Nguyen Khanh Doanh [*]
Ha Trong Quynh [**]
Nguyen Thi Thanh Xuan [***]

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UNTAPPED POTENTIAL AND HIGH-TECH TRADE: THE CASE OF ASEAN-6 COUNTRIES' EXPORTS

This study aims to quantify the impact of untapped export potential on ASEAN-6 countries' high-tech exports for the 2006-2016 period*. Our innovative aspect sheds new light on the relationship between the untapped export potential in the previous year and export performance in the current year. Using a system GMM estimator, we found several significant results. Firstly, untapped export potential in the last year has a positive impact on ASEAN-6 countries' high-tech exports in the current year. Secondly, the effect of untapped export potential on ASEAN-6 countries' high-tech exports depends on supply competencies (ASEAN-6 countries' human capital and research and development capability) and the bilateral linkage (importing countries' trade barriers and institutional similarity between ASEAN-6 countries and importing countries). Thirdly, supply competencies are the most important when ASEAN-6 countries export high-tech goods to high-income countries. In contrast, the bilateral linkage is the most crucial when ASEAN-6 countries ship high-tech products to low-income countries. Measures to enhance human capital, upgrade research and development capability, promote trade liberalization, and minimize the institutional distance with the trading partners are the remedy for ASEAN-6 countries to tap the untapped potential.*

***Keywords*:** *Untapped potential, high-tech exports, ASEAN, supply competencies, bilateral linkage.*

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[*] K. D. Nguyen, PhD, Associate Professor, International School, Thai Nguyen University, Vietnam (e-mail: nkdoanh@tnu.edu.vn; nkdoanh@yahoo.com).

[**] T. Q. Ha, International School, Thai Nguyen University, Vietnam (e-mail: quynhht@tnu.edu.vn).

[***] T. T. X. Nguyen, Deputy of Department Business Administration Faculty of Economics and Business Adimistration, Hong Duc University (e-mail: nguyenthithanhxuan@hdu.edu.vn). The paper was received on 01.06.2020. It was accepted for publication on 23.02.2021.

1. INTRODUCTION

In recent years, economists have increasingly recognized the role of high-tech exports in economic growth and sustainable development (Ekananda & Parlinggoman, 2017). Unlike primary and other exported items, high-tech exports enable exporting countries to increase their technological and innovative capability, which significantly helps them overcome economic recessions (Sandu & Bogdan, 2014). In actuality, every country desires to compete successfully in high-tech segments of industries in the world market. The reason is that high-tech exporting countries can increase their export value more efficiently than countries exporting primary goods because of the high-income elasticity in high-tech products (Güneş, Gürel, Karadam, & Akin, 2020). Simultaneously, high-tech sectors' success allows exporting countries to increase their market share in the international market.

Much of the literature on the determinants of trade has been conducted in the gravity model framework. This approach categorizes factors affecting trade flows into three groups: export supply, import demand, and trade resistances[1]. Export supply represents the exporting country's capacity to export, while import demand exhibits the importing country's ability to import. Traditionally, the gross domestic product (GDP) and population of the exporting country represent its capacity to export, whereas the importing country's GDP and population reflect its ability to import (Borgatti, 2008). Trade resistances consist of two components, either hindering or stimulating trade flows. Natural resistances are observable, such as geographical distance, common border, common language, colonial relationship, and landlocked status (Didier & Koenig, 2018; Liu, Lu, & Wang, 2020). Human-made resistances are unobservable, such as trade barriers, institutional distances, and the like. According to Armstrong (2007), such subjective obstacles are difficult to quantify and therefore lumped into the disturbance terms[2].

Previous research contributed to a comprehensive list of factors affecting trade flows. Researchers identified other crucial determinants of high-tech trade apart from the traditional gravity variables. They include trade openness, foreign direct investment inflows, exchange rate, and human capital (Tebaldi, 2011); research and development (R&D) intensity (Sandu & Bogdan, 2014); innovation, technological capability, and trade policy (Sara, Jackson, & Upchurch, 2012); capital and patent rights (Kabaklarli, Duran, & Üçler, 2017); economic freedom (Gökmen & Turen, 2013); and institutions (Mehrara, Seijani, & Karsalari, 2017).

[1] 'Trade resistances' and 'bilateral linkage' will be used interchangeably in this study. It includes the trade barriers (imposed by the importing countries) and the institutional similarity between exporting and importing countries.

