increase in the jump likelihood.

[6] A related paper is Kali et al. (2013) which focuses on a complementary growth mechanism based on synergies between the products in a country's export basket. It suggests that greater synergies among the current set of products improve the capacity of a country to move to higher income products and experience higher growth rates.

[7] Bernard et al. (2010) and Cilem et al. (2017) develop models that distinguish firm entry and exit from product adding and dropping. These models explain firms' product market entry decisions through firm and firm-product specific factors, such as productivity (supply) and consumer tastes (demand), as well as the role of local-product specific factors such as existing local capabilities in particular products that may generate spillovers for innovation in related products.

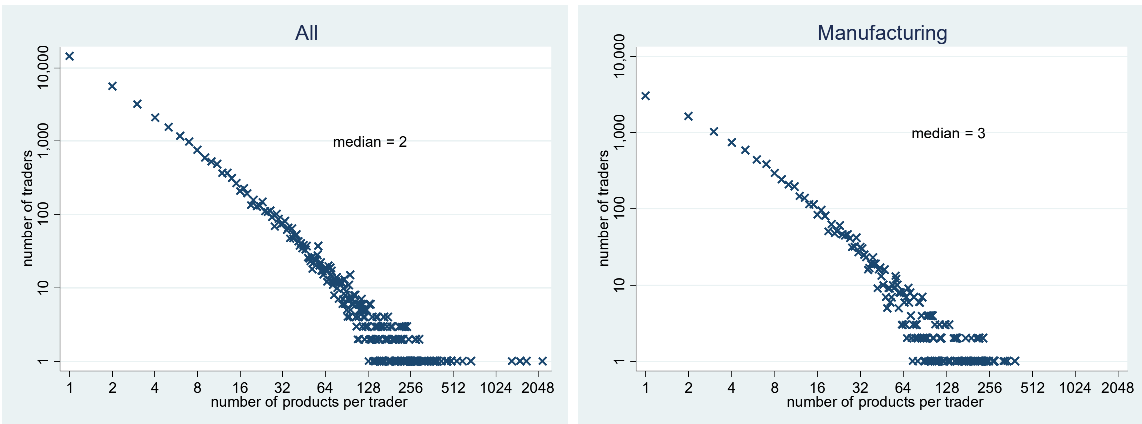
Table 2: Dynamics of Export Firms

	Exit	Stay		Enter	Total	
	2010	2010	2015	2015	2010	2015
All firms						
Number of exporters	20,054	16,236		20,376	36,290	36,612
Value of exports (bn. Baht)	596.1	4,994.3	6,159.7	838.3	5,590.4	6,998.0
Number of products exported	3,705	4,505	4,548	3,923	4,580	4,633
Manufacturing firms						
Number of exporters	2,429	7,543		3,216	9,972	10,759
Value of exports (bn. Baht)	473.1	3,828.0	4,681.6	521.0	4,301.1	5,202.6
Number of products exported	2,353	4,007	4,035	2,558	4,080	4,121
Manufacturing firms (as % of all firms)						
Number of exporters	12%	46%		16%	27%	29%
Value of exports (bn. Baht)	79%	77%	76%	62%	77%	74%
Number of products exported	64%	89%	89%	65%	89%	89%

Source: Thai Customs Department; Authors' calculation.

Our focus will be on developments over the 5-year period between 2010 and 2015. Table 2 provides an overview of the evolving landscape of export firms during this period. As of end-2015, there were 36,612 export firms exporting 4,633 products. Of these 10,759 were manufacturing firms, which together make up 74 percent of total exports and 89 percent of all products exported. Focusing on manufacturing firms, between 2010 and 2015, 7,543 firms were present in both periods (stay), 2,429 left the market (exit) and 3,216 were new exporters (enter). While manufacturing firms account for only 12, 46, and 16 percent of all export firms that exit, stay, and enter, respectively, their value share is much higher ranging between 62-79 percent. Thus, in sections below where we restrict our focus to only manufacturing firms, the representativeness of our analysis for aggregate exports as a whole is not compromised.

Figure 10: Distribution of Number of Products per Firm in 2015



Source: Thai Customs Department; Authors' calculation.

To get a sense of the prevalence of multi-product firms, Figure 10 shows the distribution of export firms by the number of products they export. The left-hand panel is for all export firms while the right-hand panel focuses only on manufacturing firms. The median number of products exported is 2 per firm overall and 3 for manufacturing firms, but the variation is large. Table 3 provides a picture of the prevalence of firms producing multiple goods in general as well as across industries and sectors. Looking at manufacturing firms, in 2015 as many as 72 percent of firms export more than one product (with a mean of 12.5 products per firm), accounting for 97 percent of total manufacturing firms' export value. As we move from multi-product to higher levels of aggregation, the portion of firms naturally falls but even at the sector level, as much as 53 percent of firms export products in multiple sectors accounting for an astonishing 90 percent of total export value.

Table 3: Prevalence of Firms Producing Multiple Products, Industries or Sectors

	Percent of firms		Percent of export value		Mean products, industries or sectors per firm	
Type of firm	2010	2015	2010	2015	2010	2015
Panel A: All exporters						
Multiple-product	63%	61%	93%	95%	10.9	12.9
Multiple-industry	52%	50%	88%	89%	5.6	6.2
Multiple-sector	45%	44%	85%	87%	3.5	3.6
Panel B: Manufacturing exporters						
Multiple-product	73%	72%	96%	97%	11.5	12.5
Multiple-industry	61%	60%	92%	92%	5.3	5.6
Multiple-sector	53%	53%	90%	90%	3.4	3.5

Source: Thai Customs Department; Authors' calculation. Notes: Multiple-product = 6-digits HS, Multiple-industry = 2-digits HS, Multiple-sector = group of 2-digits HS.

Table 4: Mean Distribution of Within-Firm Export Shares, 2015 (Manufacturing)

Product ranked by share of export value	Number of products exported by the firm										
	1	2	3	4	5	6	7	8	9	10	50
1st	100%	86%	80%	78%	76%	72%	73%	70%	68%	69%	49%
2nd		14%	16%	17%	16%	18%	16%	18%	19%	17%	21%
3rd			4%	4%	5%	6%	6%	6%	7%	7%	10%
4th				1%	2%	2%	3%	3%	3%	3%	5%
5th					0%	1%	1%	1%	2%	2%	3%
6th						0%	1%	1%	1%	1%	3%
7th							0%	0%	0%	1%	2%
8th								0%	0%	0%	1%
9th									0%	0%	1%
10th										0%	1%
50th											0%

Source: Thai Customs Department; Authors' calculation.

How does product heterogeneity manifest *within* firms? Table 4 reports the average share of firm export value represented by each of their products, sorted from largest to smallest. As shown in the table, the distribution of output across products is highly skewed, with the average share of firm output attributable to a firm's largest product declining from 86 percent for firms that produce two products to 69 percent for firms that produce 10 products. Strikingly, the importance of the third ranked product never exceeds 10 percent. Thus, for multi-product firms, the first 2 products accounts for almost all of their export output.

Table 5. Export Firms' Product Churning 2010 to 2015

			Average number of products		
	Count	Share (%)	added	dropped	maintained
Only Adding	768	10%	4.13		1.70
Both Adding and Dropping	5,044	67%	9.59	7.76	5.91
No Change	868	12%			1.28
Only Dropping	863	11%		3.51	1.85
Total	7,543	100%	6.84	5.59	4.48

Source: Thai Customs Department; Authors' calculation.

How important is product churning among Thai export firms? To answer this requires looking at the subset of firms that were present in both 2010 and 2015 (that is, "stay" firms from Table 2). Table 5 shows that product churning is very important. At the six-digit HS level, 88 percent of export firms alter their mix of products over the 5-year period, with the majority (67 percent) both adding and dropping products. This is in line with Bernard et al. (2010) who find that product adding and droppings across US firms are highly correlated.[8] The average number of products added is slightly higher than those dropped, and both are higher than the average number of products that are maintained. This suggests a fair degree of experimentation that, on net, result in firms expanding their range of products over time. One should note also that these numbers are for firms that survive over the 5-year period, thus high product churning may itself be a requirement for survival.

To assess the relative importance of product switching at the aggregate product level, we decompose a product's total export value according to the type of firm producing it. We divide product output in year t according to firms that produce the product in both t and $t-5$ ("incumbents"), surviving firms that do not produce the product in $t-5$ but do produce it in t ("adders"), and firms that do not exist in $t-5$ but produce the product in t ("entering firms"),

$$Y_{tp} = \sum_{j \in B_{tp}} Y_{tpj} + \sum_{j \in A_{tp}} Y_{tpj} + \sum_{j \in N_{tp}} Y_{tpj} \tag{5}$$

where p indexes products; j denotes firms; and B_{tp}, A_{tp}, and N_{tp} represent the set of incumbents adders, and entering firms, respectively. This decomposition can be converted into percentage decompositions for each product by dividing through by Y_{tp}, the value of product p export in t. We can also do a similar decomposition for the share of firms in each category.

[8] The results are also in line with Cilem et al. (2017) for French manufacturing firms where only 14 percent of firms maintained an unchanged export product bundle while the majority of firms (59 percent) both added and dropped products.

