

Product Space and Thailand's Export Growth and Stability



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งานวิจัยนี้ศึกษาปัจจัยที่มีผลต่อการเติบโตและเสถียรภาพของการส่งออกของไทยในระดับผลิตภัณฑ์ โดยวิเคราะห์จากข้อมูลการค้าระหว่างประเทศและมี 3 ปัจจัย ได้แก่ ระยะทางจากประเทศไทยถึงผลิตภัณฑ์ (distance) ดัชนีความซับซ้อนของผลิตภัณฑ์ (PCI) และระดับการแข่งขัน (competition) โดยระยะทางจากประเทศไทยถึงผลิตภัณฑ์สะท้อนให้เห็นถึงศักยภาพของประเทศไทยในการส่งออกผลิตภัณฑ์นั้น จากความสามารถของประเทศที่มีอยู่ ดัชนีความซับซ้อนของผลิตภัณฑ์บอกถึงระดับความซับซ้อนของกระบวนการผลิตและการส่งออกของผลิตภัณฑ์ ระดับการแข่งขันแสดงปริมาณผู้ส่งออกและศักยภาพที่ผลิตภัณฑ์จะถูกส่งออกโดยประเทศอื่น ๆ จากการศึกษาพบว่าผลิตภัณฑ์ที่มีระยะทางไกลจะเติบโตเร็วกว่าเพราะยังมีช่องว่างสำหรับประเทศไทยที่จะสามารถพัฒนาประสิทธิภาพการส่งออกให้ดีขึ้นได้ ในส่วนของผลิตภัณฑ์ที่มีความซับซ้อนสูงจะมีอัตราการเติบโตที่สูงด้วยหากระยะทางของผลิตภัณฑ์เหล่านั้นต่ำกว่า 0.73 เรายังพบอีกว่าอัตราการเจริญเติบโตและเสถียรภาพมีความสัมพันธ์แบบผกผัน หมายความว่าสินค้าส่วนใหญ่ที่มีอัตราการเติบโตสูงจะมีเสถียรภาพของอัตราการเติบโตต่ำ อย่างไรก็ตาม ณ ตำแหน่งใด ๆ ระหว่างระยะทาง 0.70 ถึง 0.73 เราสามารถพบกับผลิตภัณฑ์ที่มีอัตราการเติบโตที่สูงขึ้นและมีเสถียรภาพมากขึ้นด้วยหากพิจารณาผลิตภัณฑ์ที่มีความซับซ้อนสูงขึ้น นอกจากนี้ งานศึกษาายังพบอีกว่าผลิตภัณฑ์ที่มีการแข่งขันสูงจะมีอัตราการเติบโตในระดับที่ต่ำกว่า แต่การเติบโตนั้นจะมีเสถียรภาพมากกว่า เนื่องจากแม้ว่าผลิตภัณฑ์เหล่านี้จะมีผู้ส่งออกจำนวนมาก แต่ผลิตภัณฑ์เหล่านี้ก็ต้องการเพียงแค่ความสามารถทั่ว ๆ ไปในการผลิตและส่งออก ดังนั้นจึงเป็นการยากที่ผู้ส่งออกจะประสบความสำเร็จในการส่งออกผลิตภัณฑ์เหล่านี้ สุดท้ายเราพบว่าผลิตภัณฑ์ที่มีอัตราการเติบโตที่สูงสุดของประเทศไทยนั้นตั้งอยู่ในระยะทางที่ไกลและมี PCI ต่ำ อย่างไรก็ตามผลิตภัณฑ์เหล่านี้จะมีเสถียรภาพของอัตราเติบโตในระดับที่ต่ำมาก หมายความว่าผู้ส่งออกจะต้องเผชิญกับความเสี่ยงในระดับสูงมากสำหรับการส่งออกผลิตภัณฑ์เหล่านี้

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This research investigates the factors affecting Thailand's export growth and stability at the product level. There are 3 key factors extracted from international trade data, which are the distance from Thailand to a product (distance), Product Complexity Index (PCI), the competition level of products. Distance reflects the potential of Thailand to successfully export the product base on existing capabilities. PCI informs the complexity of producing and exporting process of the product. The competition level illustrates the number of exporters and potential of being exported by other countries. We have found that the export of far products grow fast because there is room for improvement. High complexity products have high export growth if their location is not farther than 0.73. We also have found that growth and stability have an inverse relationship. Most of the high export growth products are unstable. However, at a certain distance between 0.70 to 0.73, we can find the product with a higher export growth that is relatively more stable by looking for the higher PCI products. Moreover, highly competitive products have lower export growth but higher stability. Although they have many exporters, they require only the common capabilities to be exported. Thus, their exporters are harder to fail. Finally, we found that the highest export growth products of Thailand locate at a very far distance and have low PCI. However, these products are less stable which means their exporters must take higher risk exporting them.

Field of Study: Economics

Student's Signature

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Advisor's Signature

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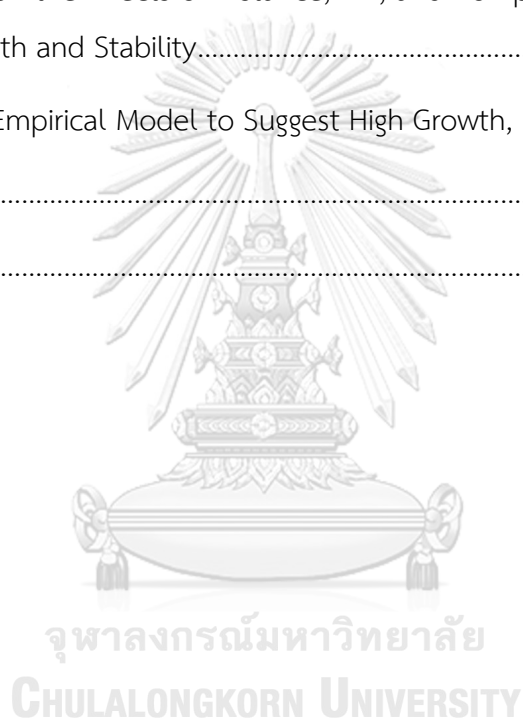
Rungrawin Warunanont

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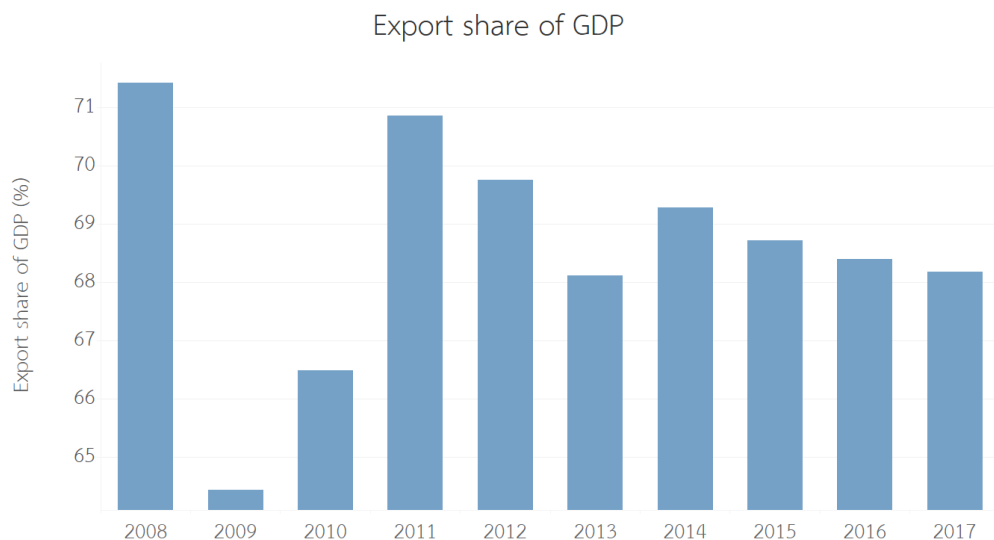


CHAPTER 1: INTRODUCTION

1.1 Importance of Thailand's Export Growth and Stability at Product Level

Thailand's economy strongly relies on the export sector. The share of export on GDP is about 70% (Figure 1). There is a positive correlation between export growth and GDP growth (Figure 2). The country can grow fast by exporting the product that has high export growth. However, export growth is not the only concerning factor but also stability of growth because some products with higher average export growth may not be stable and give low export growth over the long run. For example, the instrument panel clocks product (9104)¹, which has a high average export growth decelerates over ten years because its export growth is unstable. On the other hand, the chemical product (2918), which has a much lower average export growth positively grows over ten years because its export growth is more stable (Figure 3). An important question is how to pick the product that has high export growth and stability.

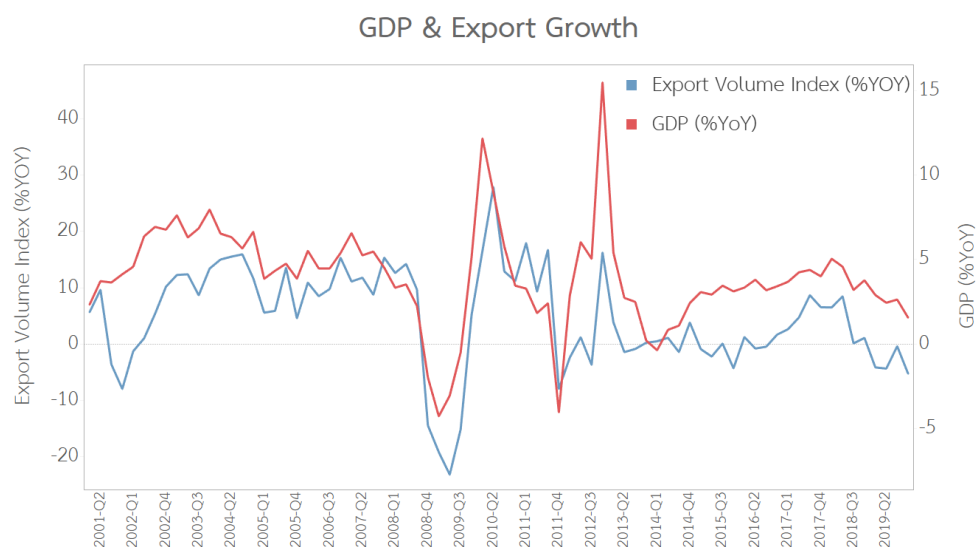
Figure 1: The Share of Export on GDP from 2008 – 2017



Source: World Bank database

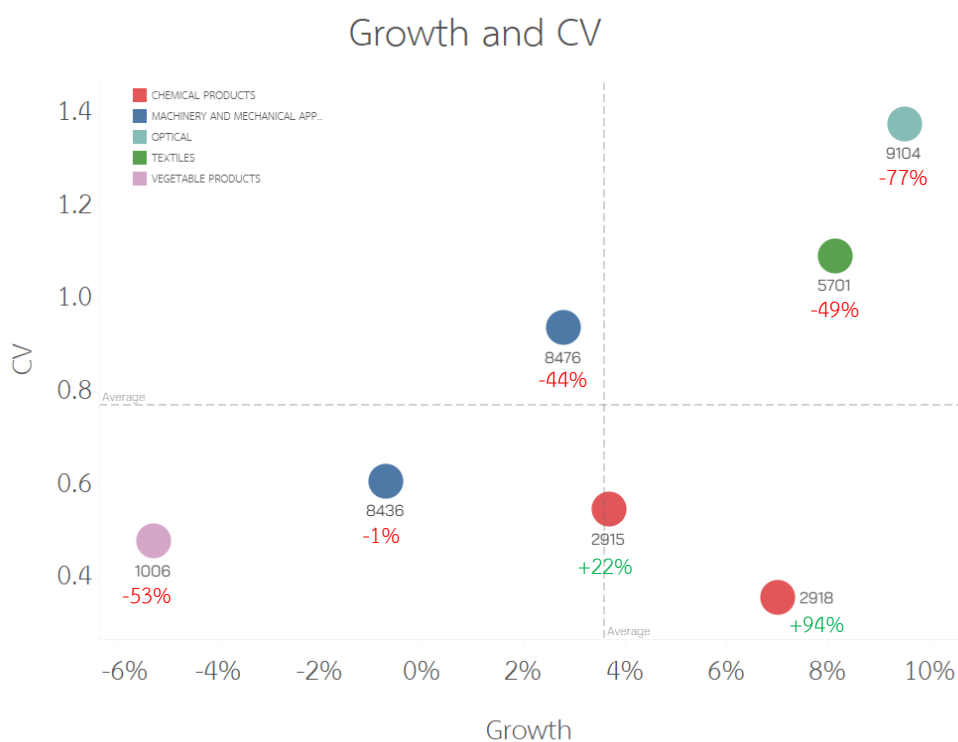
¹ Using HS-4 rev.2007 product classification system

Figure 2: The Share of Export on GDP from 2008 - 2017



Source: Office of the National Economic and Social Development, Ministry of Commerce and Bank of Thailand, and authors' calculation

Figure 3: The Sample of Average Export Growth and Stability



Source: Authors' calculation

The Thai government recognizes the importance of export at the product level. Over the past few years, the Thai government has increasingly focused on the product level by introducing a policy to support SME exporters, such as OTOP (One Tambon, One Product). Moreover, the mission of the Department of International Trade Promotion (DITP) for the Fiscal year 2020 has focused on developing the potential of Thai entrepreneurs, expanding the Thai product marketing channels, promoting and upgrading the Thai product and service (DITP, 2020).