[2] Therefore, these resistances will not appear in the equation used estimate export efficiency.

Although there have been many studies on factors affecting high-tech exports, the impact of the untapped export potential on high-tech exports, especially in the context of ASEAN countries, is still a new topic[3].

As Doan and Xing (2018) pointed out, the untapped potential is the difference between the maximum level that a country can export in the context of no restrictions (what the exporting countries can export) and the actual level of exports (what the exporting countries actually export). Theoretically, untapped potential signals room for export growth[4]. If this hypothesis is correct, the untapped potential in the previous year must undoubtedly be an approximate forecast of the possibility of increasing high-tech exports in the current year. However, to the best of our knowledge, there has been no empirical study on such a relationship. Therefore, this study aims to quantify the effect of untapped potential on ASEAN countries' high-tech exports. In accomplishing this general objective, this study has the following research objectives:

- To analyze the impact of untapped potential on ASEAN countries' high-tech exports.
- To quantify the moderating effect of supply competencies and bilateral linkage on the relationship between untapped potential and ASEAN countries' high-tech exports.
- To suggest some policy implications based on empirical results.

The rest of the paper is structured as follows: Section 2 provides theoretical explanations for the impact of untapped potential on high-tech exports. Research methods and data sources are presented in Section 3. In Section 4, we discuss the empirical findings. Section 5 summarizes the main conclusions and policy implications.

2. IMPACT OF UNTAPPED POTENTIAL ON HIGH-TECH EXPORT PERFORMANCE

When searching for markets, countries prioritize exporting high-tech products to those markets where the potential is untapped yet. The enormous untapped potential in a market is an important signal informing exporters that there are still

[3] For the purpose of brevity, we will use 'untapped potential' and 'ASEAN countries' throughout this paper to mean 'untapped high-tech export potential' and 'ASEAN-6 countries', respectively.

[4] Export Potential Map (https://exportpotential.intracen.org/en/resources/learning/faq#question1)

significant opportunities to increase high-tech exports to that market. Such favorable circumstances allow them to benefit from tapping the untapped potential. However, the untapped potential does not naturally translate into actual export performance. Tapping the untapped potential depends on exporting countries' supply competencies (the ability to produce high-quality and diversified products to meet the increasingly strict demand) and the bilateral linkage (trade resistances). Supply competencies include human capital (Atasoy, 2020) and R&D capability (Sandu & Bogdan, 2014). Bilateral linkage consists of trade barriers imposed by the importing countries (Jordaan, 2017) and the institutional distances between exporting and importing countries (Liu et al., 2020).

Human capital

Human capital is the knowledge, skills, competencies, and other attributes embodied in individuals or groups of individuals that help them be productive (Keeley, 2009). Accordingly, knowledge and human capital enable countries to transform their economies to become attractive locations for producing and exporting high-tech products (Iqbal, Mahmood, & Atiq-ur-Rehman, 2015). Simultaneously, human capital can be an essential input that demonstrates the ability to produce and export high-tech products (Mehrara et al., 2017). Countries with adequate human capital often have higher labor productivity and more remarkable ability to make better quality products. In turn, higher labor productivity and a more extraordinary ability to provide quality products mean a higher export capacity. Empirically, Cörvers and de Grip (1997), Tebaldi (2011), and Shamsuzzoha and Tanaka (2020) are among those who found the positive impact of human capital on high-tech exports. Therefore, we hypothesize that human capital would positively influence the relationship between untapped potential and high-tech exports.

Research and development

According to the endogenous growth theory, R&D can be an essential input that reflects a country's ability to produce and export high-tech products (Sara et al., 2012). *Firstly*, R&D intensity improves the national knowledge capital and technological capability, boosting the firms' capacity to produce high-tech products (Montobbio & Rampa, 2005; Sandu & Bogdan, 2014). *Secondly*, R&D intensity can stimulate firms' innovative activities, increasing the volume of high-tech ex-

ports (D'Angelo, 2010). *Thirdly*, R&D activities help the business sector strengthen its absorptive capacity[5] by allowing company employees to learn from each other and other sources, such as universities and research institutes (Zahra & George, 2002). These factors help countries improve their products' competitiveness and position themselves to compete in the international market (Sara et al., 2012). Empirically, Sandu and Bogdan (2014), Ying, Miao, and Yibo (2014), and Sezer (2018) are among studies, which proved the positive correlation between R&D capability and high-tech exports. Therefore, we hypothesize that R&D capability would positively affect the relationship between untapped potential and high-tech exports.