Table 6 : Decomposition of Export Value and Number of Firms by Exporter Type, 2015

	Firms exporting product in years t-5 and t (Incumbent)	Firms that add the product between years t-5 and t (Adder)	Firms born between years t-5 and t (Entry)
Panel A: All exporters			
Average percentage of export value	45%	36%	19%
Average percentage of number of firms	21%	50%	29%
Panel B: Manufacturing exporters			
Average percentage of export value	50%	38%	12%
Average percentage of number of firms	28%	58%	14%

Source: Thai Customs Department; Authors' calculation.

Panel A of Table 6 reports the mean product-value decompositions in percentage terms across all products for all export firms in 2015. We can see that on average roughly 45 percent of a product's total export value is produced by incumbents, 36 percent by firms adding the product, and the remaining 19 percent by entering firms. In terms of the share of firms producing a product, incumbents account for about 21 percent of firms, adders for about half, and entering firms make up around 29 percent. The results for this decomposition for manufacturing exporters only is shown in panel B of Table 6. The picture is broadly similar with the distribution shifting slightly from entry firms to product adding firms. Overall, the contribution of product adding by existing and entry firms to the average products' export value is roughly as large as that of incumbent firms.

To look at product churning *within firms*, we decompose the output of surviving firms over the 5-year period to 2015 according to whether the products are continuously produced versus recently added. In this decomposition, there is no contribution from firm entry or exit because the decompositions are undertaken for surviving firms only. As shown in Table 7, we find that products added within the previous five years on average accounted for half of on average of firms' total product range and around 33 percent of firm output. For manufacturing firms, new products on average accounted for 25 percent of firms' total exports. These shares suggest that product switching exerts considerable influence on firm activity.

Table 7. Decomposition of Firm Export by Product Type, 2015

	Product exported in years t-5 and t	Product added between years t-5 and t
Panel A: All exporters		
Average percentage of export value	67%	33%
Average percentage of number of products	49%	51%
Panel B: Manufacturing exporters		
Average percentage of export value	75%	25%
Average percentage of number of firms	51%	49%

Source: Thai Customs Department; Authors' calculation.

2.3 Determinants of Firm Product Innovation

How do firms innovate? The conceptual framework we have emphasized is underpinned by the idea that the creation and growth of industries relies on the transfer of knowledge and sharing of inputs. Firms have to combine existing capabilities in their locality to diversify and upgrade their products along the product space. This is facilitated by the presence of know-how in closely related products. Given the potential importance of the availability of a local pool of diverse knowledge and capabilities, geographical proximity among firms may emerge as a fundamental driver of innovation. Indeed, as far back as Marshall (1890), it was argued that firms clustered together benefit from a reduction in transport costs, namely the cost of moving goods, people, and ideas. The literature has shown that knowledge externalities are geographically localised and importantly enhance firm innovation (Arrow, 1962; Grossman and Helpman, 1993, Jaffe et al., 1993, Audretsch and Feldman, 2004).

Regional dimensions of firms' product innovation is thus something we will also explore by looking at local product spaces. To do so, we divide Thailand into 9 regions. In Table 8, considering only manufacturing firms that export both in 2010 and 2015, we see that about one-third of firms reside in Bangkok accounting for roughly the same share of total export value. The distribution of firms, in both numbers and export value, is clearly concentrated in the central region and in the east, reflecting the importance of the Map Ta Phut Industrial Estate in Rayong. The average number of products per firm has increased in all regions with firms in the central region exporting the most number of products.

Table 8. Manufacturing Firms Exporting Both in 2010 and 2015 By Region

	Number of firms		Export value (bn. baht)				Average number of products per firm	
	Count	(%)	2010	(%)	2015	(%)	2010	2015
Bangkok	2,633	35%	1,151.1	30%	1,349.8	29%	9.4	10.3
Samut Prakan	1,025	14%	470.0	12%	587.3	13%	9.5	10.6
Nonthaburi & Pathum Thani	579	8%	407.8	11%	467.5	10%	13.4	14.4
Central	365	5%	280.1	7%	447.5	10%	16.1	17.2
East	1,354	18%	919.0	24%	1,244.7	27%	12.1	15.5
West	867	11%	184.6	5%	209.5	4%	6.7	6.8
North	300	4%	65.6	2%	76.9	2%	11.3	11.0
North-east	158	2%	66.9	2%	69.2	1%	7.9	10.2
South	262	3%	282.9	7%	229.1	5%	3.9	4.1
Total	7,543	100%	3,828.0	100%	4,681.6	100%	10.1	11.3

Source: Thai Customs Department; Authors' calculation.

To assess regions' capabilities, we build the local product space based on products that the region exports with revealed comparative advantage at the region level. The region's RCA is expressed by:

$$RCA_{lp} = \frac{\frac{a_{lp}}{\sum_p a_{lp}}}{\frac{\sum_l a_{lp}}{\sum_l \sum_p a_{lp}}} \tag{6}$$

where a_{lp} is the value of product p exported by region l. In Table 9, we count the products with RCA>1 in each region. We can see that Bangkok and the eastern regions have the highest number of products with regional RCA while the north-east and southern regions have the lowest.

Table 9. Number of Products Exported with RCA by Region

	2010		2015	
	Number of products exported	Number of products exported with RCA	Number of products exported	Number of products exported with RCA
Bangkok	3,359	1,854	3,452	1,802
Samut Prakan	2,517	957	2,587	975
Nonthaburi & Pathum Thani	2,082	708	2,105	724
Central	1,695	434	1,744	435
East	2,528	1,007	2,740	1,085
West	1,906	891	1,979	909
North	1,243	469	1,351	488
North-east	802	274	1,035	292
South	480	121	540	141

Source: Thai Customs Department; Authors' calculation.

Explanations of product switching fall into three broad categories according to whether they focus on factors that are specific to products, specific to firms, or idiosyncratic to firm-product pairings. The first category of explanations emphasizes forces that are product specific but common to all firms, such as changes in relative demand (eg. changing fashions) or relative supply (eg. changing technology). A second class of explanations focuses on factors that are specific to firms but common to products such as firm size, productivity, and organizational flexibility. The third category encompasses firm-product characteristics such as firms' accumulated experience in a particular product area that enables them to innovate easily in the line of business. We will examine all three dimensions.

We will use measures of relatedness outlined below to measure the importance of existing capabilities embodied in the product structure at the country, regional, and firm levels. That is, we ask whether product innovation is influenced by existing productive capabilities of the country, of the region where firms operate, and of the firm. The first is specific to products but common to all firms, the second is specific to products but common to all firms within a given locality, and the third is specific to unique product-firm combinations.

Our focus on firm-level determinant of product innovation and the consideration of regional dimensions is in line with recent work. Lo Turco and Maggioni (2014) study the evolution of Turkish firms' product space and how this depends on product relatedness to firms' local production base. Cilem et al. (2017) undertake a similar exercise for French manufacturing firms, finding that local product space matters in firms' choice of which product to produce. They also find that firms' products which are more aligned with the core capabilities of the locality generate greater revenue. Poncet and de Waldemar (2013) find that export of Chinese firms whose goods have denser links to those currently produced in their locality grow faster. Finally, using firm-level data, Javorcik et al. (2017) find that Turkish firms in sectors or regions where foreign affiliates are present tend to introduce more complex products.

Our main variable of interest is the probability of firms adding and dropping a product during the interval between 2010-2015. We construct this variable by taking the universe of all possible products as a base and then compare firms' product mix in 2015 to that of 2010 to construct a vector of product adding and dropping. We run the following logit model

$$y_{ip} = \beta_0 + \beta_1 * CHAR_i + \beta_2 * Relatedness + \beta_3 * RCA + \delta_l + \eta_s + \epsilon_{ip} \quad (7)$$

where y_{ip} = 1 if firm i adds/drops product p to/from its basket and 0 otherwise. For firm's characteristics, $CHAR_i$, we control for asset turnover (revenue to assets – a proxy for efficiency), size (log of firms' assets value), firms' initial PCI score, and the number of products that firm produces. The number of firms producing the same product is included to control for market and non-market interactions between exporting firms. We also include RCA at both the country level (RCA_p^{TH}) and the regional level (RCA_{lp}^{region}) to control for the effects of regional and country specialization unrelated to technological proximity. Finally, δ_l and η_s respectively denote region and sector dummies and ϵ_{ip} is the error term.

Our main focus will be on *Relatedness* at three levels: i) relatedness to *country's* product space defined as

$$Relatedness_p^{TH} = \frac{\sum_{p'} M_{TH,p'} * \phi_{pp'}}{\sum_{p'} \phi_{pp'}} \quad (8)$$

where $M_{TH,p}$= 1 if Thailand exports product *p* with RCA>1 and 0 otherwise. This is analogous to equation (3) above; ii) relatedness to *regions'* product space defined as

$$Relatedness_{lp}^{region} = \frac{\sum_{p'} M_{lp'} * \phi_{pp'}}{\sum_{p'} \phi_{pp'}} \quad (9)$$

where M_{lp}= 1 if region *l* exports product *p* with RCA>1 and 0 otherwise (note that we use *regional* RCA here as define in equation (6); and iii) relatedness to *firms'* product space as

$$Relatedness_{ip}^{firm} = \frac{\sum_{p'} M_{ip'} * \phi_{pp'}}{\sum_{p'} \phi_{pp'}} \quad (10)$$

where M_{ip}= 1 if firm i exports product *p* and 0 otherwise. We will also add interaction terms to see how the importance of relatedness varies with the level of sophistication of the product being added and dropped. In the regressions below, we restrict our analysis only to manufacturing firms because we are interested in assessing capabilities to produce so that activity of trading firms that simply import for re-export are not informative.