Although the government intends to improve the export at the product level, most of the existing studies have focused on the export at the aggregate level. Because the data at the product level is incomplete, so most of the available literature at the product has focused on a specific industry, and cannot provide the whole picture of export at the product level.

We employ the International Trade Network Analysis (ITN) to extract the determinants of products that explain the different level of growth and stability using the available trade data.

This study can help policymakers to understand the determinants of products that affect their export growth and stability in order to design the appropriate policy for achieving higher export growth with stability and extending Thailand's exporting ability.

1.2 Research Objectives

- 1) To investigate the effect of distance² from Thailand to a product, the complexity of the product, and the competition level of the product on Thailand's product export growth and stability
- 2) Show how to use empirical results to suggest the high growth, high stability products for Thailand



² Distance from a country to a product reflects the country's potential to export the product, based on country's existing export products, more information in section 2.2.1, b)

CHAPTER 2: LITERATURE REVIEW AND RELATED CONCEPT

We divide this chapter into two sections. In section 2.1, we will discuss the factors affecting the export growth from the previous studies. Then, we explore the use of Network Analysis (NA) on economic works. Also, we will discuss the information extracted from ITN, how the other works use this information to explain the export and economic development, how using ITN benefit our study, and how our research differs from literature. In section 2.2, we review the key concepts used in our study. Lastly, in section 2.3, we summarize key factors and provide a sample of Thailand's export products.

2.1 Literature Review

2.1.1 Macro-Policy

Most of the study of export growth has focused at the aggregate level. These include the impact of Foreign direct investment (FDI), the effect of Institutions development, R&D expenditures, and the characters of firms on a country's development and export growth.

FDI explains the pattern of export in some country. For Nigeria, the inward FDI positively relates to export growth (Enimola, 2011). Vice versa in India and Turkey, there is no significant positive spillovers from FDI to export growth (Sharma, 2000; Temiz & Gökmen, 2011).

The investigation of the effect of Institutions, size, and age in transition economies on an export growth established that firm size affects the export growth and the level of institutional development is significant in explaining export growth (Shinkle, 2010). In Japan, the export volume positively relates to the R&D expenditures and the size of a firm. The credit constraints also impact the growth of

export at the early stages of exporting. Exporting from the more credit-constrained and riskier exporters has higher growth (Besedeš, Kim, & Lugovskyy, 2014).

Besedeš and Prusa (2011) studied the effect of the extensive and intensive margins on the growth of trade, using the Merlitz (2013) model of heterogeneous firms and empirical model. They have found that developing countries can gain higher export growth by improving their performance concerning the key components of the incentive margin.

Although there is plenty of research at the aggregate level, it is still a lack of studies at the product level. Most of the available literature is an analysis for a single product or single sector of the industry, which could not be generalized for all products.

We will see the studies that can solve the problem mentioned above, in section 2.1.4. They apply Network Analysis (NA) to the available international trade data and extract the information, which is able to explain the determinants of export products at the product level.

2.1.2 Competition

Not only the macro-policies mentioned above, but the market structure like competitiveness also can explain the performance of an exporting country or a firm. At an aggregate level, competitiveness and the country's productivity sent feedback to each other because the productivity of the country increase by trade through the knowledge spillovers and efficiency of trade is more magnified by the effects of market competition (Reis, Wagle, & Farole, 2010).

By focusing on export perspective, the OECD's has been defined the export-competitiveness as the differential between the country's export price and that of its competitors on their conventional markets (Durand & Giorno, 1987). The cost varieties of firms measure the firm's competitiveness. The firm's competitiveness can determine the firm's pattern of trade. The higher competition induces a firm to

collapse its export toward its best-performing products. So, the number of the export product of a firm will decrease, and the relative market share of the more specialized products will increase (Mayer, Melitz, & Ottaviano, 2014).

There are measurements for the competitiveness of a country and a firm. But, there is no measurement for the competition level of an export product. This research will introduce the competition level of an export product using Network Analysis (NA), in topic 2.2.3.

2.1.3 The Use of Network Analysis (NA) in Economics Research

Network Analysis (NA) is widely used in many fields of economics. In the financial industry, NA is used to investigate the social structural patterns of traders that affect the direction and magnitude of option price volatility (Baker, 1984).

The centrality measures, which is the tools in NA, are used to study the network of commercial banks. These measures can capture a bank that possibly distresses when other banks are in distress (Acemoglu, Ozdaglar, & Tahbaz-Salehi, 2015). They are used to calculate the Debt Rank, which measures the fraction of the total economic value that is potentially lost in the case of the distress (Battiston, Puliga, Kaushik, Tasca, & Caldarelli, 2012).

Also, the eigenvector centrality is used to identify the most systemic financial institutions and determine the stability of the global OTC derivatives markets (Markose, Giansante, & Shaghghi, 2012). In labour economics, NA is used to develop a model of job opportunities (Calvo-Armengol & Jackson, 2004).

These studies applied NA to the various kind of data and extracted the meaningful subject from them. Some studies also applied NA to ITN and provided significant information on export products.

2.1.4 The Information from International Trade Network (ITN)

As mentioned above in section 2.1.1 and 2.1.2, the factors from previous studies cannot be used to investigate the export growth and stability at the product level. However, some studies can extract the product level information from ITN. These studies apply Network Analysis (NA) to international trade data and introduce measurements that can explain the characters of each product, such as distance from product to country and Product Complexity Index (PCI). Moreover, some research uses these measurements to explain export and economic development.

Product Space is a tool for extracting insights from the ITN. It informs the similarity of products that illustrates by the form of the product's map, the closer products on the map, the more similarity of the export capabilities. Moreover, we can locate a country on the map at the average position of the country's export products. Then, we can measure the distance from a country to a product. This measurement reflects the potential of the country to export the product base on the existing capabilities of the country (Hidalgo & Hausmann, 2009).

Product Complexity Index (PCI) is also the information extracted from ITN. PCI is able to rank the products by their sophistication. This index has the associated index called Economic Complexity Index (ECI), which can classify the countries by the level of economic complexity. Both indexes excellently explain the economic growth and the income level of a country (Hausmann et al., 2014).

Moreover, ITN and Product Space can be further analyzed using other Network Analysis (NA) method, e.g. centrality measure. This method can extract intuitive information that helps us characterized export products. The following is the literature on the distance from country to product and PCI on the export and economic development.

a) The Effect of Distance from Country to Product on the Export

A country tends to significantly export³ the product that similar to the existing export product (Hidalgo, 2009). In the case of Sub-Saharan Africa (SSA) countries, most of the exports are unsophisticated such as agricultural products. Additionally, the country cannot diversify the exports to a higher sophisticated industry because most of the highly advanced products are farther from the existing products of those countries (Abdon & Felipe, 2011). Apaitan, Ananchotikul, and Disyatat (2017) studied the export data of 99 countries from 1995 to 2015. This study has found that the successful export probability of a product positively relates to the distance from country to the product.

According to the above studies, we can conclude that exporting closer products has more chance to be successful. Hypothetically, close products may not provide much high growth because the country has reached the best export performance. However, the existing studies did not explain the effect of distance from country to a product on the product's export growth and stability. Therefore, this research pays attention to the impact of the distance on the product's export growth and stability.

b) The Effect of Product Complexity Index (PCI) on an Exporting Country

The major exporters of the high complexity products are the high-income countries, and the higher income countries export higher complexity products (Felipe, Kumar, Abdon, & Bacate, 2012). Moreover, the economies have tended to grow more rapidly when they have increasingly specialized in exporting high-

³ Balassa's definition of Revealed Comparative Advantage (RCA)

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

RCA_{cp} is the Revealed Comparative Advantage of countries c on products p. X_{cp} is the value that country c exports product p (Balassa, 1965). The export is significant at $RCA > 1$.

technology as opposed to traditional or low-technology goods (Lee, 2011). Exporting higher PCI product can provide a higher economic growth because it constructs a more complex productivity structure and enables countries to engage in high productivity activities that lead to faster development (Felipe et al., 2012).

According to the existing studies, exporting high PCI products provides positive externality to the economy and leads to higher economic growth. In this research, we show that exporting high PCI products also provides high export growth.

Table 1: The Summary of Studies Related to the Research

Macro-Policy	
(Enimola, 2011) (Sharma, 2000; Temiz & Gökmen, 2011)	FDI has a positive impact on Nigeria's export, but the effect is not significant for India and Turkey.
(Shinkle, 2010)	The size of the firm and the institutional development is significant impact the export growth.
(Ito & Pucik, 1993)	The R&D expenditures positively relate the export volume.
(Besedeš et al., 2014)	Exporting from the more credit-constrained and riskier exporters has higher growth
(Besedeš & Prusa, 2011)	The developing countries can gain higher export growth by improving their performance concerning the critical components of the incentive margin
(Idsardi, 2010)	The factor affecting agricultural export growth in South Africa
Competition	
(REIS ET AL., 2010)	There is a correlation between the competitiveness of a country and its productivity.
(DURAND & GIORNO, 1987)	The competitiveness is the difference between the country's export price and that of its competitors on

	their conventional markets.
(MAYER ET AL., 2014)	The cost varieties of the firm can measure the competitiveness of the firm in the export market

The Use of Network Analysis (NA) in Economics Research	
(BAKER, 1984)	Using NA investigate the social patterns of traders that affect the direction and magnitude of option price volatility
(ACEMOGLU ET AL., 2015)	Using centrality measure to study the network of commercial banks
(BATTISTON ET AL., 2012)	Using centrality measure calculates the Debt Rank
(MARKOSE ET AL., 2012)	Using the eigenvector centrality identify the most systemic financial institutions and determine the stability of the global OTC derivatives markets
(CALVO-ARMENGOL & JACKSON, 2004)	In labour economics, NA is used to develop a model of job opportunities

The Effect of Distance from Country to Product on The Product's Export	
(HIDALGO, 2009)	A country tends to export the product similar to the existing export product.
(ABDON & FELIPE, 2011)	SSA countries cannot diversify the exports to a higher sophisticated because they are farther from the existing export product.
(APAITAN ET AL., 2017)	There is a positive relationship between successful export probability and the distance from country to a product.

The Effect of Product Complexity Index (PCI) on an Exporting Country	
(FELIPE ET AL., 2012) (LEE, 2011)	The high growth and high-income countries export high PCI products.
(FELIPE ET AL., 2012)	Exporting higher PCI product constructs a more complex productivity economic structure that leads to faster development.

According to the literature review, INT analysis can provide information at the product level. This information explains the successful export and development of exporter country. However, these studies still miss some aspect of export growth at the product level. Therefore, we focus on the impacts of this information on the growth and stability of Thailand's export products.

The key factors in our study are the distance from Thailand to a product, PCI, and product's competition level. Distance from Thailand to a product explains the potential of Thailand to export a product base on existing Thailand's capabilities. The PCI explains the complexity of a product's required supply chain. Lastly, the level of product's competition explains the export demand of other countries on the product, noted that the competition level is firstly introduced in our research. The next section will explain these key factors in details and related concepts.