Trade barriers

Trade barriers are the government policies regulating international trade (Feenstra & Taylor, 2011). They consist of tariff and non-tariff barriers, which result in the reduction of overall economic efficiency and bilateral trade (Kinzius et al., 2019). Usually, importing countries use tariffs to protect their domestic production. By imposing high taxes on foreign origins, imported goods' selling prices would be higher than those of domestically produced commodities (Adekola & Sergi, 2016). Hence, tariffs would have adverse effects on trade flows (Kinzius, Sandkamp, & Yalcin, 2019; Seyoum & Ramirez, 2019). Non-tariff barriers are measures other than tariffs applied to restrict trade. They include quantitative restriction, embargo, import licenses, quotas, voluntary export restrictions, technical requirement, and mandatory localization. Scholars acknowledge that non-tariff barriers are essential obstacles to bilateral trade (Grundke & Moser, 2019; Kinzius et al., 2019). Therefore, we hypothesize that trade barriers would negatively influence the relationship between untapped potential and high-tech exports.

Institutional similarity

International trade has been recognized as complicated because cross-border interactions involve at least two countries with separate sovereignty. To complete any transaction, an exporter must conduct market research, find an appropriate trading partner, negotiate the deal, sign the contract, and enforce the signed agree-

[5] The ability of enterprises to exploit external high-tech knowledge. Malik, Xiang, and Huo (2021) found the significant effect of national absorptive capacity on high-tech exports.

ment (den Butter & Mosch, 2003). *Firstly*, traders in two countries with similar institutions are more familiar with each other's cultural traditions, business practices, and economic environments (de Groot, Linders, Rietveld, & Subramanian, 2004). This familiarity lowers search and information costs (de Mendonça, Lirio, Braga, & Silva, 2014). *Secondly*, comparable institutions reduce uncertainty (Zelekha & Sharabi, 2012) and the potential risk of trading abroad (Hou, Wang, & Xue, 2020). According to Liu et al. (2020), compatible institutions provide traders with effective contract enforcement and transaction mechanisms, which encourage bilateral trade (Anderson & Marcouiller, 2002). *Thirdly*, as exporting and importing countries' institutions are similar, traders in these two countries find it easier to develop rapport and bilateral trust, facilitating bilateral trade (Xing & Zhou, 2018). Empirically, researchers confirmed the positive impact of institutional similarity on trade flows (Bojnec & Fertő, 2009). Therefore, we hypothesize that institutional similarity would positively affect the relationship between untapped potential and high-tech exports.

3. METHODOLOGY

3.1. Model specification

This study adopts the gravity model to investigate the lagged effect of untapped potential on current high-tech exports. Based on the literature review, our empirical model is as follows:

$$\ln EH_{ij,t} = \alpha_{ij,t} + \beta_1 \ln EH_{ij,t-1} + \beta_2 HC_{i,t} + \beta_3 R\&D_{i,t} + \beta_4 TF_{j,t} + \beta_5 IS_{ij,t} + \beta_6 \ln EP_{ij,t-1} + \varepsilon_{ij,t} \quad (1)$$

Where:

- i denotes the ASEAN member country; j denotes the ASEAN country's trading partner, t is year t.
- $EH_{ij,t}$ is the value of high-tech exports from country i to country j in year t, measured in billion USD.
- $HC_{i,t}$ is the human capital of country i in time t.
- $R\&D_{i,t}$ is the R&D capability of country i in time t. It includes quality of scientific research institutions, company spending on R&D, university-industry collaboration in R&D, and scientists and engineers' availability.

We measure R&D capability by the principal component analysis (PCA) whose result is in Appendix 1.

- $TF_{j,t}$ is the trade freedom index of country *j* in time *t*, measured on a scale from 0 to 100 (free trade). It is a proxy for trade barriers.
- $IS_{ij,t}$ is the institutional similarity between country *i* and country *j* in time *t*. We compute it based on the formula of Grubel and Lloyd (1975):

$$IS_{ij,t} = \left(1 - \frac{|Institution_{i,t} - Institution_{j,t}|}{Institution_{i,t} + Institution_{j,t}}\right) \times 100 \quad (3)$$

$Institution_{i,t}$ and $Institution_{j,t}$ are the institutional quality of country *i* and country *j* in year *t*, respectively. This index ranges from 1 (worst) to 7 (best).