Table 10 lays out the estimation results for product adding. For ease of interpretation, we report odds ratio instead of regression coefficients. The odds ratio captures changes in probability of the event corresponding to 1-unit change of the regressor. For example, an odds ratio of 1.5 means that the probability of the event is 1.5 times higher (or 50 percent). Given the extremely large dimension of our data (over 36 million data points), coefficient estimates are very precise. Unsurprisingly, we obtain very high significance levels for almost all coefficients. We thus focus on economic significance rather than simply statistical significance. This is gauged by scaling the marginal impact of a variable by its standard deviation. The figures reported in square brackets is the impact on the odds ratio of a one standard deviation change in the relevant variable (i.e. exponential of the coefficient times its standard deviation). Given the logitistic model, note that values below 1 indicate a negative impact (reduction in odds ratio). We will consider a variable to be economically significant if it changes the odd ratio by more than 15 percent (i.e. values above 1.15 or below 0.85). These are in bold.

Firm characteristics have the expected sign with larger, more efficient, and more sophisticated firms having a higher probability of adding products while those already exporting many products have a lower their probability of adding more. Interestingly, products with a higher number of firms already producing them have a higher chance of being added. This effect is a bit weaker for more sophisticated products as reflected in the interaction term. This suggests potential synergies in product adding with the presence of other firms already producing the product acting to support other firms to add the product. We turn to this issue directly in the relatedness variables.

Table 10. Determinants of Product Adding

VARIABLES	(1) odds ratio y	(2) odds ratio y	(3) odds ratio y
Asset turnover	1.012***	1.010***	1.010***
	(3.972)	(3.032)	(3.092)
	[1.021]	[1.016]	[1.017]
Size	**1.279*** **	**1.272*** **	**1.272*** **
	(84.26)	**(82.40)**	**(82.40)**
	[1.626]	**[1.609]**	**[1.609]**
Firm PCI	1.090***	1.087***	1.087***
	(11.20)	(10.80)	(10.83)
	[1.088]	[1.084]	[1.085]
Number of products	**0.976*** **	**0.974*** **	**0.975*** **
	(-61.22)	**(-62.81)**	**(-61.37)**
	[0.639]	**[0.615]**	**[0.622]**
PCI	**1.572*** **	**0.611*** **	**0.626*** **
	(71.81)	**(-16.68)**	**(-16.01)**
	[1.571]	**[0.611]**	**[0.626]**
Number of firms	**1.004*** **	**1.006*** **	**1.006*** **
	(242.0)	**(212.3)**	**(209.6)**
	[1.182]	**[1.279]**	**[1.276]**
Number of firms*PCI		0.997***	0.997***
		(-82.24)	(-80.36)
		[0.883]	[0.885]
Country relatedness	**460.7*** **	**403.3*** **	**7,839*** **
	(44.36)	**(41.77)**	**(41.42)**
	[1.274]	**[1.267]**	**[1.424]**
Region relatedness	**2.123e+09*** **	**4.649e+11*** **	**2.732e+10*** **
	(76.92)	**(81.73)**	**(72.37)**
	[11.33]	**[20.83]**	**[15.12]**
Firm relatedness	**1.317e+63*** **	**6.677e+66*** **	**6.731e+65*** **
	(103.7)	**(104.5)**	**(103.0)**
	[1.849]	**[1.917]**	**[1.899]**
Country relatedness*PCI		**10.95*** **	**11.95*** **
		(21.43)	**(22.40)**
		[1.772]	**[1.809]**
Region relatedness*PCI		**6.950*** **	**6.745*** **
		(37.88)	**(37.52)**
		[1.687]	**[1.673]**
Firm relatedness*PCI		29.20***	27.59***
		(10.86)	(10.67)
		[1.016]	[1.016]
Country RCA			0.747***
			(-18.37)
			[0.887]
Region RCA			**1.520*** **
			(41.70)
			[1.193]
Constant	4.30e-10***	6.55e-11***	8.85e-11***
	(-173.3)	(-168.6)	(-162.2)
Observations	36,396,574	36,396,574	36,396,574
Region dummies	yes	yes	yes
Sector dummies	yes	yes	yes

Source: Thai Customs Department; Authors' calculation. Note: z-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 11. Determinants of Product Dropping

VARIABLES	(1) odds ratio y	(2) odds ratio y	(3) odds ratio y
Asset turnover	0.937***	0.951***	0.954***
	(-8.050)	(-6.244)	(-5.896)
	[0.933]	[0.948]	[0.950]
Size	0.957***	0.965***	0.966***
	(-9.039)	(-7.355)	(-6.996)
	[0.912]	[0.927]	[0.930]
Firm PCI	1.067***	1.030**	1.027*
	(4.369)	(1.967)	(1.776)
	[1.062]	[1.028]	[1.025]
Number of products	**1.011*** **	**1.017*** **	**1.017*** **
	(19.70)	**(26.74)**	**(26.69)**
	[1.793]	**[2.380]**	**[2.385]**
PCI	0.922***	1.128**	1.096*
	(-6.471)	(2.463)	(1.902)
	[0.922]	[1.128]	[1.097]
Number of firms	**0.999*** **	**0.999*** **	**0.999*** **
	(-32.44)	**(-27.22)**	**(-26.97)**
	[0.763]	**[0.694]**	**[0.696]**
Number of firms*PCI		1.001***	1.001***
		(8.394)	(8.034)
		[1.133]	[1.128]
Country relatedness	**0.00333*** **	**0.00483*** **	0.471*
	(-21.21)	**(-19.20)**	(-1.713)
	[0.806]	**[0.818]**	[0.972]
Region relatedness	**0.0264*** **	**0.0135*** **	**0.132*** **
	(-7.654)	**(-7.741)**	**(-3.579)**
	[0.667]	**[0.619]**	**[0.798]**
Firm relatedness	**0*** **	**0*** **	**0*** **
	(-25.32)	**(-32.20)**	**(-32.64)**
	[0.466]	**[0.345]**	**[0.338]**
Country relatedness*PCI		1.048	1.722***
		(0.268)	(3.107)
		[1.012]	[1.152]
Region relatedness*PCI		0.650***	0.608***
		(-5.409)	(-6.226)
		[0.882]	[0.865]
Firm relatedness*PCI		**5.84e-06*** **	**5.52e-06*** **
		(-22.23)	**(-22.20)**
		[0.758]	**[0.757]**
Country RCA			**0.693*** **
			(-13.93)
			[0.839]
Region RCA			**0.676*** **
			(-24.28)
			[0.822]
Constant	58.92***	57.97***	11.79***
	(18.74)	(16.73)	(9.718)
Observations	73,734	73,734	73,734
Region dummies	yes	yes	yes
Sector dummies	yes	yes	yes

Source: Thai Customs Department; Authors' calculation. Note: z-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 12. Determinants of Product Survival

VARIABLES	(1) odds ratio y	(2) odds ratio y	(3) odds ratio y
Asset turnover	1.048***	1.041***	1.041***
	(6.386)	(5.465)	(5.464)
	[1.046]	[1.039]	[1.039]
Size	1.017***	1.014***	1.014***
	(3.975)	(3.189)	(3.257)
	[1.036]	[1.029]	[1.030]
Firm PCI	0.949***	0.952***	0.952***
	(-4.073)	(-3.821)	(-3.806)
	[0.955]	[0.957]	[0.957]
Number of products	**0.992*** **	**0.990*** **	**0.990*** **
	(-12.68)	**(-16.15)**	**(-16.18)**
	[0.709]	**[0.629]**	**[0.628]**
PCI	1.049***	**0.820*** **	**0.809*** **
	(4.544)	**(-4.082)**	**(-4.336)**
	[1.046]	**[0.828]**	**[0.817]**
Number of firms	**1.001*** **	**1.001*** **	**1.001*** **
	(27.60)	**(20.14)**	**(19.70)**
	[1.187]	**[1.220]**	**[1.215]**
Number of firms*PCI		1.000***	1.000***
		(-3.501)	(-3.232)
		[0.962]	[0.965]
Country relatedness	4.988***	4.410***	1.927
	(6.262)	(5.696)	(1.541)
	[1.057]	[1.053]	[1.023]
Region relatedness	**9.753*** **	**24.62*** **	**15.47*** **
	(5.317)	**(6.430)**	**(5.411)**
	[1.279]	**[1.413]**	**[1.344]**
Firm relatedness	**3.353e+17*** **	**3.007e+21*** **	**3.691e+21*** **
	(18.83)	**(21.98)**	**(22.03)**
	[1.643]	**[1.838]**	**[1.843]**
Country relatedness*PCI		1.478**	1.438**
		(2.154)	(1.986)
		[1.095]	[1.088]
Region relatedness*PCI		1.434***	1.462***
		(4.714)	(4.966)
		[1.101]	[1.107]
Firm relatedness*PCI		**2,544*** **	**2,591*** **
		(14.37)	**(14.40)**
		[1.139]	**[1.139]**
Country RCA			1.065**
			(2.477)
			[1.029]
Region RCA			1.086***
			(5.502)
			[1.041]
Constant	0.0560***	0.0441***	0.0599***
	(-14.53)	(-14.25)	(-12.23)
Observations	119,878	119,878	119,878
Region dummies	yes	yes	yes
Sector dummies	yes	yes	yes

Source: Thai Customs Department; Authors' calculation. Note: z-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Relatedness at the country, regional, and firm level all turn out to be statistically and economically significant in explaining the probability of product adding. Regional relatedness is especially important with the odds of a product being added being 15 times higher for products that are one standard deviation closer in proximity to the regions' product structure (third column of Table 10). The interaction terms indicate that relatedness at all levels matter more for more complex products, though at the firm level this is not economically significant.