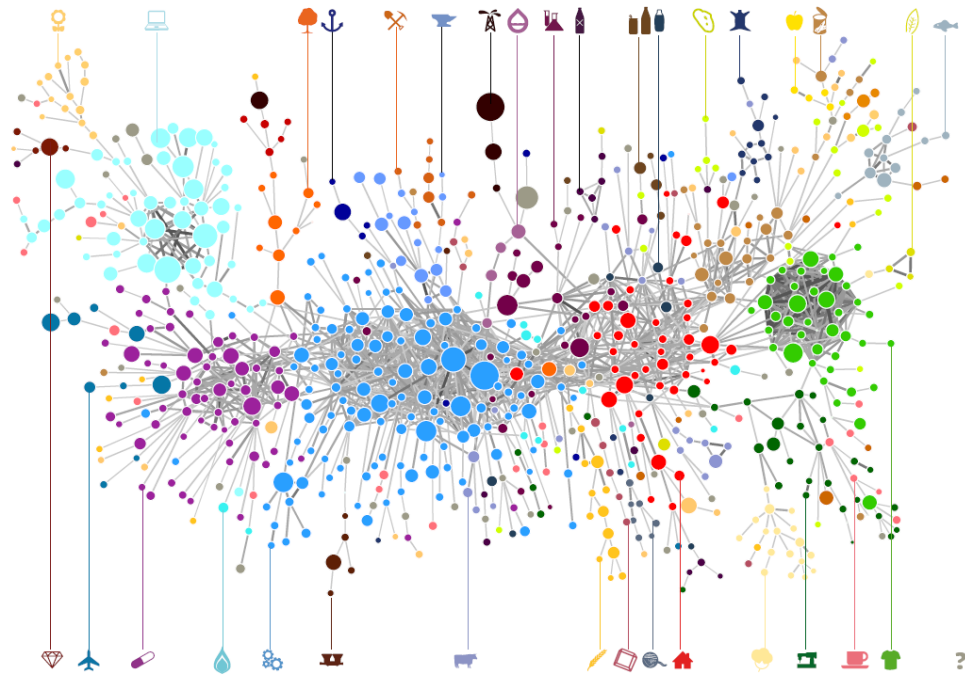
2.2 Key Factors and Related Concept

In this section, we will explain the concept idea of the following topics

- I. Product Space which consists of distance from product to product and distance from country to product
- II. Product Complexity Index (PCI)
- III. The competition level of products defined by strength centrality

2.2.1 Product Space

Figure 4: The Product Space of the year 2008



Source: (Hausmann et al., 2014)

“Product Space is a tool for extracting insights from the ITN. It informs the similarity of products that illustrates by the form of the product’s map, the closer products on the map, the more similarity of capabilities required to export the products.”

Figure 4 is the Product Space of the year 2008. Each node represents products, and the distance between each pair of nodes represents the similarity of their set of capability requirement. This distance is called *“distance from product to product”*.

Product space informs not only the similarity of products but also the potential of a country to export a new product base on the country’s existing exports. This information about the potential of a country is captured by *“distance*

from country to product". Next, we explore in more detail about the distance from product to product and the distance from country to product.

a) Distance from Product to Product

How much similar the capabilities requirement between the two export products? "*Capabilities*" of a country represents every factor that makes a country successfully produce and export the product, e.g. input factors, institution development, infrastructure, regulation, weather, etc. However, counting capabilities is tough work because the data is not available. How can we measure the similarity of capabilities requirement using the available data?

Hidalgo and Hausmann (2009) introduced an idea to measure the similarity of capabilities requirement using international trade data. He suggested that if two products require a similar set of capabilities to be produced and exported, the products must be produced and exported from the same country. By this idea, we can measure the product's similarity by co-export level.

To measure the co-export level, we first assigned which country export which product. If a country exports a product with $RCA > 1$, the country is an exporter of the product. Then, we use this information to calculate the co-export level and map this relationship into the distance from product to product.

Consider an example to be clarified. Assume that there are only three countries in the World: Nigeria, Thailand, and the United State (US), and there are four products: crude oil, crops, cars, and spacecraft. Nigeria exports crude oil and crops. Thailand exports crops and cars. The US exports crude oil, crops, cars, and spacecraft, as shown by Figure 5. To find the distance from product to product, we first calculate the co-export level of each pair of products.

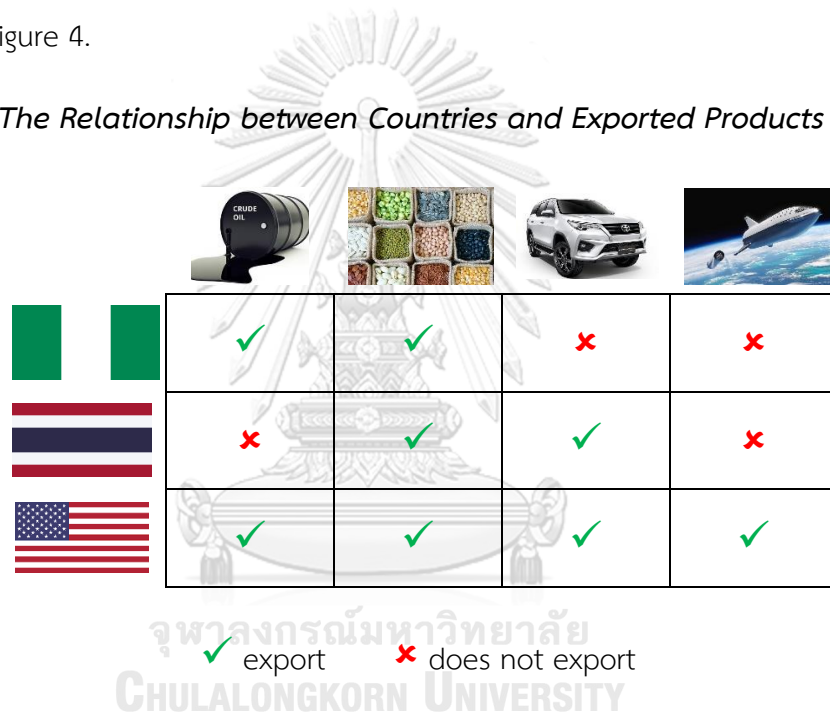
As shown in figure 6, the co-export level of car-crop is $2/3$ because they both exported by two countries (Thailand and US) from three countries exporting crops (Thailand, US and Nigeria). The co-export level of spacecraft-crop is $1/3$ because they

both exported by only one country (US) from 3 countries exporting crops (Thailand, US and Nigeria). After applying the same method for every pair of products, we receive the co-export level of every product, as shown in figure 6.

This co-export level reflects the similarity between products. To find the distance from product to products, we subtract the co-export level by 1—the closer products, the more similar they are, as shown in figure 7.

This concept is applied to the real data and give us World Product Space, as shown in figure 4.

Figure 5: The Relationship between Countries and Exported Products



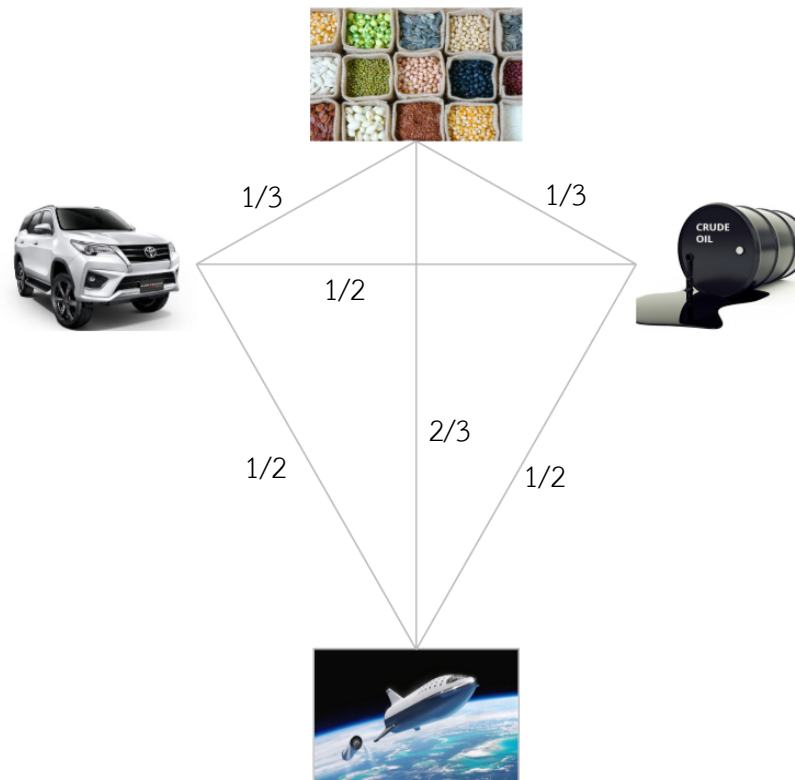
Source: Authors

Figure 6: The Co-export Level of Each Pair of Products



Source: Authors' calculation

Figure 7: The Distance from Product to Product



Source: Authors' calculation

b) Distance from Country to Product

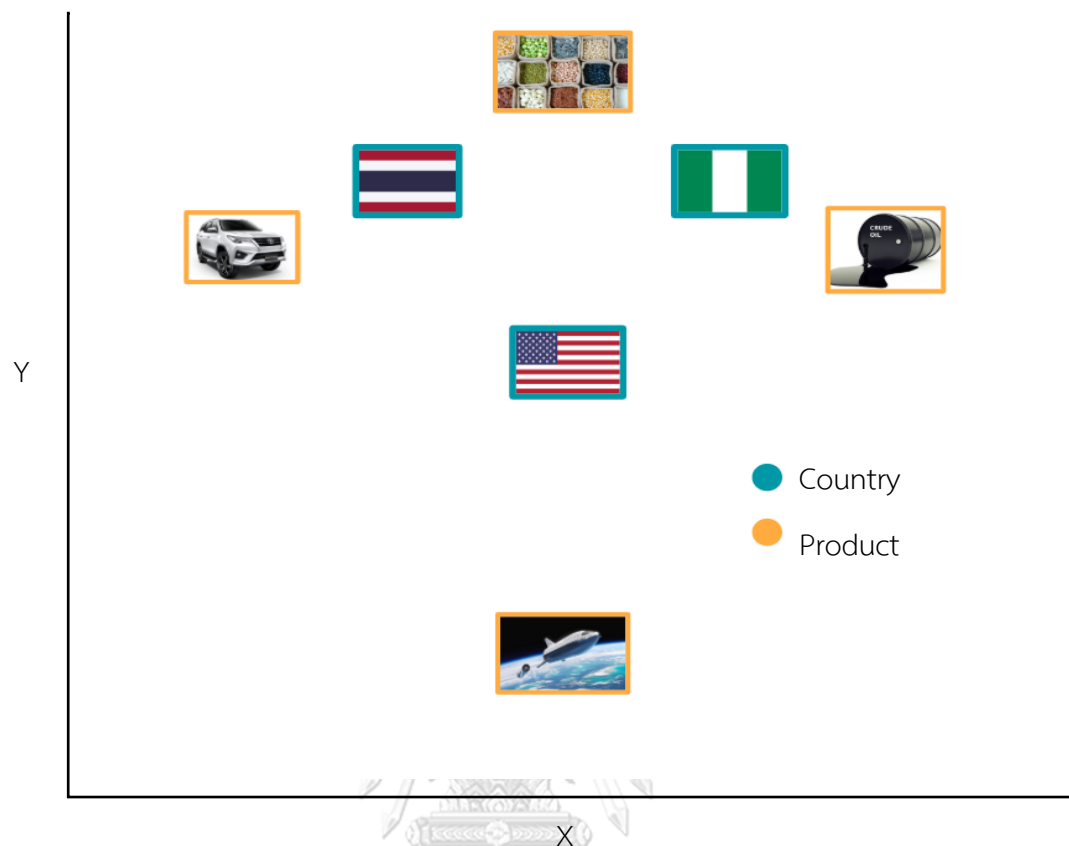
To define the group of country's export products, we can locate the position of a country on the Product Space at the average position of the country's export products. This position reflects the capabilities of the country's existing export products. Here, the Product Space shows the location of product and country. So, we are able to measure the distance from the country's position to the product's position.

Now, we have distance from country to product, which measures the similarity between a country and a product based on the existing export product of the country. *“In other words, the distance from country to product represents the potential of a country to export a product based on existing exports of the country.”*

As shown in figure 8, Thailand exports cars and crops so we can locate the position of Thailand between the car and the crop. As well as other countries, we also determine their position as the average position of their export products. Here, Product Space contains both positions of countries and products.

From figure 8, the position of Thailand is closer to the crude oil than the spacecraft. We can interpret Thailand has more potential to export the crude oil than spacecraft. As well as Nigeria that exports crude oil and crops, the distance from Nigeria to the car is shorter than the distance to spacecraft. Thus, Nigeria has more potential to export the car than the spacecraft. The US exports all products, so the US locates in the middle and is close to all products.