- $EP_{ij,t-1}$ is the country *i*'s untapped potential with country *j* in year *t-1*.
- $\varepsilon_{ij,t}$ is the error term.

To measure ASEAN countries' untapped potential, we apply the stochastic frontier gravity model with the decomposed error term (Battese & Coelli, 1988):

$$\begin{aligned} \ln EP_{ij,t} = {} & \alpha_{ij,t} + \beta_1 \ln GDP_{i,t} + \beta_2 \ln GDP_{j,t} + \beta_3 \ln POP_{i,t} + \beta_4 \ln POP_{j,t} \\ & + \beta_5 \ln DIST_{ij} + \beta_6 Landlocked_j + \beta_7 Colony_{ij} + \beta_8 Language_{ij} \\ & + \beta_9 Border_{ij} + v_{ij,t} - u_{ij,t} \end{aligned} \quad (6)$$

Where:

- $GDP_{i,t}$ *and* $GDP_{j,t}$ are the gross domestic products of country *i* and country *j* in year *t*, respectively (measured in billion USD).
- $POP_{i,t}$ *and* $POP_{j,t}$ are total populations of country *i* and country *j* in year *t*, respectively (measured in million people).
- $DIST_{ij}$ is the geographical distance between country *i* and country *j* (measured in kilometer).
- $Landlocked_j$ is a dummy variable, taking a value of 1 if country *j* is landlocked and zero otherwise.
- $Colony_{i,j}$ is a dummy variable, taking a value of 1 if country *i* was ever colonized by country *j* or vice versa, and zero otherwise.
- $Language_{ij}$ is the percentage of country *i*'s and country *j*'s populations speaking a common language.

- $Border_{ij}$ is a dummy variable, taking a value of 1 if country *i* and country *j* have a common border and zero otherwise.
- υ_{ijt} is a pure random term, a two-sided error term with the asymmetric distribution.
- u_{ijt} is the export inefficiency.

Following Battese and Coelli (1988), we compute the export efficiency of ASEAN countries with their trading partners in given year *t* as follows:

$$Export\ efficiency_{ij,t} = \frac{Actual\ Export_{ij,t}}{Potential\ Export_{ij,t}} = \frac{exp(x_{ijt}\beta + v_{ij,t} - u_{ij,t})}{exp(x_{ij,t}\beta + v_{ij,t})} = exp(-u_{ij,t})$$

Then we calculate the untapped potential as follows:

$$EP_{ij,t} = Potential\ Export_{ij,t} - Actual\ Export_{ij,t}$$

As explained in Section 2, the impact of untapped potential on ASEAN countries' high-tech exports depends on ASEAN countries' supply competencies and bilateral linkage. Therefore, based on Equation 1, we set up the following four equations with interaction variables:

$$\begin{aligned}\ln EH_{ij,t} = {} & \alpha_{ij,t} + \beta_1 \ln EH_{ij,t-1} + \beta_2 IS_{ij,t} + \beta_3 TF_{j,t} + \beta_4 HC_{i,t} + \beta_5 R\&D_{i,t} \\ & + \beta_6 \ln EP_{ij,t-1} \times HC_{i,t} + \varepsilon_{ij,t} \end{aligned} \quad (2)$$

$$\begin{aligned}\ln EH_{ij,t} = {} & \alpha_{ij,t} + \beta_1 \ln EH_{ij,t-1} + \beta_2 IS_{ij,t} + \beta_3 TF_{j,t} + \beta_4 HC_{i,t} + \beta_5 R\&D_{i,t} \\ & + \beta_6 \ln EP_{ij,t-1} \times R\&D_{i,t} + \varepsilon_{ij,t} \end{aligned} \quad (3)$$

$$\begin{aligned}\ln EH_{ij,t} = {} & \alpha_{ij,t} + \beta_1 \ln EH_{ij,t-1} + \beta_2 IS_{ij,t} + \beta_3 TF_{j,t} + \beta_4 HC_{i,t} + \beta_5 R\&D_{i,t} \\ & + \beta_6 \ln EP_{ij,t-1} \times TF_{j,t} + \varepsilon_{ij,t} \end{aligned} \quad (4)$$

$$\begin{aligned}\ln EH_{ij,t} = {} & \alpha_{ij,t} + \beta_1 \ln EH_{ij,t-1} + \beta_2 IS_{ij,t} + \beta_3 TF_{j,t} + \beta_4 HC_{i,t} + \beta_5 R\&D_{i,t} \\ & + \beta_6 \ln EP_{ij,t-1} \times INS_{ij,t} + \varepsilon_{ij,t} \end{aligned} \quad (5)$$