Turning to product dropping, Table 11 reaffirms the importance of technological proximity in firms' decision of which products to drop. The likelihood of products being dropped by firms falls for products that are more closely related to existing product structures at the country, region, and firm level. This effect is especially strong for firm relatedness. The interaction terms are generally not as significant economically as before, except at the firm level where it confirms that the importance of firm relatedness in reducing the probability of product dropping is greater for more complex products. In terms of firm controls, though they are not economically significant, the results suggest that more efficient and bigger firms have lower probability of dropping products.

Finally, we examine also the relationship between relatedness and product survival. The estimates above are based on comparing firms' product basket in 2010 and 2015. Thus product adding essentially covers products that were added during the 5-year window and survived to 2015 while products dropped are those that were present in 2010 but no longer 5 years later. But we know that product churning among firms is significant, so that many products are added but do not survive until the end. To investigate product survival, we construct a data set that consists of all products added during 2010-2015 and designate products that survive as those that were still present in 2015 (we did not require that they be present in all consecutive periods to increase coverage). Essentially, we are looking at the flow of goods being added and comparing those that survive and those that don't.

Table 12 shows that products added by bigger and more efficient firms have a higher probability of survival, while for more sophisticated firms and for those that already produce larger number of products the probability is lower. This suggests that high PCI firms face higher obstacle to success. Indeed, the results indicate that more complex products in general have lower survival probability. Relatedness at the region and firm levels are again important for survival but not at the country level. And while the interaction terms indicate that relatedness matters more for higher PCI products, it is economically significant only at the firm level.

Overall, our results confirm that technological proximity at the country, regional, and firm levels are significant drivers of firms' choice and ability to add new products and expand their product basket. Products that are closer to firms' own product structure, as well as those of their locality, are not only more likely to be added, but also more likely to survive. And the effect is stronger for more complex products. This finding is consistent with economies of scale and scope and knowledge spillovers from product-level relatedness. It also confirms that firms do not diversify randomly, rather they spread towards activities that demand similar capabilities to the ones they already have. Firms' product choices are characterised by strong path dependence.

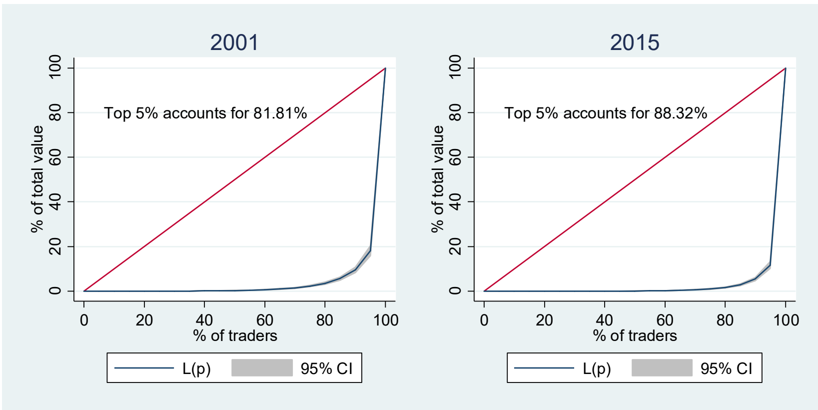
3. One for All or All for One: Distributing the Fruits of Innovation

In the framework that we have used thus far, the complexity of goods produced by firms can be taken as a rough proxy for the sophistication of firms engaged in producing those goods. From this perspective, when viewed at an aggregate level, Thailand has done quite well in gaining footholds in complex goods and the firms engaged in these goods have achieved sophisticated know-how and advanced organizational capabilities. But Thailand's impressive achievement in climbing up the complexity ranking is tempered by its low income per capita levels relative to other countries at similar levels of complexity, as well as the sluggish economic growth experienced over the last decade. This begs the question of what is holding Thailand back from realizing its full potential?

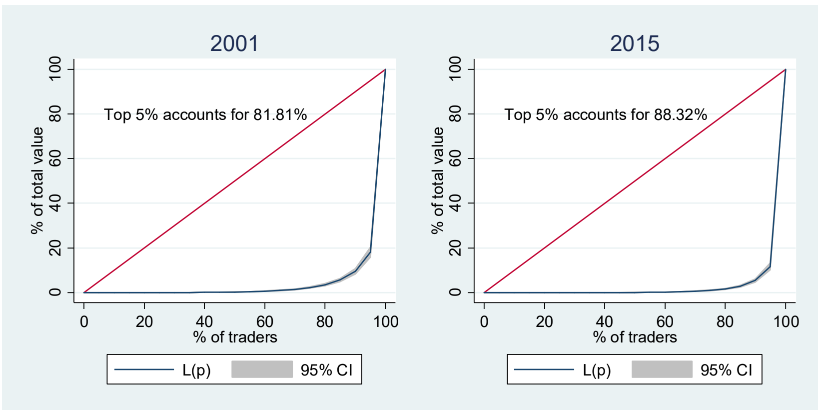
The perspective of structural change stresses two key elements: the process of diversifying into new industries and the reallocation of factors of production into these higher productive activities. Thailand has clearly done well with respect to the former. We now turn our attention to the latter. In light of Thailand's overall success in moving into more complex products, have the gains from such product upgrading been widely shared? Analysis at the firm level allows us to make inroads into this question.

Figure 11: Export Firm Concentration

All Firms



Manufacturing Firms

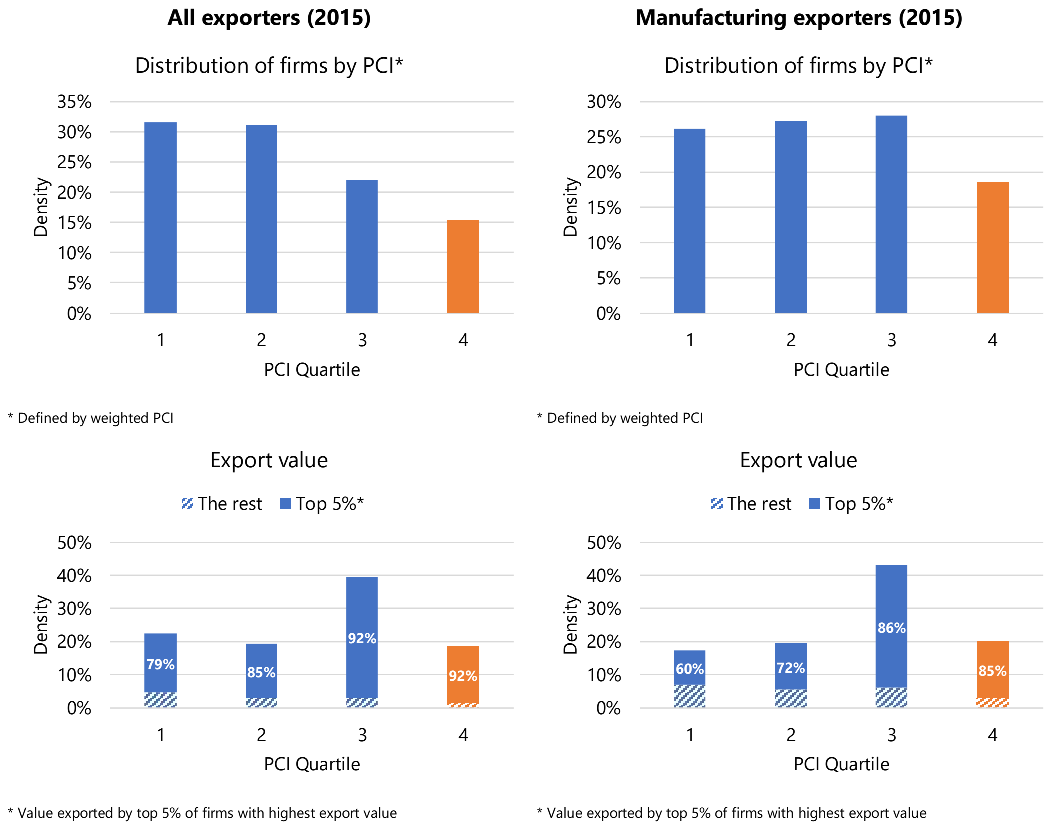


Source: Thai Customs Department; Authors' calculation.

3.1 Firm Concentration

The first observation to note is that even though exports make up as much as 70 percent of GDP, export firms account for only 5.7 percent of the over 400,000 registered firms in Thailand in 2015 (Apaitan et al (2016)). Moreover, among export firms, concentration is extremely high. Figure 11 show that in 2015, the top 5 percent largest export firms account for a staggering 88.3 percent of export value. Among manufacturing exporters, this figure is 78.9 percent. For both groups, the level of concentration has increased markedly since 2001. Hence already at this general level, one can see the highly skewed distribution of firms. Export firms make up a tiny portion of all Thai firms and among exporters, only a handful of them drive Thailand's total exports.