Figure 8: Distance from Country to Product



Source: Authors

2.2.2 Product Complexity Index (PCI)

Different products require a different set of capabilities. Some products seem easier to be produced and exported, such as crops, because the supply chain needed is not complicated. In contrast, a spacecraft that requires higher technology is more complicated. However, “*Product Complexity Index (PCI) proxies the complexity of a product’s required supply chain using trade data.*”

Hidalgo and Hausmann (2009) have quantified the countries’ economic complexity from international trade data with products disaggregated and introduced the indicator called Economic Complexity Index (ECI). This index can rank the complexity level of countries based on what they export, diversity and ubiquity of their commodities. This metric is used to quantify the product’s complexity, based

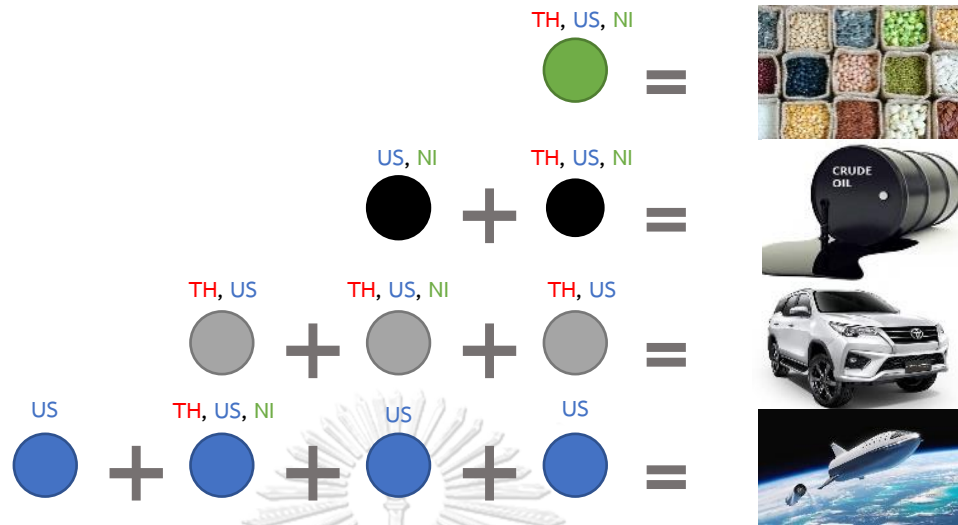
on how many countries can produce and export the product and how complicated the economy of those countries is.

Consider the figure 9, this shows the required supply chain of products and the capabilities that a country has on the supply chain. Only the country that has every component of the product can export the product. The crop's backward supply chain has only one component while the spacecraft has four components. Moreover, every country has every component of the crop's supply chain while the only US that has every component of the spacecraft. So, every country can export crop while the US is the only country that can export spacecraft. In other words, the crop is less complex than spacecraft.

In this example, we can rank products from the most to the least complex as the spacecraft, the car, crude oil and crops, respectively. Moreover, we also can rank countries from the most to the least complex as The US, which is the only country that has every component and can export everything, Thailand, which can export car, and Nigeria, respectively.

If the product is exported by a smaller number of highly sophisticated countries, the product must be highly complex, for example, the spacecraft. On the other hand, if every country, including the least complex country, can export the product, the product must be low complexity product, for example, crops. Table 2 concludes the complexity of products and countries in this example.

Figure 9: The Example of Product's Supply Chain



Source: Authors

Table 2: The Product Complexity and Country Complexity, Descending Order

Country	Product
US 	Spacecraft 
Thailand 	Car 
Nigeria 	Crude Oil 
	Crop 

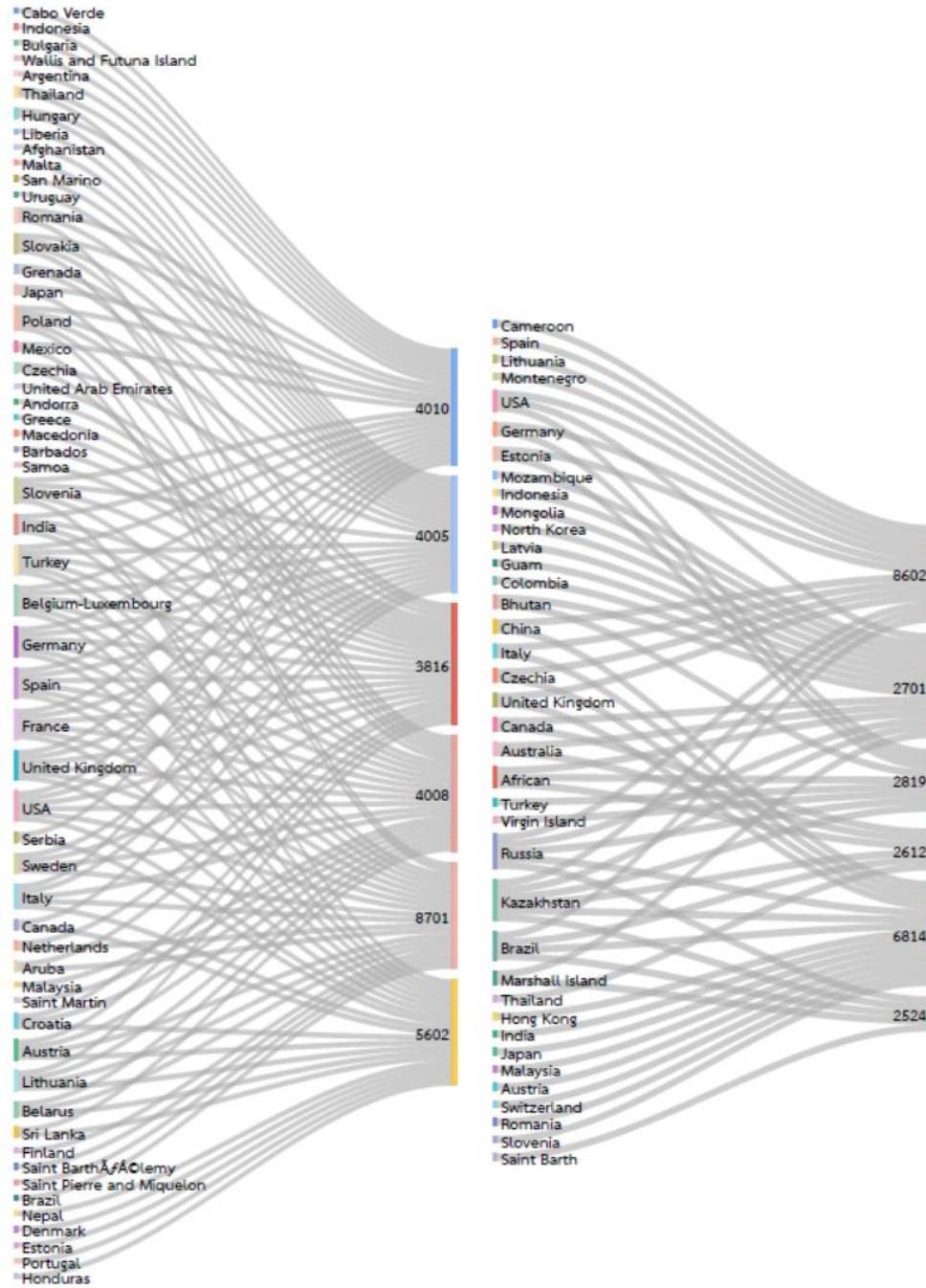
Source: Authors

2.2.3 The Competition Level of Products Measured by Strength Centrality of Product Space

The strength centrality of Product Space is the summation of similarity of each product in the Product Space. In this work, we define it as the product's competition level. Because *“the product's competition level captures the quantity of how many countries export the product and the potential that a new country will export the product.”*

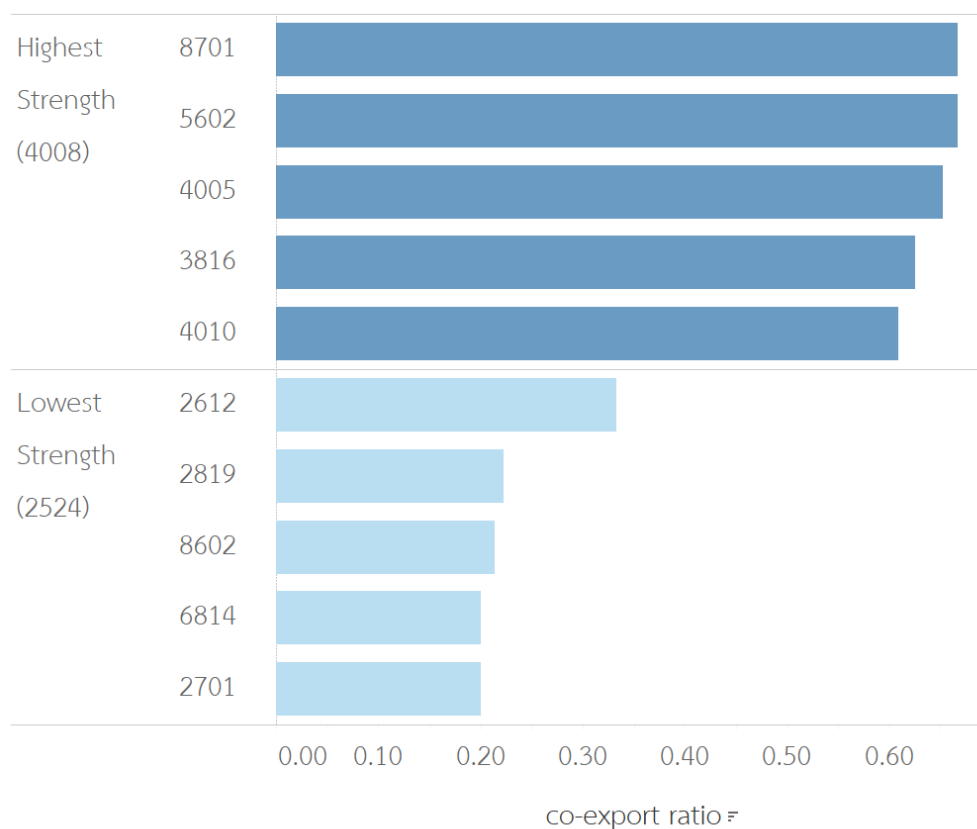
Figure 10 shows the number of countries that export the most and the least competition level products in 2017. Rubber product (4008 HS-code) is the product with the highest competition level. The top 5 most similar products of 4008 are 4010, 4005, 3816, 8701, and 5602. Asbestos (2524 HS-code) is the product with the lowest competition level. It's top 5 similar products are 2710, 2612, 2819, 8602, and 6814. As shown in figure 10, 4008, and its similar products have a higher number of exporters compare to 2524 and its similar products. Moreover, The Rubber product has a higher probability of being export by the exporters of its nearest products compare with asbestos Figure 11.

Figure 10: The Export Countries of The Highest (left) and The Lowest (light) Competition Level Product in 2017 and Their Top 5 Similar Products



Source: Authors

Figure 11: Competition Level and The Potential of Being Exported by the Exporters of Similar Products⁴



Source: Authors' calculation



⁴ The co-export ratio in figure 12 is calculated by the number of countries that export both products divided by the number of countries that export the second product. For example, the co-export ratio of 4008 and 8701 is the number of countries that export both 4008 and 8701 divided by the number of countries that export 8701. The co-export ratio can inform the probability of being export by the exporters of a similar product. For example, the nearest product of 4008 is 8701. The co-export ratio of 4008 and 8701 is 0.6 which means that 60% of countries exporting 8701 also export 4008. The nearest product of 2524 is 2612. The co-export ratio of 2524 and 2612 is about 0.35 which means that 35% of countries exporting 2612 also export 2524. According to the examples, the probability that 2524 will be exported by the exporters of 2612 is much less than the probability that 4008 will be exported by the exporters of 8701 and this information can be captured by competition level.

2.3 Distance from Country to Product, PCI, and Competition Level, Summary and examples

The distance from country to product (distance) explains the characteristics of products from the country's perspective. This measurement demonstrates the potential of a country in exporting a product. Since each country exports different things, they have a different set of capability. Thus, the distances from different countries to a product are different.

On the other hand, PCI describes the characteristic of products by illustrating the complexity of their required supply chain. The higher PCI product requires more complex or higher technology. In other words, the high PCI products are challenging to be produced or exported.

The competition level of product (competition) captures the number of product's exporters and the potential of being exported by the new countries. This measurement explains export demand for a product from other countries' point of view.

We would like to inform that distance, PCI, and competition level can change over time, as the export products of countries in the world are varying with dynamic. Exporting new products can extend a country's capabilities and shorten the distance from the country to other products. New technology may disrupt a product's required supply chain cause the rearrangement of PCI ranking. The competition also can change because there is always a new country exporting new products, and the country that leaves the market.