3.2. Method of estimation

Our empirical models can potentially suffer from endogeneity problems (e.g., causality running from exports to GDP) and serial correlation (e.g., due to the appearance of the lagged dependent variable). Hence, traditional estimators such as

OLS, fixed effects, or random effects may be biased (Kabir, Salim, & Al-Mawali, 2017). Following Heo and Doanh (2015), we opt for a system Generalized Method of Moments (GMM) estimator proposed by Arellano and Bover (1995). This estimator can control the potential endogeneity by using appropriate lagged values of the variables as instruments (Ageliki & Ioannis, 2016) and solving serial correlations by instrumenting the lagged dependent variable with its further lags (Kahouli & Maktouf, 2014). We conduct the Sargan test of over-identifying restriction to check the validity of the instruments (Sargan, 1958) and the Arellano-Bond (AR) test to check if the error term is serially correlated (Arellano & Bond, 1991). Besides, we implement the Granger causality test to verify whether there is a relationship running from untapped potential to export performance (Granger, 1969).

$$\ln EH_{ij,t} = \sigma_{ij} + \sum_{l=1}^{m} \gamma_{ij,l} \ln EH_{ij,t-l} + \sum_{l=1}^{m} \beta_{ij,l} \ln EP_{ij,t-l} + \varepsilon_{ij,t} \qquad (7)$$

Where the lag order is assumed to be identical for all individuals, and the panel has to be balanced; $\varepsilon_{ij,t}$ is the residual. The null hypothesis of Equation 7 is as follows:

$$H_0: \beta_{ij,l} = \cdots = \beta_{ij,m} = 0$$

If H_0 is rejected, we conclude that a relationship runs from untapped potential to high-tech export performance.

3.3. Data

Our panel dataset includes exports from ASEAN countries (Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam) to their trading partners for the 2006-2016 period. We select these ASEAN countries because they are the main trading actors in ASEAN and choose 58 ASEAN's trading partners based on the data's availability[6]. The value of high-tech exports from ASEAN countries to their trading partners is available from the World Integrated Trade Solution. The GDP and population data are extracted from the International Monetary Fund. The geographical distance, landlocked status, colonizer relationship, common language, and the shared border data are available from CEPII. Data on institutions and R&D capability-related dimensions are adapted from WEF (World Economic Forum). The human capital is sourced from Feenstra, Inklaar, and Timmer (2015). Finally, the trade freedom index is obtained from The Heritage.

[6] The list of countries in the sample can be obtained from authors upon request.

4. EMPIRICAL RESULTS

4.1. Estimating the untapped potential

As a convention, we implement the Levin-Lin-Chu test, whose null hypothesis is that the time series contains a unit root for all variables (Levin, Lin, & James Chu, 2002). According to Table 1, *Adjusted t** is statistically significant at the 0.01 level. Given these results, it is clear that all variables do not have unit-roots.

Table 1:

LEVIN-LIN-CHU TEST

Variables	Unadjusted t	Adjusted t*	P-value
$lnEH_{ij,t}$	-27.552	-15.244	0.000
$lnGDP_{i,t}$	-22.556	-10.393	0.000
$lnGDP_{j,t}$	-12.247	-8.948	0.000
$lnPOP_{i,t}$	-32.405	-31.623	0.000
$lnPOP_{j,t}$	-6.866	-1.823	0.034
$HC_{i,t}$	-16.727	-2.265	0.000
$R\&D_{i,t}$	-52.305	-39.501	0.000
$TF_{j,t}$	-55.790	-35.114	0.000
$IS_{ij,t}$	-49.030	-36.629	0.000
$lnEP_{ij,t-1}$	-16.396	-7.496	0.000