Figure 12: Distribution of Firms By PCI Quartile



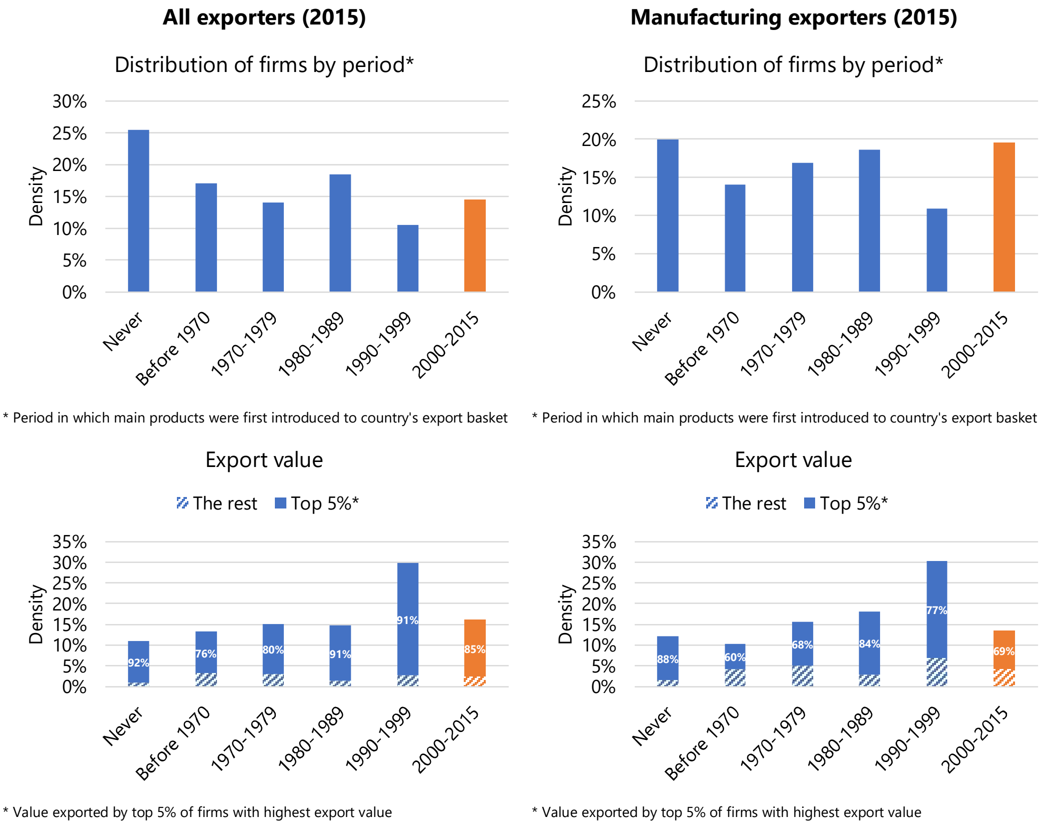
Source: Thai Customs Department; Authors' calculation.

How widespread has firm participation been in Thailand's overall product upgrading? This can be gauged by looking at the distribution of firms according to their level of sophistication. We calculate firms' level of complexity by taking the weighted average of their products' PCI score. We also experimented with just using the PCI score of their main export with similar results. This is not surprising given that for most firms, their main product accounts for the bulk of their largest total export value (Table 4). We sort firms by complexity quartile and take the highest quartile as a rough representation of high complexity firms. The top panel of Figure 12 shows that the share of high complexity firms is quite low, at around 15 percent for all exporters and 18 percent for manufacturing firms. Their share of total export value is also limited at roughly 20 percent.

Moreover, among high complexity firms, concentration is high (top 5 percent making up 85 percent of export value for manufacturing firms) and generally higher than those in the lower PCI quartiles.

To gauge the prevalence of firm's involvement in product innovation, we look at the distribution of firms according to their engagement in "new" products, defined as products that gained RCA>1 only in the recent period. Recall that underlying the ECI measure is the number and type of products that a country can export with revealed comparative advantage. Thus, the evolution of the ECI is driven by the dynamics of new products that enter with RCA>1, and hence responsible for a country's migration across the product space. By looking at the firms that are engaged in these products we can get a sense of the distribution of firms according to their contribution to the country's overall product dynamism.

Figure 13: Distribution of Firms By RCA Vintages



Source: Thai Customs Department; Authors' calculation.

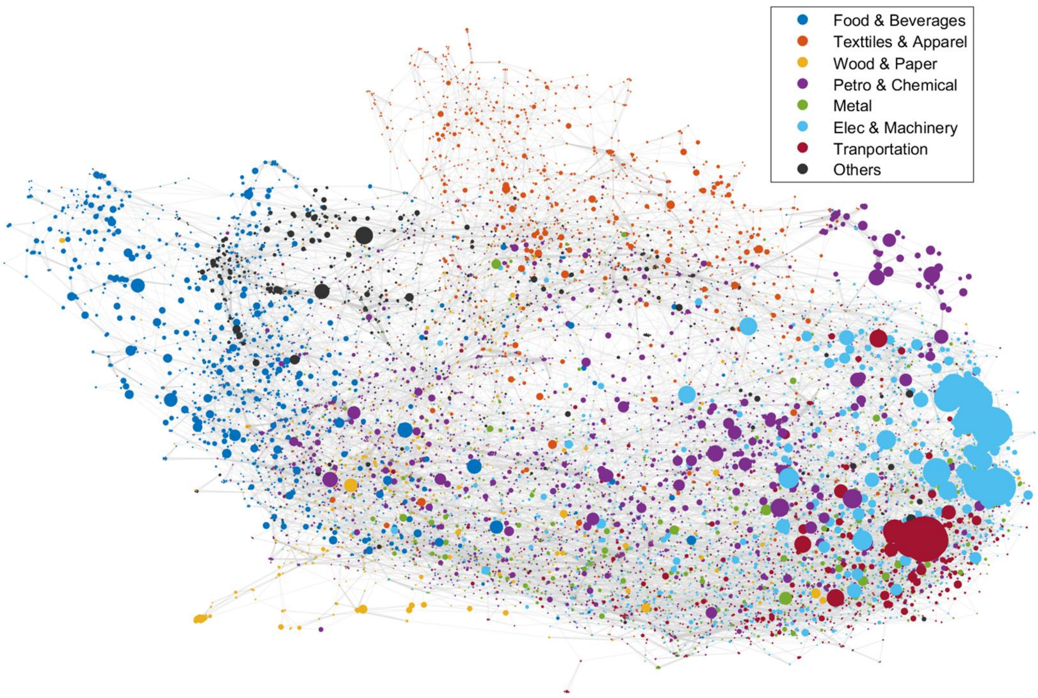
Figure 13 shows the distribution of firms according to their involvement in different vintages of RCA products.[9] It is analogous to Figure 6 above but instead of looking at export shares, we look at the share of firms. Among manufacturing firms, the top panel of Figure 13 shows that only 20 percent of firms are engaged in new products that recently gained RCA during the last 15 years. These firms account for just under 15 of total manufacturing exports though concentration is high with the top 5 percent accounting for 69 percent of exports among this group (bottom panel of Figure 13).

[9] We classify firms according to their main product so that each firm is only assigned one product.

A deeper picture of how firms agglomerate can be had by examining how firms relate to one another based on their product structure. This is analogous to the concept of the country space described in section 1.3 but now calculated at the firm level. We call this the "firm space". For each firm, we construct a vector of product relatedness as in (10). Firm similarity is then simply the pair-wise correlation of these relatedness vectors. We use the correlation matrix to build the firm space using similar steps taken in building the country space. To avoid cluttering we only keep the top 4 strongest links for each node while the size of the nodes reflect firms' export value.

The firm space is a succinct way to capture visually the landscape and distribution of firms based on the similarity of their export baskets. We restrict our attention to manufacturing firms. Figure 14 shows the firm space where the nodes have been colour-coded according to the sectors to which firms belong. Not surprisingly, the relatedness of firms display clear sectoral clustering. That said, some sectors, such as transportation and electrical and machinery, are tightly packed together while others, such as petroleum and chemicals, are quite spread out. For the latter, this reflects that the sector acts as a basis for production in a wide range of goods in many sectors.