The following table are the implications of distance, PCI, and competition level of Thailand's export products.

Table 3: The Implications of Distance, PCI, and Competition Level

Features	Implications
High distance products	require the capabilities that different from Thailand's capabilities
Low distance products	require the capabilities that exist in Thailand's capabilities
High PCI products	require a complex supply chain, and are difficult to be produced and exported
Low PCI products	require less complex supply chain, and are easy to be produced and exported
High competition level products	have many exporters and high potential to be exported by new countries
Low competition level products	have a low number of exporters and low potential to be exported by new countries

In this section, we give some example of Thailand's export products at a different level of distance, PCI, and competition. We categories the sample products into eight categories which are the combination of high and low distance, PCI, and competition, as shown in table 4.

Table 4: The Sample of Thailand's export products at a different level of distance, PCI, and competition Level

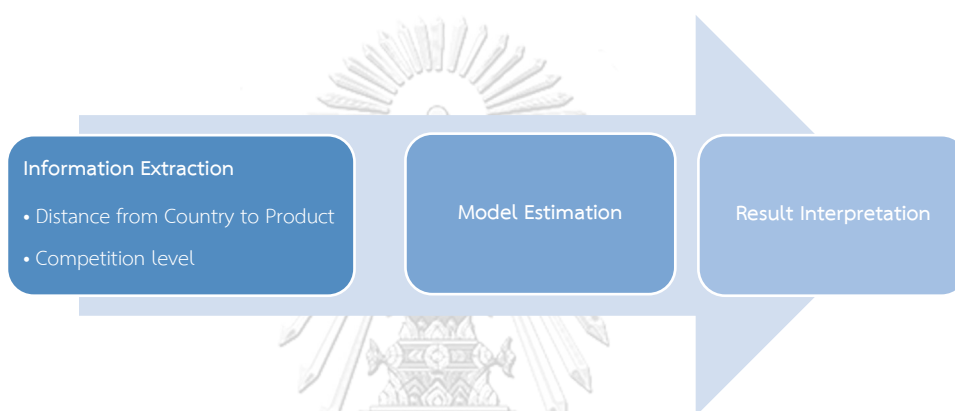
The Export Products with High Distance, High PCI, and High Competition Level	
<p><u>Explanation</u></p> <p>They require a complex supply chain, and different capabilities from those existing in Thailand. Moreover, they have many exporters and risky to be exported by other countries.</p>	<p><u>Example</u></p> <ul style="list-style-type: none"> ● Escalators (machinery; 8428) ● Pressure-reducing valves and thermostatically controlled valves (machinery; 8481) ● Plant or laboratory equipment (machinery; 8419)
The Export Products with High Distance, High PCI, and Low Competition Level	
<p><u>Explanation</u></p> <p>They require a complex supply chain, and different capabilities from those existing in Thailand. However, they have a low number of exporters and low potential to be exported by a new country.</p>	<p><u>Example</u></p> <ul style="list-style-type: none"> ● Blown glass (glass; 7004) ● Clock (optical; 9105) ● Microscopes, diffraction apparatus (optical; 9012)
The Export Products with High Distance, Low PCI, and High Competition Level	
<p><u>Explanation</u></p> <p>They require different capabilities from those existing in Thailand. They have many exporters and risky to be exported by the new countries. But, they need less complex supply chain and easy to be produced and exported.</p>	<p><u>Example</u></p> <ul style="list-style-type: none"> ● Buckwheat, millet and canary seed (vegetable; 1008) ● Milk and cream (animal product; 401) ● Cheese and curd (animal product; 406)
The Export Products with High Distance, Low PCI, and Low Competition Level	
<p><u>Explanation</u></p> <p>They require different capabilities from those existing in Thailand, but they have a low number of exporters. Moreover, they require a less complex supply chain, so they are easy to be produced and exported.</p>	<p><u>Example</u></p> <ul style="list-style-type: none"> ● Petroleum oils (mineral, 2709) ● Coffee (vegetable, 901) ● Niobium, tantalum, vanadium or zirconium ores (mineral, 2615)

The Export Products with Low Distance, High PCI, and High Competition Level	
<p><u>Explanation</u></p> <p>These products require a complex supply chain, have many exporters, and risky to be exported by the new countries. However, they require the capabilities that exist in Thailand.</p>	<p><u>Example</u></p> <ul style="list-style-type: none"> ● Printed Circuit Board (machinery; 8534) ● Sound or video recording apparatus (machinery; 8522) ● Electrical capacitors (machinery; 8532)
The Export Products with Low Distance, High PCI, and Low Competition Level	
<p><u>Explanation</u></p> <p>Although these products require a complex supply chain, they require the capabilities that exist in Thailand, and they have a low number of exporters.</p>	<p><u>Example</u></p> <ul style="list-style-type: none"> ● Watch movements (optical; 9108) ● Watch or clock movements (optical; 9110) ● Electronic integrated circuits (optical; 8542)
The Export Products with Low Distance, Low PCI, and High Competition Level	
<p><u>Explanation</u></p> <p>They have many exporters and risky to be exported by the new countries. But, they require the capabilities that exist in Thailand, and they require a less complex supply chain. Hence, they are easy to be produced and exported.</p>	<p><u>Example</u></p> <ul style="list-style-type: none"> ● Hard rubber (Plastic; 4017) ● Frozen Vegetables (vegetables; 710) ● Twine, cordage, ropes and cables (textile; 5607)
The Export Products with Low Distance, Low PCI, and Low Competition Level	
<p><u>Explanation</u></p> <p>They require capabilities that exist in Thailand. They have a low number of exporters. Also, they need a less complicated supply chain which means they are easy to be produced and exported.</p>	<p><u>Example</u></p> <ul style="list-style-type: none"> ● Travel sets: for personal toilet, sewing, shoe or clothes cleaning (miscellaneous; 9605) ● Fish fillets and other fish meat, fresh, chilled or frozen (animal product; 304) ● Tin: unwrought (base metal; 8001)

CHAPTER 3: METHODOLOGY

This research uses the distance from Thailand to products, PCI, and competition level as the product's determinants. Then, we study their effects on Thailand's product export growth and stability, using OLS regression. This chapter gives details about how we prepare the data. There are three sections in this chapter; data sources, data preparation, and basic model.

Figure 12: Main Process



3.1 Data Sources

There are two sets of data used in this research: product trade by year and country and Product Complexity Index (PCI), yearly from 2008 to 2017. The first data set consists of export volume and product's Reveal Comparative Advantage (RCA). The following data is PCI of each product calculated by Harvard's Growth Lab. These provide information on 222 countries and 1,221 products. The products are classified base on HS-4 Rev.2007 and grouped into 21 sectors. The original data comes from the United Nations Statistical Division (COMTRADE) and is cleaned by the BACI team using their methodology of harmonization. We download the product trade by year and country data from OEC data sources ("Data sources," 2020) and the PCI data from OEC Product Complexity ranking ("Product Complexity Rankings (PCI)," 2020).

Table 5: The Summary of Data

Data	Description	Source
Product trade by year and country	Consist of: <ol style="list-style-type: none"> 1. Trade volume by product and country 2. RCA by product and country Details: <ul style="list-style-type: none"> ● 222 countries and 1,221 products ● Frequency yearly ● Range from 2008 – 2017 ● HS-4 Rev.2007 product classification 	("Data sources," 2020)
Product Complexity Index (PCI)	Consist of PCI by product Details: <ul style="list-style-type: none"> ● Frequency yearly ● Range from 2008 – 2017 ● HS-4 Rev.2007 product classification included sector code ● Calculated by Harvard's Growth Lab 	("Product Complexity Rankings (PCI)," 2020)

3.2 Data Preparation

This section explains the calculation details for preparing the variables used in the model. The independent variables are the distance from Thailand to products, PCI, and competition level. The distance and competition level are calculated in this study, but PCI can be downloaded from the OEC Product Complexity ranking ("Product Complexity Rankings (PCI)," 2020). The dependent variables are product export growth and CV.

3.2.1 Distance from Product to Product

As described in section 2.2.1 Product Space is the network that illustrates the similarity of export capabilities required between product pair. The similarity is explained by co-export level and distance from product to product.

From trade volume by product and country data, we construct the relationship between country and product. Let us consider the example in section 2.2.1. We write the country-product relationship as the adjacency matrix, as shown in figure 13. The element in the matrix equals to 1 if the country exports the product with $RCA \geq 1$ and is 0 otherwise (equation 1). Then, we calculate the distance between products using equation 2. The adjacency matrix of country and product will transform to the distance between products matrix, which is Product Space (figure 14).

$$M_{cp} = \begin{cases} 1 & \text{if } RCA_{cp} \geq 1 \\ 0 & \text{otherwise} \end{cases} \quad [1]$$

$$distance_{pp'} = 1 - \frac{\sum_c M_{cp} M_{cp'}}{\text{Max}(k_{p,0}, k_{p',0})} \quad [2]$$



The fraction term in equation 2 shows the co-export ratio between product p and p' when $k_{p,0} = \sum_c M_{cp}$. Then, the ratio is subtracted by 1 to provide the distance. The higher distance means less similarity.

Figure 13: The Example of the Adjacency Matrix of Country and Product

				
	1	1	0	0
	0	1	1	0
	1	1	1	1

Source: Authors

Figure 14: The Example of The Distance from Product to Product Matrix

				
	0	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{1}{2}$
	$\frac{1}{3}$	0	$\frac{1}{3}$	$\frac{2}{3}$
	$\frac{1}{2}$	$\frac{1}{3}$	0	$\frac{1}{2}$
	$\frac{1}{2}$	$\frac{2}{3}$	$\frac{1}{2}$	0

Source: Authors' calculation

3.2.2 Distance from Country to Product

From Product Space and the adjacency matrix, we calculate distance from country to product using equation 3. As shown in figure 15, the set of distance is different in each country. In this research, we select the distance from Thailand to a product as the independent variable and call it “*distance*”.

$$\text{distance}_{cp} = \frac{\sum_{p'} (1 - M_{cp'}) (1 - \text{distance}_{pp'})}{\sum_{p'} \text{distance}_{pp'}} \quad [3]$$

In figure 15, the values of the distance shown in the matrix are relative. The distance from Thailand to crop and car are the same which is 0.375, while the distance from Thailand to crude oil is farther which is 0.563, and the distance from Thailand to spacecraft is farthest which is 0.643.

Figure 15: The Example of Distance from Country to Product Matrix



				
	0.563	0.375	0.375	0.643
	0.375	0.375	0.563	0.643
	X	X	X	X

Source: Authors' calculation

3.2.3 The Competition Level of Product

We calculate the competition level of a product using the strength centrality of Product Space using equation 4. The competition level of a product is the summation of distance from the product to every product in Product Space.

$$\text{competition}_p = \sum_{p'} (1 - \text{distance}_{pp'}) \quad [4]$$

Figure 16: The Example of Product's Competition Level



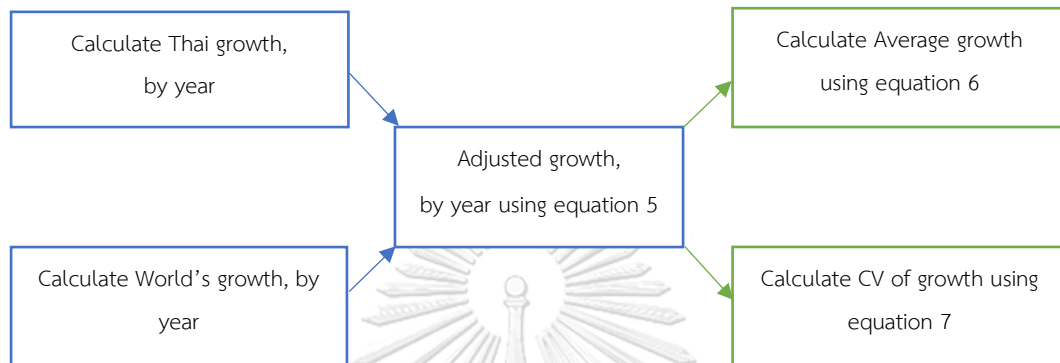
Source: Authors' calculation

Figure 16 shows the competition level of 4 products. In this example, crude oil, crop, and car have the same level of competition while the spacecraft has the lowest competition level.

3.2.4 Average and Coefficient of Variation (CV) of Thailand's Product Export Growth

The following diagram shows the steps to calculate growth and CV.