Figure 14: Firm Space By Sector – 2015

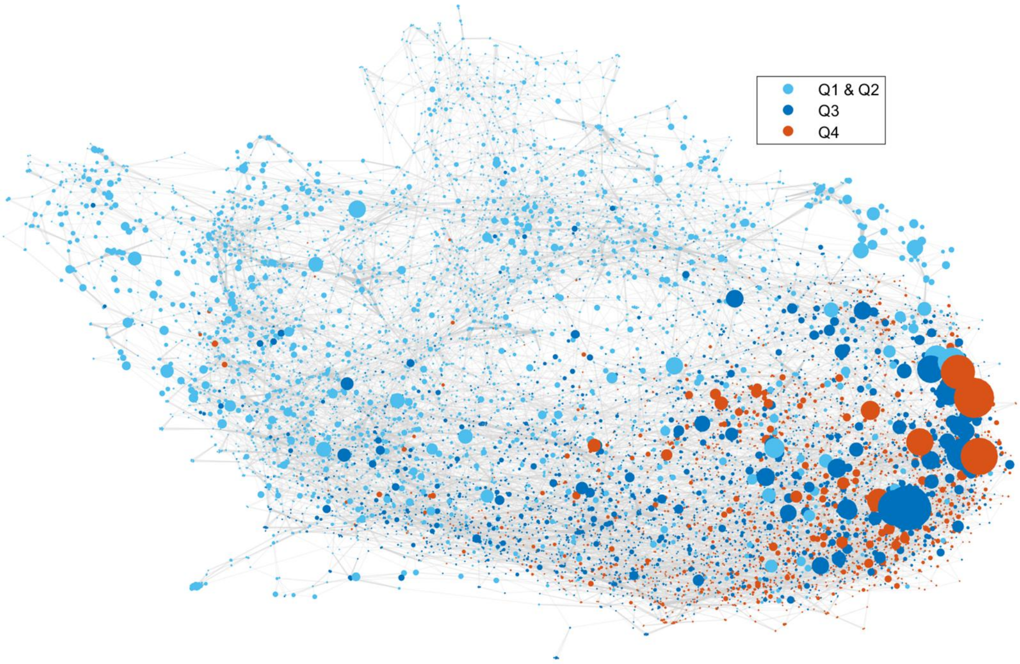


Source: Thai Customs Department; Authors' calculation.

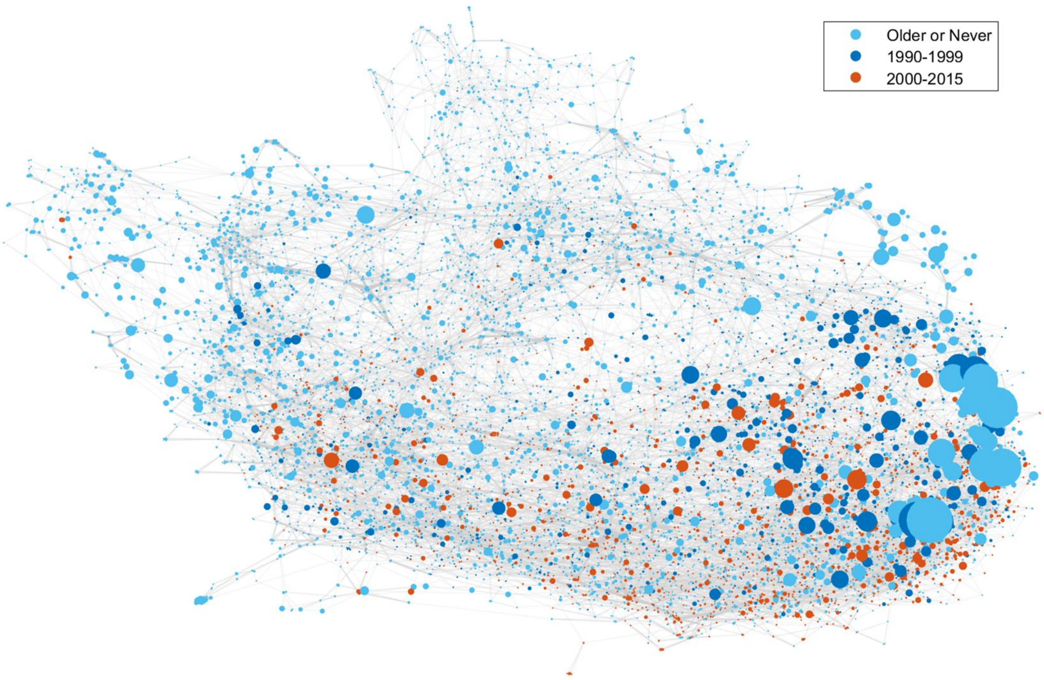
The top panel of Figure 15 shows the firm space colour-coded by PCI quartiles. High PCI firms (top two quartiles) are clustered to the right of the graph and their network density are also higher. This may reflect the importance of a close supporting network of inputs for more complex products (such as value chains). The higher concentration among high PCI firms as well as their fewer numbers are also evident. This is consistent with the distribution summarized in Figure 12.

Figure 15: Firm Space– 2015

PCI Quartiles



RCA Vintages



Source: Thai Customs Department; Authors' calculation.

The bottom panel of Figure 15 colour codes firms by their contribution to different vintages of RCA products. It is analogous to Figure 13 and captures firms' dynamism in terms of their role in Thailand's overall product migration. The bulk of the firms involved in products that Thailand recently attained RCA (between 2000-2015) are on the right side of the firm space where sophistication tends to be higher. Indeed, many of these firms overlap with the highest PCI quartile firms. This is consistent with the rising share of sophisticated products in Thailand's exports over the last 15 years (Figure 5). The relatively small size of firms involved in recent RCA vintages, as summarized in Figure 13, is also apparent.

Overall, firm participation in Thailand's product migration and upgrading appears limited. The recent wave of product migration has been driven by only a small number of firms that together make up an equally small share of total export value. And among these firms, participation has been skewed with only a handful accounting for the bulk of export value. The picture is similar in terms of firm participation in highly sophisticated goods. Thailand's success in gaining footholds in numerous and increasingly sophisticated products appears to be driven by a minority of firms many of whom are limited in size, either by choice or because of frictions that prevents them from growing. If so, such resource misallocation could be a key obstacle preventing Thailand from reaping the full benefits of product innovation and industrial upgrading.

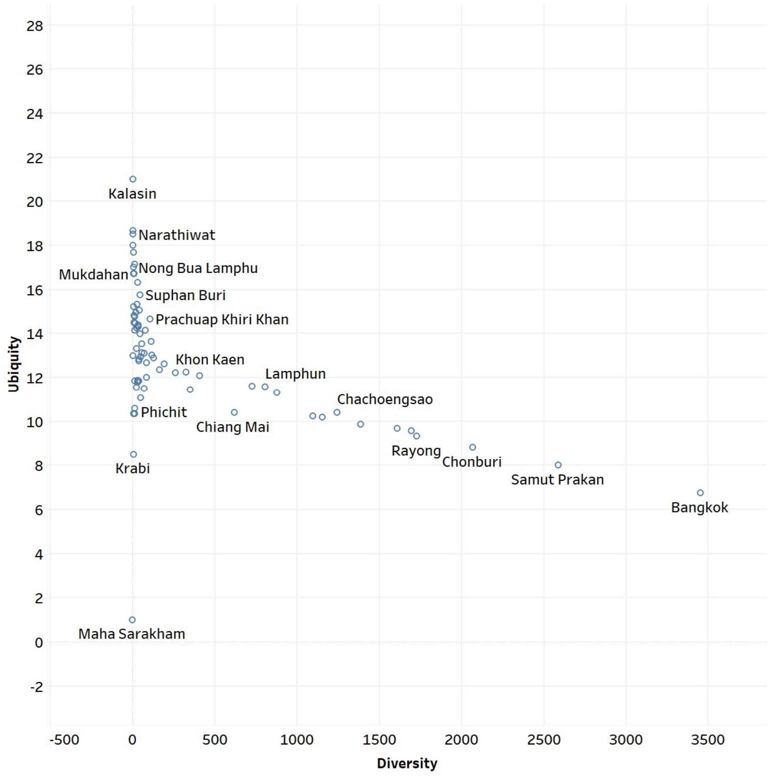
Indeed, there is a growing literature on productivity heterogeneity within industries. This has documented the fact that most industries in the developing world are a collection of smaller, typically informal firms that operate at low levels of productivity along with larger, highly productive firms that are better organized and use more advanced technologies. McKinsey Global Institute (2003) analysis of Turkish firms, for example, finds that on average the modern segment of firms is almost three times as productive as the traditional segment. Bartelsman et al. (2013) and Hsieh and Klenow (2009) similarly found evidence of very large dispersion in plant productivity levels in China and India. For Thailand, Amarase et al. (2017) documents the large dispersion of productivity among manufacturing firms that has grown wider over time. This echoes the finding of Amarase et al (2013) who document the bifurcated nature of Thailand's growth process characterized by the existence of stagnant sectors alongside a few vibrant sectors.

3.2 Regional Concentration

Our analysis of the determinants of product upgrading has highlighted the importance of regional product structure in firms' decisions about which products to add and drop. This suggests that firms benefit from local agglomeration so that their choice of where to operate may be importantly influenced by pre-existing capabilities of each locality. Indeed, Table 8 indicates that the distribution of Thai firms displays high geographical skewness. This begs the question: do high complexity firms tending to cluster together in specific regions? If so, does firm location play a part in the driving differences in product structure, and hence income levels, across regions? To further investigate this, we now analyse the pattern of export sophistication across Thai provinces.

In line with the analysis at the country level, cross-province differences in complexity can be gauged by calculating for each province the number of products that it produces (diversity) and the average number of other regions that are able to produce the same product (ubiquity). This relation between diversity and ubiquity across Thai provinces is plotted in Figure 16. There is a clear downward slope: provinces that are more diverse tend to also produce products that are unique. The absolute difference in diversity across provinces is huge, with Bangkok producing almost 3500 products while the least diverse provinces producing just one product. Even among the top provinces, the difference is very large with Samut Prakhan – the second most diverse province – exporting around 1000 less products than Bangkok and Chonburi – the third most diverse province – exporting 500 products less than Samut Prakhan.