Figure 17: The Steps to Calculate Growth and CV



$$\text{growth}_{p,t} = \text{Thai_growth}_{p,t} - \text{World_growth}_{p,t} \quad [5]$$

$$\text{growth}_p = \text{mean}(\text{growth}_{p,t}) \quad [6]$$

$$\text{CV}_p = \frac{\text{S.D.}(\text{growth}_{p,t})}{\text{growth}_p} \quad [7]$$

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Thailand's product export growth is reflected by the variable name "growth" which is average Thailand's product export growth adjusted by the world's growth. The variable name "CV" indicates the stability of growth, the higher CV, the lower stability.

3.3 Basic Model

We start our study of the effects of distance, PCI, and competition level on growth and stability of export product using equation 8 and 9 and OLS regression. Then, we will put others additional terms for robustness check our model and discuss the result in the next chapter.

$$\text{growth}_p = \beta_0 + \beta_1 \text{distance}_p + \beta_2 \text{PCI}_p + \beta_3 \text{competition}_p + \text{others} + \epsilon_p \quad [8]$$

$$\text{CV}_p = \beta_0 + \beta_1 \text{distance}_p + \beta_2 \text{PCI}_p + \beta_3 \text{competition}_p + \text{others} + \epsilon_p \quad [9]$$



CHAPTER 4: RESULTS

The first section of this chapter discusses the estimation results, including the basic model, the model with distance square and interaction between distance and PCI. Then, we check the robustness of the model by adding the product's sector fixed effect and use clustered robust standard errors at sector levels. Additionally, the interpretation of estimation results is express in section 4.2.

4.1 Results

4.1.1 Basic Model

We estimate the effects of distance, PCI, and competition level on growth and CV using OLS regression. The basic model is shown in equation 8 and equation 9. According to the regression results of growth (Table 6), all variables significantly affect the growth of export product both in the separated model and combined model and the signs of the coefficient are consistency. For the regression results of CV (Table 7), all variables are significant except PCI, and the coefficient signs are the same as growth.

Distance has a positive relationship with growth, which mean that a product located at a far distance tends to have higher export growth. However, the coefficient of distance on the CV model is also positive, so this product grows with less stability. PCI positively affect the growth, so a more complex product grows faster. However, PCI is not significant for the CV basic model. The competition gives a negative effect both on growth and CV, so a product with higher competition level is more stable but has a lower growth. We can see that both growth and CV models have the corresponding sign for all coefficients. The correlation coefficient between growth and CV is 0.6, so most of the high growth products are less stable.

Table 6: Basic Growth Model

Dependent Variable	growth	growth	growth	growth
distance	1.969469*** (.1961958)			1.965903*** (.2108627)
PCI		.0231844*** (.006907)		.0166341** (.0077984)
competition			-.0006977*** (.0001472)	-.0010445*** (.0001539)
constant	-1.333064*** (.1422492)	.0928864** (.0066453)	.2345343*** (.0305012)	-1.11964*** (.1572479)
observation	1,054	1,054	1,054	1,054
R-squared	0.087	0.0106	0.0209	0.1261

OLS Regression, *** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculation



Table 7: Basic CV Model

Dependent Variable	CV	CV	CV	CV
distance	7.230975*** (.5699739)			8.315985*** (.5930713)
PCI		.0085994 (.020691)		-.0254111 (.0219336)
competition			-.003504*** (.0004301)	-.0041002*** (.0004329)
constant	-4.331942*** (.4132523)	.905304*** (.0199071)	1.614072*** (.089091)	-4.288043*** (.4422746)
observation	1,054	1,054	1,054	1,054
R-squared	0.1327	0.0002	0.0593	0.2216

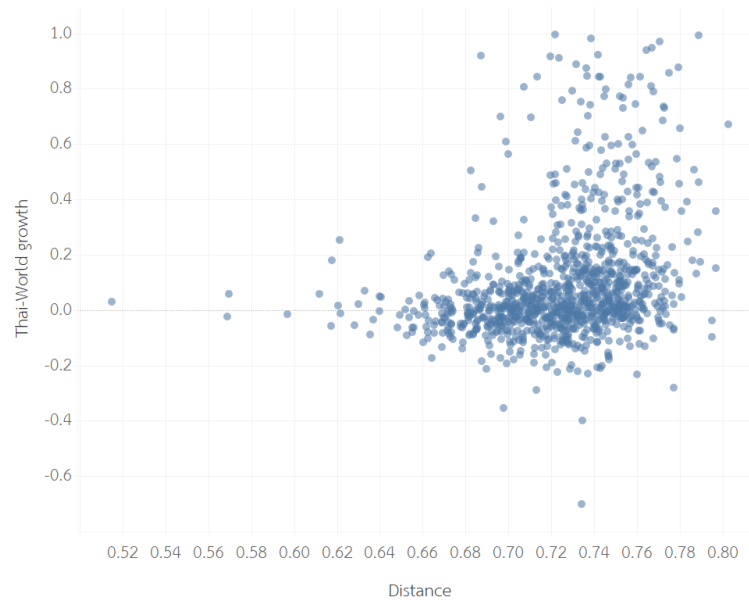
OLS Regression, *** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculation

4.1.2 Model with Quadratic Effect of Distance and Interaction of Distance and PCI

We plot the scatter of growth and distance to see the pattern of their relationship. As shown in Figure 18, at a higher distance, the products have higher growth. However, the relationship does not seem to be linear, but the relationship appears to be quadratic. The export growth is much higher for the products at higher distance. Hence, we add the distance square into our model and expect the coefficient sign of distance to be negative and the coefficient sign of distance square to be positive.

Figure 18: Growth and Distance



Source: Authors

According to the study of Apaitan et al. (2017), the effect of distance and PCI on the increase in RCA, they put the interaction term between distance and PCI to justify the alter effect of distance caused by PCI. The result of this study suggests that the impact of distance is stronger for complex products. So, we decide to test the interaction term of distance and PCI in our model.

From the discussion above, we extend the basic model by adding distance square and the interaction term of distance and PCI. Thus, our model is augmented, as shown in equation 10 and equation 11.

Table 8 and 9 show the estimation result of equation 10 and equation 11. For growth, all variables are significant. Similar to the CV model, all variables are significant, including PCI. For both growth and CV, the coefficient sign of distance and distance square are negative and positive, respectively. This finding confirms that growth and CV increase with increasing rate, respect to distance. Moreover, the significances of distance*PCI indicate the different effect of distance on growth and

stability at the different PCI. Finally, competition level still negatively affects growth and CV.

$$\begin{aligned} \text{growth}_p = & \beta_0 + \beta_1 \text{distance}_p + \beta_2 \text{PCI}_p + \beta_3 \text{competition}_p \\ & + \beta_4 \text{distance}_p * \text{PCI}_p + \beta_5 \text{distance}^2 + \epsilon_p \end{aligned} \quad [10]$$

$$\begin{aligned} \text{CV}_p = & \beta_0 + \beta_1 \text{distance}_p + \beta_2 \text{PCI}_p + \beta_3 \text{competition}_p \\ & + \beta_4 \text{distance}_p * \text{PCI}_p + \beta_5 \text{distance}^2 + \epsilon_p \end{aligned} \quad [11]$$

Table 8: Growth Model with Distance Square and the Interaction of Distance and PCI

Dependent Variable	growth	growth	growth	growth
distance	1.965903*** (.2108627)	1.954819*** (.2108735)	-8.306244* (4.889086)	-14.06048*** (5.356526)
PCI	.0166341** (.0077984)	.2156149 (.1341342)	.010743 (.0082743)	.3875077*** (.1454539)
competition	-.0010445*** (.0001539)	-.0010604*** (.0001542)	-.0008943*** (.0001695)	-.0008407*** (.0001703)
distance* PCI		-.2750439 (.1850955)		-.5253329** (.2024835)
distance ²			7.27174** (3.457816)	11.33022*** (3.786627)
constant	-1.11964*** (.1572479)	-1.10487*** (.1574716)	2.467703 (1.713041)	4.498071** (1.879096)
observation	1,054	1,054	1,054	1,054
R-squared	0.1261	0.1280	0.1298	0.1354

OLS Regression, *** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculation

Table 9: CV Model with Distance Square and the Interaction of Distance and PCI

Dependent Variable	CV	CV	CV	CV
distance	8.315985*** (.5930713)	8.25214*** (.5911042)	-27.06339** (13.73653)	-55.29545*** (14.95048)
PCI	-0.0254111 (.0219336)	1.120765*** (.3759946)	-0.0457014* (.0232478)	1.802824*** (.4059731)
competition	-0.0041002*** (.0004329)	-0.0041917*** (.0004322)	-0.0035826*** (.0004761)	-0.0033199*** (.0004752)
distance*PCI		-1.584317*** (.5188454)		-2.577447*** (.5651471)
distance ²			25.04536** (9.715185)	44.95755*** (10.56877)
constant	-4.288043*** (.4422746)	-4.202963*** (.4414121)	8.067501* (4.813014)	18.02912*** (5.244702)
observation	1,054	1,054	1,054	1,054
R-squared	0.2216	0.2284	0.2265	0.2415

OLS Regression, *** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculation

4.1.3. Robustness Check

Because this research uses the data at product level which is highly heterogeneous so we would like to robustness check our model by adding the product's sector fixed effect and clustering the robust standard errors at the product's sector level.

From the regression result table 10 and table 11, after adding the two controls, the coefficient of each variable is still significant, and the signs remain unchanged.

Table 10: The Robust Regression Result for Growth

Dependent Variable	growth	growth	growth	growth
distance	-14.06048*** (5.356526)	-12.78618** (5.450632)	14.06048** (5.070027)	-12.78618** (5.359968)
PCI	.3875077*** (.1454539)	.3278054** (.148047)	.3875077*** (.1343838)	.3278054** (.1385682)
competition	-.0008407*** (.0001703)	-.0007721*** (.0001801)	-.0008407*** (.000268)	-.0007721** (.0003114)
distance*PCI	-.5253329** (.2024835)	-.4481967** (.205536)	-.5253329** (.1857212)	-.4481967** (.190719)
distance ²	11.33022*** (3.786627)	10.31165*** (3.858993)	11.33022*** (3.637442)	10.31165** (3.833004)
constant	4.498071** (1.879096)	4.075752** (1.90842)	4.498071** (1.721423)	4.075752** (1.832558)
observation	1,054	1,054	1,054	1,054
control	non-control	sector fixed effect	robust standard errors adjusted for 21 clusters in the sector	sector fixed effect & robust standard errors adjusted for 21 clusters in the sector
R-squared	0.1354	0.1617	0.1354	0.1617

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculation

Table 11: The Robust Regression Result for CV

Dependent Variable	CV	CV	CV	CV
distance	-55.29545*** (14.95048)	-55.17444*** (14.8572)	-55.29545*** (12.31037)	-55.17444*** (12.51328)
PCI	1.802824*** (.4059731)	1.723771*** (.403543)	1.802824*** (.3992151)	1.723771*** (.4420115)
competition	-.0033199*** (.0004752)	-.0032783*** (.000491)	-.0033199*** (.0004831)	-.0032783*** (.0004861)
distance*PCI	-2.577447*** (.5651471)	-2.473867*** (.5602452)	-2.577447*** (.5502864)	-2.473867*** (.5899231)
distance ²	44.95755*** (10.56877)	44.65057*** (10.51875)	44.95755*** (8.741638)	44.65057*** (8.91724)
constant	18.02912*** (5.244702)	18.03156*** (5.201928)	18.02912*** (4.268882)	18.03156*** (4.353973)
observation	1,054	1,054	1,054	1,054
control	non-control -14.06non-control	sector fixed effect	robust standard errors adjusted for 21 clusters in the sector	sector fixed effect & robust standard errors adjusted for 21 clusters in the sector
R-squared	0.2415	0.2986	0.2415	0.2986

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculation

4.2 Summary of Results

we summarize results into three parts which are the effect of competition level, distance, and PCI on growth and stability, respectively. After understanding the effect of each factor separately, we will jointly interpret them.

4.2.1 The Effects of Distance, PCI, and Competition Level on Growth and CV, Separated Interpretation

a) The Effect of Competition Level on Growth and Stability

The effect of competition level on growth and CV is negative, which means that products with high competition level have lower growth but higher stability. According to our definition of competition level, the product with high competition level has many exporters and has the capabilities requirement that is similar to many products. So, the potential of being exported by the exporter of similar product is high. The explanation is that exporting the products with many competitors seem challenging to achieve high growth. However, these products require common capabilities, so they are more likely to be successful and stable.

b) The Effect of Distance on Growth and Stability

According to estimation results, the distance's coefficient is negative, and the coefficient of distance square is positive for both growth and CV. So, the effect of distance on growth or CV is quadratic, as shown in figure 19. At a constant PCI and competition level, the growth increases with distance by an increasing rate. So, a product that requires different capabilities from the existing capabilities in Thailand has higher growth because there is room to learn and to improve export performance.