Figure 16: Diversity vs. Ubiquity (Province Level - 2015)

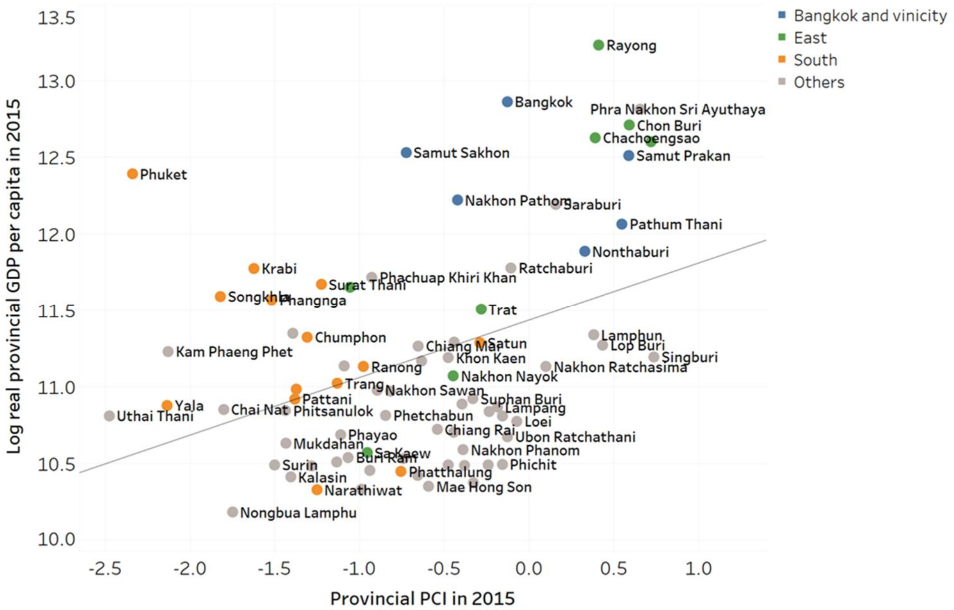


Source: Thai Customs Department; Authors' calculation.

Thai provinces therefore exhibit considerable variation in product structure and sophistication, which translate into differences in overall development. One important question for our analysis is the extent to which differences in the levels of development across provinces can be accounted for by the variance in provincial complexity. We thus proceed to construct provincial export sophistication measure in analogous fashion to firm sophistication as above. Specifically, provincial sophistication is constructed as the weighted PCI score of each province's export basket derived from export products by firms registered within the province.

Figure 17 shows the relationship between real income per capita and export sophistication across provinces in 2015. There is a clear positive correlation of 0.39 between these two variables. Unsurprisingly, provinces in the eastern seaboard and around Bangkok stand out both in terms of having high export sophistication as well as high income levels. Provinces in the south generally score lower on the sophistication scale though some, such as Phuket and Krabi, enjoy high per capita income levels. This reflects the prominence of service income and activity in these areas which are not considered in our metric. Apart from differences in income *levels*, how do variations in provincial complexity relate to income *growth* over time?

Figure 17: Provincial PCI vs. Log Real Provincial GDP Per Capita, 2015

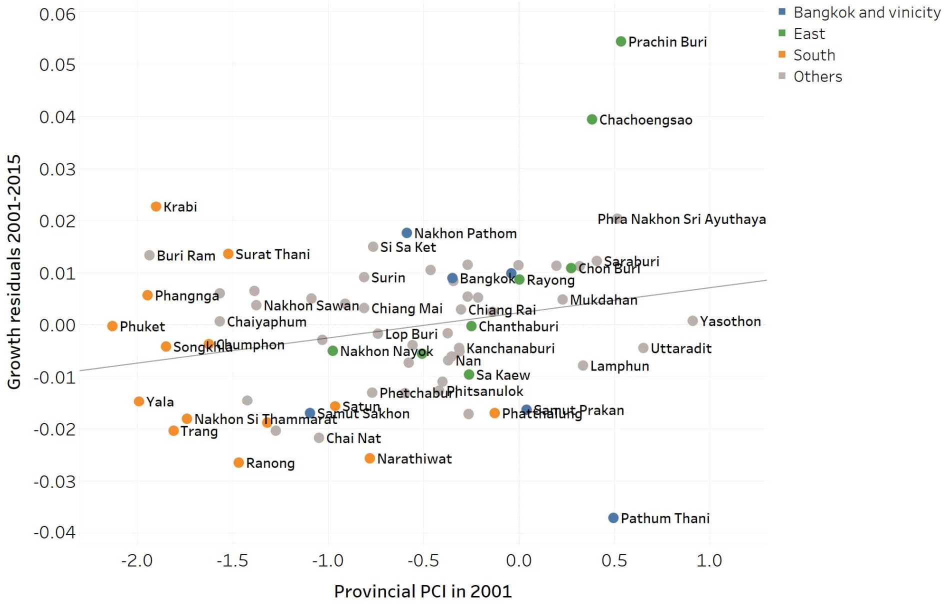


Source: Thai Office of the National Economic and Social Development Board, Thai Customs Department, the Observatory of Economic Complexity, and authors' calculation.

Figure 18 shows the relationship between export sophistication in 2001 and real income per capita growth rates between 2001 and 2015 across Thai provinces, after controlling for initial levels of GDP per capita. The growth residuals are calculated from a regression of real income per capita growth rates between 2001 and 2015 on the log of GDP per capita in 2001. Thus, a positive residual implies that growth in that province exceeds what would have been predicted simply based on initial income levels. We find a clear positive correlation (of 0.35 excluding Pathum Thani which is a clear outlier stemming from the effects of extensive flooding in 2011), indicating that provinces' initial sophistication levels are able to explain subsequent growth performance over and above initial levels of income. In other words, highly sophisticated provinces tend to grow faster controlling for income levels.

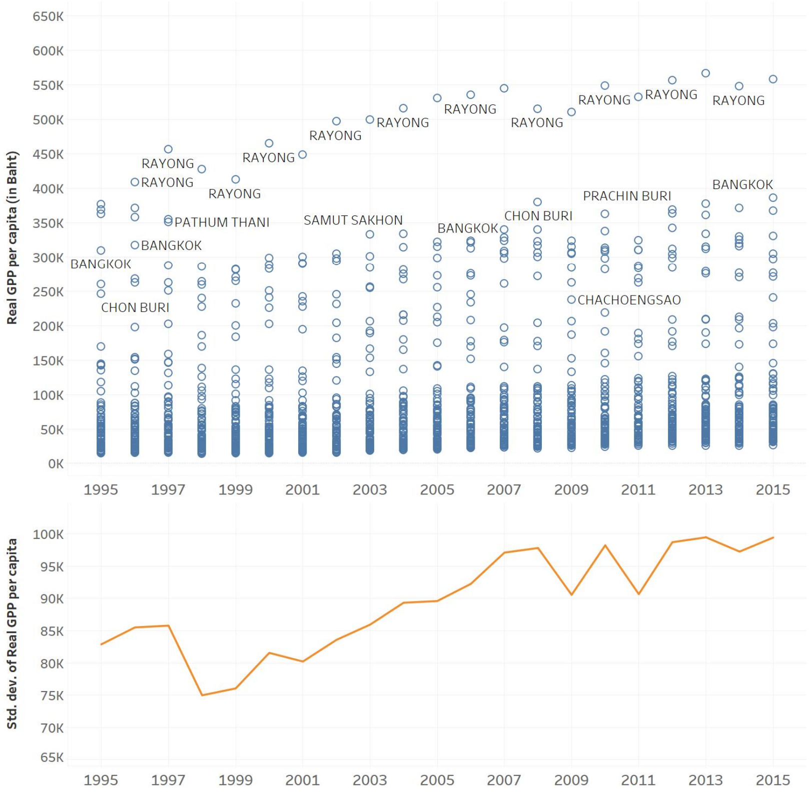
Such dynamics imply a worrying trend: more sophisticated provinces not only tend to have higher income levels, but they also tend to grow faster. This leads to a widening gap between leading and lagging provinces. The evolution of provincial income over time has indeed exhibited these dynamics. Figure 19 shows not only the large dispersion in Thailand's real per capita provincial income levels but also that this dispersion has risen over time. The leaders are pulling ahead and the laggards are falling further behind. To the extent that geographical proximity is an important part of product innovation, path dependence in the product space may also entail path dependence in regional development. That is, localities that have a high agglomeration of firms will be more attractive to new firms while regions where firms are sparse will be increasingly left behind. This not only exacerbates regional inequality, but may also act as an increasing drag on the country's overall economic growth and development.

Figure 18: Provincial PCI vs. Provincial GDP Growth Residuals 2001-2015



Source: Thai Office of the National Economic and Social Development Board, Thai Customs Department, the Observatory of Economic Complexity, and authors' calculation. Note: Growth residuals calculated from the regression of real provincial GDP per capita growth rates between 2001 and 2015 on the log of provincial GDP per capita in 2001.

Figure 19: Dispersion in Real Per Capita Gross Provincial Product



Source: Office of the National Economic and Social Development Board; Authors' calculation.

3.3 Sustaining Growth through Structural Change

We have emphasized the critical role that structural change plays in countries' long-term economic growth. Developed countries are not simply blown-up version of developing ones, they are structurally different. Structural change comprises of two key elements: diversification into new industries and reallocation of factors of production into these higher productive activities. One can view this as development on the extensive margins – migration into new goods and industries coupled with resource movements between firms.

In terms of product innovation and industrial upgrading, Thailand has performed well as reflected in its steady climb up the economic complexity ranking. This metric looks only at a country's ability to achieve success in certain goods and sectors, but does not take into account extent of *participation* in those successes within the country. Whether export success in a particular good reflects achievement by a large number of firms operating broadly in many regions or just handful of them all located in one city does not matter. Nor does it consider the relative weight of production across difference sectors beyond the threshold of RCA>1.[10]

But this is precisely the second dimension of structural change: the extent to which improved capabilities translate into growth dividends at the aggregate level depends on how broadly agents in the economy participate in reaping the benefits from success. On this metric, the Thailand's performance is much more mixed. Our analysis has revealed significant heterogeneity across export firms in Thailand. The distribution of firms is highly skewed, with a very small number of firms accounting for a disproportionately large share of total exports. Firms engaged in complex products are few in numbers and do not appear to be able to attain the significant size that they perhaps should. Moreover, among these high sophistication firms, concentration is high so that only a few are driving much of the activity. The same picture holds with respect to firms displaying product dynamism who contribute to recent footholds in new products. There is also a marked geographic concentration in firms' location in terms of numbers, diversity of products, and complexity.

Overall, the picture that emerges is one of Two-Thailands, one of leaders and another of laggards. A handful of sophisticated firms have been driving product upgrading and a handful of provinces that attract these firms host the bulk of economic activity in the country. As a result, capabilities and know-how have not dispersed widely enough throughout the country. Moreover, there is no indication that these disparities are getting smaller over time. And at the provincial level, they have gotten worse. The result is stunted structural transformation and sluggish economic growth. While a full-fledged analysis of this issue is beyond the scope of this paper, we provide some perspective by conducting a simple decomposition to assess the evolving contribution of structural change to Thailand's overall productivity growth.

Following Oulton and Srinivasan (2005), aggregate labour productivity growth can be written as

$$Q = V/L \tag{11}$$

where V is value added and L is total employment. The growth of labour productivity is then

[10] The ECI is based on products exported with RCA>1. Beyond this threshold, it does not matter by how much the good is being exported. Two products may both have RCA>1 yet one being much more important in the country's export basket – and hence employing a much larger share of resources – than the other.

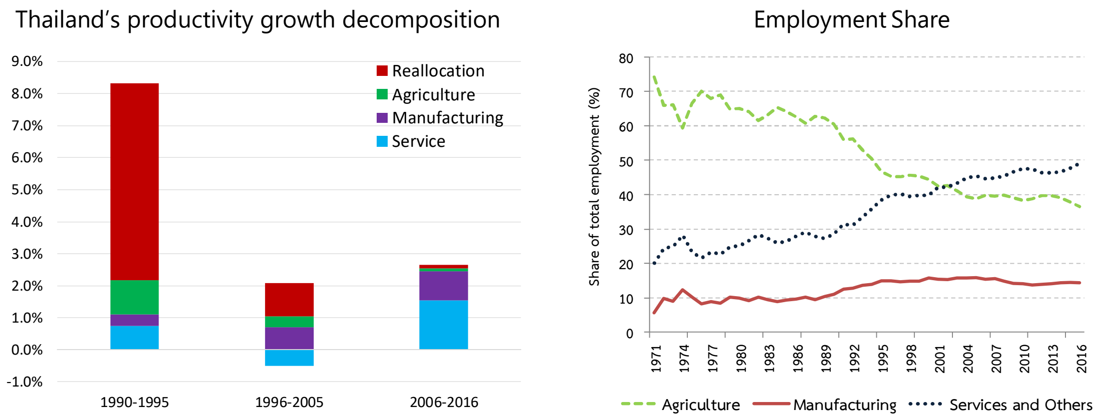
$$\hat{Q} = \hat{V} - \hat{L} = \sum_i s_i \hat{V}_i - \sum_i r_i \hat{L}_i \qquad (12)$$

where s_i is the share of sector i's value added in aggregate value added, namely $s_i = P_iV_i/PV$, with P_i being the GDP deflator in sector i, V_i is sectoral real value added, and PV is the nominal GDP. The hats above variables indicate growth rates. Let r_i be the share of employment in sector i, H_i/H, and Q_i be labour productivity of sector i. With some manipulation, (11) can be expressed as

$$\hat{Q} = \sum_i s_i \hat{Q}_i + \sum_i r_i \left(\frac{P_iQ_i}{PQ} - 1\right)(\hat{L}_i - \hat{L}) \qquad (13)$$

Thus, the growth of aggregate labour productivity can be decomposed into (i) the contribution of productivity growth within sectors (first term in equation (13), the 'within' effect), and (ii) the contribution to aggregate productivity growth from labour reallocation across sectors (second term in equation (13), the 'between' effect). This second term captures the structural change effect.

Figure 20: Structural Change in Thailand



Source: Labor Force Survey, National Statistical Office of Thailand, and the Office of National Economic and Social Development, authors' calculations.

The left-hand panel of Figure 20 shows the results of this decomposition where aggregate labour productivity is calculated as GDP per worker and average labour productivity in a specific sector is real value added per hour worked in the sector. As can be seen, Thailand benefited enormously from structural change in the early part of the 1990s, a period where there were also substantial productivity gains within the agriculture and services sectors. In the 10-year period from 1996, the reallocation effect was much smaller though still important relative to overall productivity growth. But subsequently over the last decade, the contribution from structural change seems to have virtually disappeared.

This outcome is reflected in the evolution of sectoral labour shares displayed in the right-hand panel of Figure 20. In the early 1990s the share of labour in agriculture, where productivity is lowest, declined substantially while those in manufacturing, where productivity is highest, rose rapidly, driving reallocation gains. This process started to slow after the 1997 financial crisis and the share of labour in manufacturing has been flat over the last 10 years and even declining somewhat in the most recent period.

Thus, a major element of Thailand's productivity enhancing structural change has stalled. Our analysis provides suggestive evidence that this observation at the aggregate level may, to some extent, reflect the rising disparity in productivity and resource allocation among firms. Thai firms are succeeding in expanding into higher value-added products and industries, but there are simply not enough of them and they don't seem to be able to attain substantial enough size. Hence the overall economic gains are not very apparent at the aggregate level.

The upside of these allocative inefficiencies is that fixing them can potentially yield large growth dividens. When labour and other resources move from less productive to more productive activities, the economy grows even if there is no productivity growth within sectors. This kind of growth-enhancing structural change can be an important contributor to overall economic growth. Unlocking this potential, however, is not easy. Resource misallocation often results from a large number of poorly designed economic policies and market failures that prevent the expansion of efficient firms and promote the survival of inefficient ones. Reducing misallocation is therefore a complex and multidimensional task that requires action on many fronts. Financial, labour, fiscal and product market reforms have been identified as important contributors in this respect (see Banerjee and Duflo (2005), Andrews and Cingano (2014), Gamberoni et al. (2016), Lashitew 2016), and IMF (2017).

Conclusion

Unleashing the power of productivity growth is key to achieving sustained economic expansion in the long run. This has underpinned the development path of all countries that have successfully reached high income status. But development entails more than just aggregate growth. It requires significant transformation in the productive structure of the economy. We have emphasised the critical role of product innovation in this process. Countries' long run growth performance hinges on their ability to develop and harness knowledge and capabilities to produce a greater number of increasingly sophisticated products. This is part and parcel of the structural transformation that economies go through as they mature. Understanding this process sheds light on Thailand's development path thus far and the challenges it faces going forward.

In terms of industrial upgrading and overall product diversification, Thailand has achieved much and rightly deserves the envy that many less-developed countries have bestowed upon it. There is also great potential to go much further by leveraging on the wide-ranging capabilities that have been attained, as reflected in the numerous initial footholds in many sophisticated goods and industries. Doing so requires addressing the stark disparities in capabilities across firms and regions that we have highlighted. For as long as technological upgrading and product dynamism is confined to a minority of firms in a few key provinces, the benefits will not scale at the aggregate level. The fact that some businesses in Thailand have managed to achieve high levels of efficiency, possibly close to those of the world frontier in that industry, implies that existing conditions within the country *are* compatible with higher levels of productivity. If resource allocation were improved, particularly through laggard firms catching up with frontier firms, there would be substantial productivity gains for the economy as a whole.

The policy message is thus clear. Apart from creating an environment where product innovation that leads to greater diversity and complexity can thrive, efforts should be directed to ensure that resource allocation to these activities occurs in large enough scale so that they can drive overall economic growth. Countries are more likely to succeed in this agenda if they focus on products that are close to their current set of productive capabilities, as this would leverage on existing know-how and networks. Aiming for the creation of very distant industries is a high-risk strategy since the lack of necessary supporting infrastructure, institutions, and networks may imply long incubation periods before positive diffusion effects occur. That said, one should be aware, open, and receptive to new opportunities that come and go in today's rapidly changing world. Because development *is* path dependent, the path we forge today will have lasting repercussions on the possibilities that will be available in the future. Countries would do well to make sure not to miss the opportunities that they have presently.

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