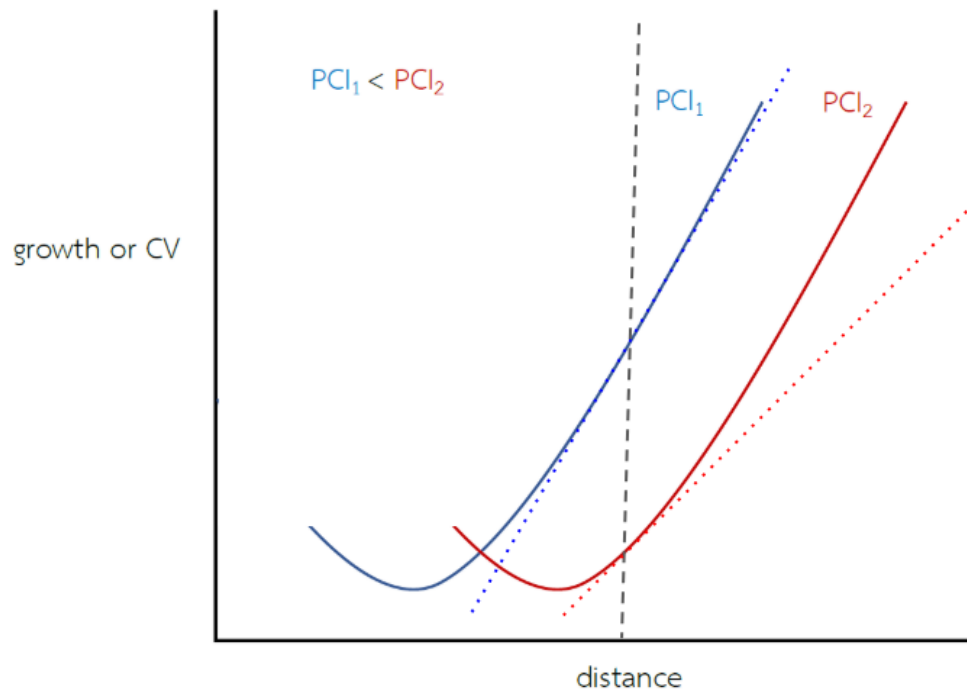
However, there is a different effect caused by PCI; at higher PCI, the line in figure 19 shifts to higher distance position. At the same distance, the slope of the higher PCI line is less the lower PCI line, which means that at higher PCI, the effect of distance on growth and CV is weaker. Therefore, exporting a product located at a far

distance provides high growth if it is not too complicated. In other words, exporting an unfamiliar product would benefit if the product requires basic capabilities.

c) The Effect of PCI on Growth and Stability

At a fixed distance and a competition level, PCI linearly affects growth and CV. However, the relationship depends on distance; as distance increase, the positive effect of PCI on growth and CV decrease and can be negative. As shown in figure 20, at a small distance, there is a straight line with a positive slope. However, as the distance increase, the slope of the line decreases. At distance cutoff, the slope becomes zero, so growth and CV unaffected by PCI. The distance cutoff is 0.73 and 0.70 for growth and CV, respectively. Beyond the distance cutoff, the PCI negatively affects growth and CV. The finding suggests that exporting the high complex products will be beneficial if the product does not require the unavailable capabilities in Thailand.

Figure 19: Effect of Distance on Growth and CV⁵



Source: Authors



⁵ From our estimation results,

$$\text{growth} = 4.076 - 12.786\text{distance} + 0.328\text{PCI} + 0.0007721\text{competition} - 0.448\text{distancs*PCI} + 10.312\text{distance}^2.$$

So, at a constant PCI and competition level, the relationship between distance and growth is quadratic.

Let us consider the first derivative of growth, $\frac{\partial \text{growth}}{\partial \text{distance}} = -12.786 - 0.448\text{PCI} + 20.624\text{distance}$.

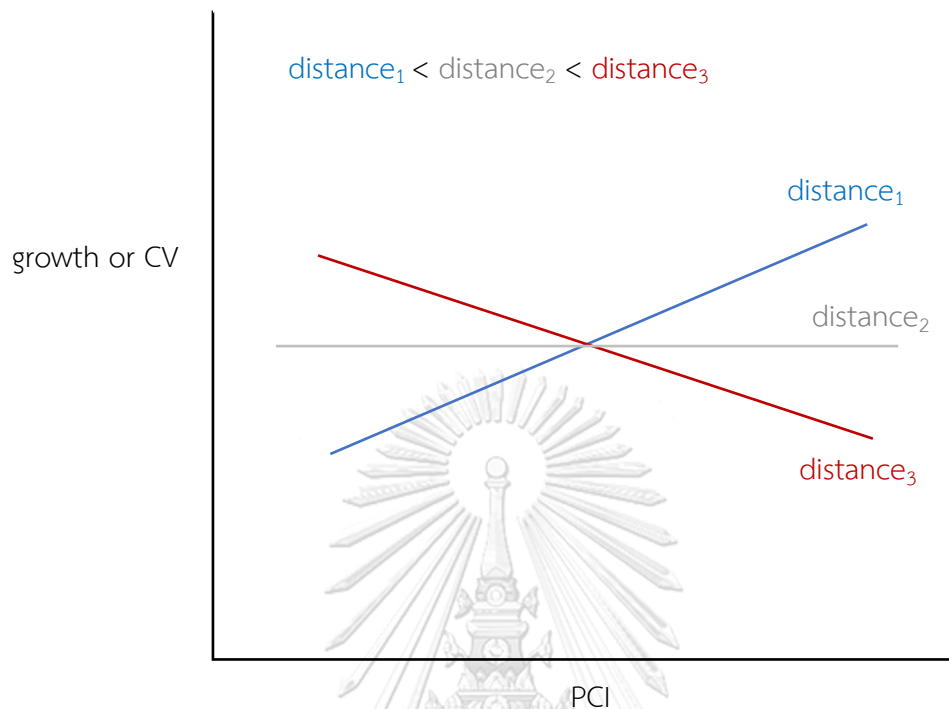
This means that at a constant PCI, as distance increase, the growth increase with higher rate.

At minimum point, $\frac{\partial \text{growth}}{\partial \text{distance}} = 0$. So, $\text{distance} = \frac{12.786 + 0.448\text{PCI}}{20.624}$,

which means that the minimum point increase with PCI, so growth shift to the right.

CV also can be interpreted by the same method.

Figure 20: Effect of PCI on Growth and CV⁶



Source: Authors

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⁶ From our estimation results,

$$\text{growth} = 4.076 - 12.786\text{distance} + 0.328\text{PCI} + 0.0007721\text{competition} - 0.448\text{distance} \times \text{PCI} + 10.312\text{distance}^2.$$

So, at constant distance and competition, the effect of PCI on growth depends on distance.

Let us consider the first derivative of growth, $\frac{\partial \text{growth}}{\partial \text{PCI}} = 0.328 - 0.448\text{distance}$.

This means that at higher distance the, effect of PCI on growth is less positive and can be negative.

At a cutoff, $\frac{\partial \text{growth}}{\partial \text{PCI}} = 0$. So, distance = 0.73,

which means that closer than 0.73 the effect of PCI on growth is positive but farther than 0.73 the effect is negative. CV also can be interpreted by the same method and the cutoff for CV is 0.70.

4.2.2 The Effects of Distance, PCI, and Competition Level on Growth and CV, Joint Interpretation

We can jointly interpret the effects of distance and PCI, as shown in figure 21 – 23⁷. In figure 21, the arrows indicate the directions of change in growth. The top-left corner shows the region where the products that have lower distance and higher PCI grows faster than the higher distance and lower PCI products. At the middle area, growth increases as PCI and distance increase. Beyond the distance of 0.73, the growth still increases distance but decreases with PCI.

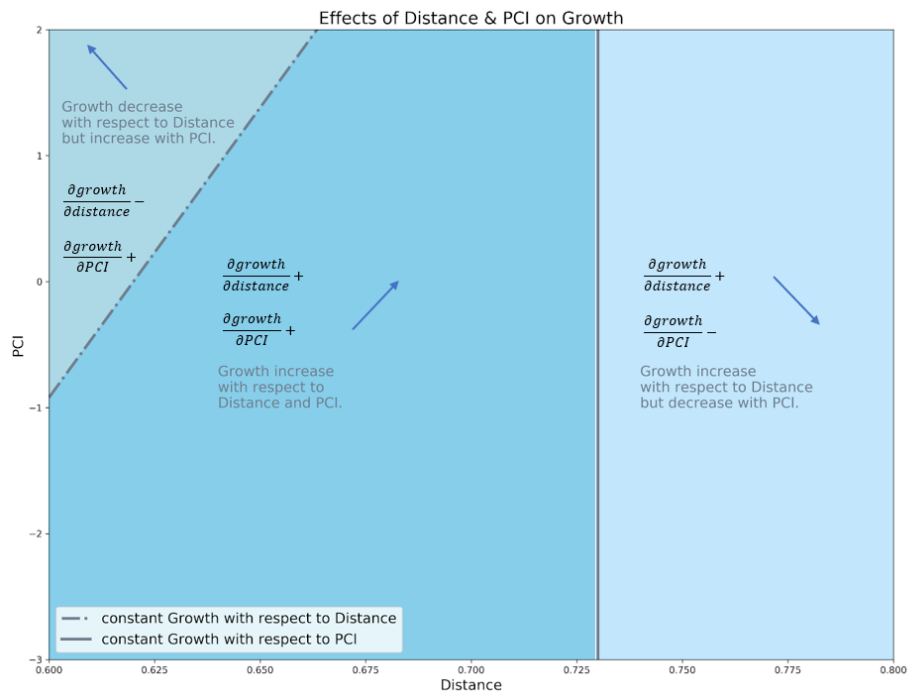
Because of the high correlation between growth and CV, figure 21 and 22 have the same pattern. One difference is the position of distance cutoff. At a distance farther than 0.70, the relationship between CV and PCI is negative.

As shown by figure 23, most of Thailand export products (scatter dots on the graph) located in the middle-right region on the figure. It is interesting that between the distance of 0.70 to 0.73, the products with higher PCI have higher growth and higher stability. So, at a certain distance between this range, we can find a higher growth product that is relatively more stable by looking for the more top PCI products.

Overall, our predicted growth and CV at a different level of distance, PCI, and competition level, as shown in figure 24 and 25. At the constant competition level, the highest growth and CV products are at the bottom-right area in the figures, which is the farthest distance and lowest PCI area. And, as the competition level is higher, the overall growth and CV of products decrease.

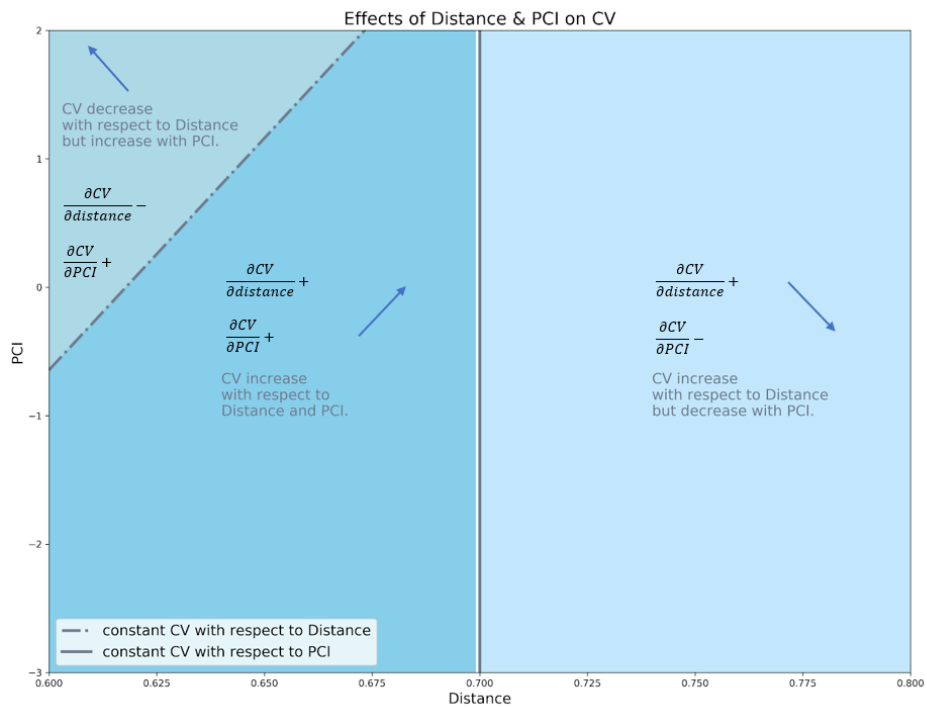
⁷ These figures are generated using equation 10 and 11, including the fixed effect of reference group (sector 1).

Figure 21: The Effect of Distance and PCI on Growth



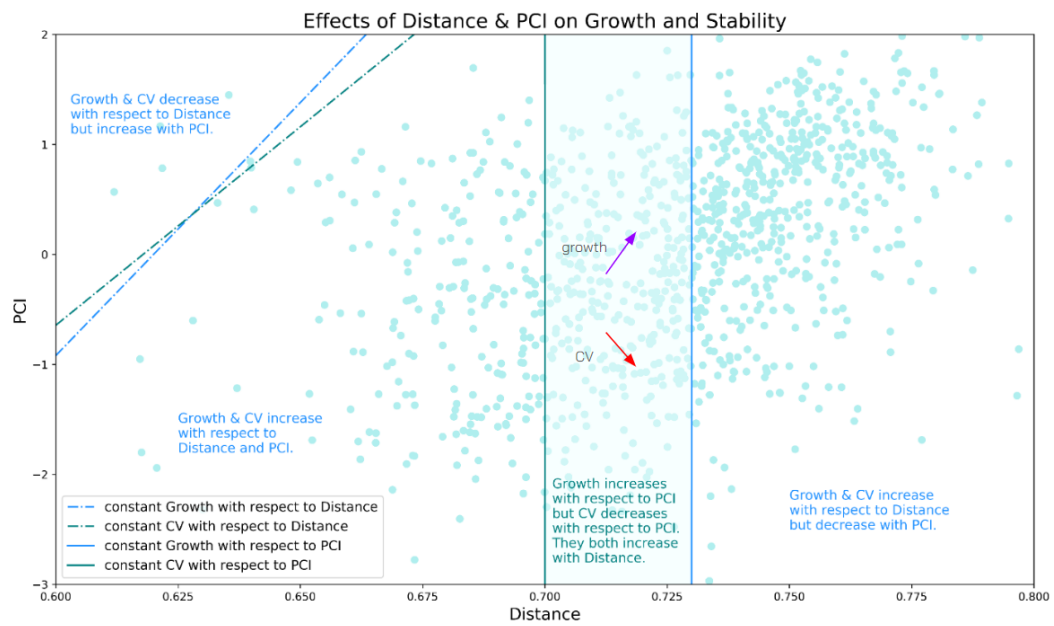
Source: Authors' calculation

Figure 22: The Effect of Distance and PCI on CV



Source: Authors' calculation

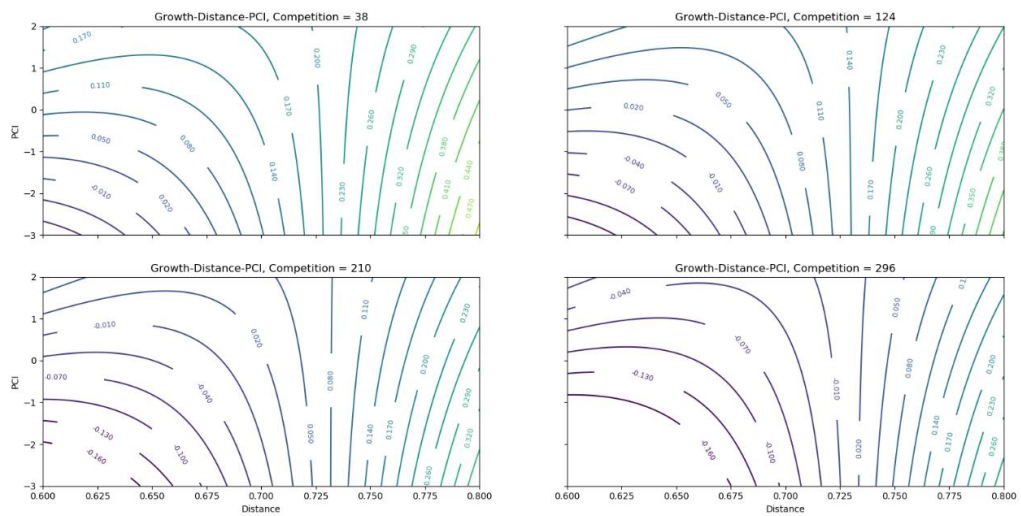
Figure 23: The Interception Area in PCI – Distance of Growth and CV



Source: Authors' calculation

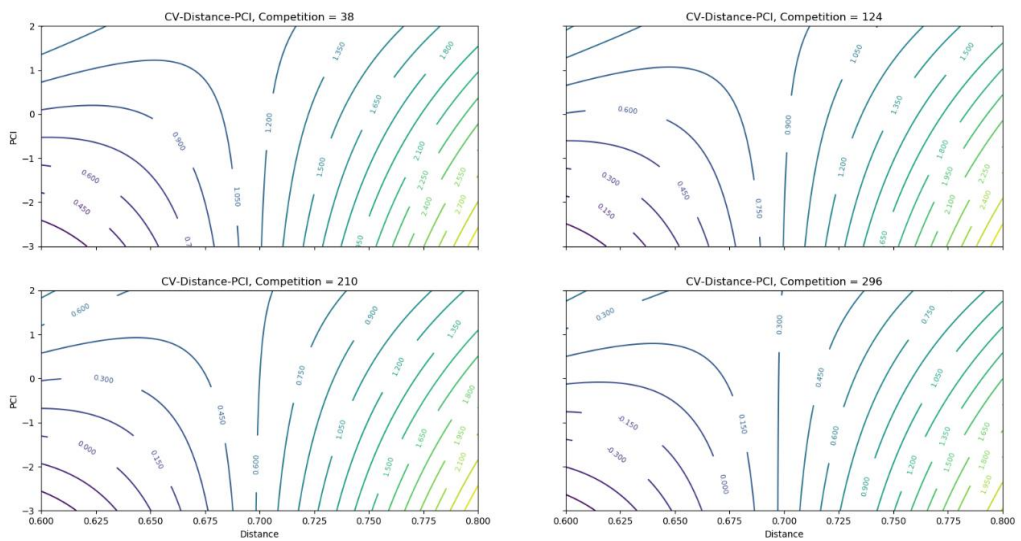


Figure 24: Growth at a Different Distance, PCI, and Competition ⁸



Source: Authors' calculation

Figure 25: CV at a Different Distance, PCI, and Competition



Source: Authors' calculation

⁸ Figure 23 and 24 have 4 sub-plots with 4 difference level of competition (38, 124, 210, 296). Each sub-plot illustrates the growth or CV by varying distance and PCI at fixed competition level. The same line on each sub-plot shows the same level of growth or CV. The number on the line is the growth or CV of that level. Colors also illustrate the level of growth or CV, the lighter color, the higher growth, or the higher CV.

CHAPTER 5: CONCLUSION AND APPLICATION

There are two sections in this chapter. The first section concludes the effects of distance, PCI, and competition level on Thailand's product export growth and stability. The second section gives examples of using the empirical model in the suggestion of high export growth and stability product or the evaluation of old policies.

5.1 Conclusion on the Effects of Distance, PCI, and Competition Level on Product's Export Growth and Stability

This research defines the factors affecting Thailand's product export growth and stability by applying Network Analysis methods on international trade data. This analysis provides the three meaningful determinants of the products, which are the distance from Thailand to a product, Product Complexity Index (PCI), and the competition level of products.

Distance from Thailand to a product reflects the potential of Thailand to success in exporting the product, based on existing capabilities of Thailand. This measurement can be considered as the export product's characteristics from the Thailand perspective. PCI describes the nature of products by illustrating the complexity of their required supply chain. Lastly, the competition level of products captures the number of product's exporters and the potential of being export by new countries.

Also, we investigate the effects of these factors on Thailand's product export growth and stability. We have found that growth and stability have an inverse relationship, the higher growth, the lower stability.

The products with high distance grow fast because Thailand might be in the process of improving the country's capabilities. On the other hand, Thailand might

achieve the highest specialization on closer products. So, there is no room for improvement. We emphasize that exporting the high distance products not only benefits Thailand with high export growth but also extends Thailand's capabilities and exporting potential.

Exporting high PCI products gives high export growth only if the products located closer than 0.73. It is difficult for Thailand to export a highly complex product that requires unavailable capabilities in Thailand. Nevertheless, at a certain distance between 0.70 to 0.73, the higher PCI products provide higher growth that is relatively more stable.

Moreover, this research also has found that highly competitive products have lower growth, but their growth is more stable. Although they have to face many exporters, they require only the conventional capabilities to be exported, so they are harder to fail.

Finally, at a fixed level of competition, the highest growth products of Thailand locate at a very far distance and have low PCI. However, these products are less stable, which means their exporters must take higher risk exporting them.

In summary, this research explains the effects of distance, PCI, and competition level on the export growth and stability at the product level. Also, this research predicts the export growth and stability of Thailand's export products, as shown in the next section. This work excellently provides the whole picture of export at the product level. However, there is still some limitation. It cannot explain the specific mechanism on each individual case.

5.2 The Use of Empirical Model to Suggest High Growth, High Stability Products

To increase economic growth, Thailand should export a high export growth product. This research provides the determinants of Thailand's export product that affects export growth and stability and predicts the level of growth and stability. But,

in order to pick the appropriate high growth products, it depends on the preference level of growth and stability of the country. Additionally, it also depends on other objectives of policymakers.

For example, suppose that Thailand would like to export a product with export growth of 10% yearly. From our prediction, we can list the top 10 of the most stable products that grow approximately 10%, as shown in table 12. However, it depends on objectives of policymakers to pick the most appropriate product from that list.

For example, if DITP would like to develop the potential of Thai entrepreneurs and expand the Thai product marketing channels in the chemical sector. The chemical product (2927), which is diazo, would be a good start. Not only diazo provides growth of 10% yearly but also the closest distance from Thailand, so it is most comfortable for Thailand to export this product and gain 10% of export growth. Moreover, its competition level is quite low, which means it is an available market for expanding.

In addition, if DITP would like to improve the agricultural sector and support farmers, buckwheat, the vegetable (1008) is an interesting choice, buckwheat does not require a complex supply chain. However, Thailand must collect more capabilities and face more risk to export it.

For more example, given that the Thai government would like to encourage OTOP, as shown in table 12, the artificial flowers can be one of OTOP that provide export growth about 10% yearly. The products are easy to be made and exported because they have very low PCI. Moreover, they have a very low competition level. Therefore, artificial flowers are an interesting choice for community products.

Table 12: The Most Stable Products that Grow Approximately 10% Yearly⁹

Description	hs07	section	distance	PCI	Competition	Predicted growth	Predicted CV
Glues	3506	Chemical	0.74	0.94	251	10.1%	0.76
Pigments	3212	Chemical	0.74	0.85	250	10.0%	0.76
Diazo	2927	Chemical	0.69	0.57	136	10.0%	0.79
Trailers	8716	Vehicles	0.74	0.55	264	10.1%	0.79
Boats	8907	Vehicles	0.71	0.15	192	10.0%	0.81
Artificial Flowers	6702	Footwear	0.70	-0.44	94	10.1%	0.83
Measuring Instruments	9031	Optical	0.75	1.49	214	10.1%	0.84
Globes	4905	Pulp of Wood	0.75	0.56	225	10.0%	0.85
Activated carbon	3802	Chemical	0.73	-0.49	204	10.1%	0.88
Buckwheat	1008	Vegetable	0.73	-1.13	204	10.0%	0.89

Source: Authors' calculation

The prediction also can be used to evaluate the old policies. The most concerned sector is textile products. For example, garments (6111) and textile fibres from plants (5305) have predicted yearly export growth about -10% and -9%, respectively¹⁰. These products are often promoted as community products such as OTOP. However, due to the low export growth, policymakers must consider replacing these textiles by higher export growth products, such as artificial flowers.

As mentioned above, this work provides the whole picture of export but lacks explanations for each specific case. Hence, further work might be searching for an optimized product for Thailand base on the preference level of growth and stability by adjusting the level of distance, PCI, and competition. Then, the research must focus deeper in detail about the chosen products in order to improve the country's ability and to achieve high export growth.

⁹ The growth and CV are predicted using the results from table 10 and 11, including product sector fixed effect.

¹⁰ The growths are predicted using the results from table 10 and 11, including product sector fixed effect.

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