Source: Empirical results

The estimated results of the stochastic frontier model are in Appendix 2. Most of the estimated coefficients, except $Landlocked_j$ and $Colony_{ij}$, are statistically significant. *Firstly*, GDP plays a vital role in the growth of high-tech exports. *Secondly*, ASEAN countries and their trade partners' populations negatively affect bilateral trade, indicating the absorption effect's dominance. *Thirdly*, ASEAN countries tend to trade less with distant trading partners due to the higher cost of international transportation and access to relevant market information. *Fourthly*, ASEAN countries tend to export more high-tech products to countries speaking the same language, having a colonial relationship, and sharing a common border. Our estimated results are in line with the theoretical prediction. Table 2 presents ASEAN countries' export efficiency with the rest of the world (ROW).

Table 2:

ASEAN COUNTRIES' UNTAPPED POTENTIAL WITH ROW

Year	**Actual Export** (billion USD)	**Export Efficiency (EE)**	**Potential Export** (Billion USD)	**Untapped Potential (UP)** (Billion USD)
2006	185.243	0.559	331.554	146.312
2007	272.196	0.592	459.471	187.274
2008	254.289	0.562	452.794	198.505
2009	227.899	0.561	406.275	178.376
2010	277.202	0.563	492.795	215.594
2011	279.952	0.535	522.984	243.032
2012	299.631	0.546	548.787	249.156
2013	316.186	0.551	573.389	257.204
2014	324.265	0.556	583.423	259.159
2015	325.668	0.566	575.093	249.425
2016	328.256	0.563	583.125	254.868

The efficiency of ASEAN countries' high-tech exports to ROW is moderate, ranging from 0.535 to 0.592. Over the period, it increased slightly but with fluctuations. From 2007 to 2009, ASEAN countries' actual export and export efficiency slightly decreased, from 0.592 to 0.535. The main reason was the adverse effects of the world financial crisis in 2007. During 2011-2016, both the actual export and export efficiency increased, perhaps due to most ASEAN countries' improved institutional quality. Besides, all ASEAN countries' human resources and innovation index have increased. Although the increase in total exports and export efficiency is not significant, ASEAN countries have been using human resources and R&D to tap high-tech export opportunities. Table 3 presents ASEAN countries' untapped potential with low, middle, and high-income countries.

Table 3:

ASEAN COUNTRIES' UNTAPPED POTENTIAL WITH TRADING PARTNERS GROUPED BY THEIR INCOME LEVELS

Year	High-income$_{j,t}$		Middle-income$_{j,t}$		Low-income$_{j,t}$	
	EE	UP	EE	UP	EE	UP
2006	0.558	133.435	0.562	47.909	0.532	3.899
2007	0.596	178.002	0.586	91.952	0.553	2.242
2008	0.566	163.370	0.553	88.891	0.560	2.028
2009	0.567	149.669	0.551	78.054	0.302	0.175
2010	0.570	176.302	0.550	100.679	0.360	0.221
2011	0.538	174.202	0.530	105.226	0.503	0.524
2012	0.553	188.319	0.534	110.898	0.414	0.414
2013	0.564	200.395	0.531	115.311	0.446	0.479
2014	0.573	208.129	0.528	115.515	0.490	0.620
2015	0.590	208.505	0.528	117.163	-	-
2016	0.591	213.159	0.517	115.098	-	-

Note: UP is in a million USD

As the data reveal, the export efficiency is the highest in the case of ASEAN countries' high-tech exports to high-income countries, followed by middle and low-income countries. It means that the untapped potential is the lowest when ASEAN countries export to high-income countries and highest when ASEAN countries export to low-income countries. This result is plausible because high-income countries often have open trade policies and excellent institutional quality. For that reason, ASEAN countries have almost exhausted their export potential. They can only increase their high-tech exports to this group of countries by improving the quality and diversifying products. By contrast, ASEAN countries' high-tech products are diversified and qualified enough to meet the consumers' needs in low-income countries. However, the main problem is that low-income countries often have untransparent trade policies and weak institutions. These trade resistances hinder ASEAN countries' high-tech exports.

4.2. The impacts of untapped potential on ASEAN countries' high-tech exports

Table 4 provides the results of the Granger causality test. Based on the estimated results, we can reject the null hypothesis of granger non-causality running from untapped potential to actual export performance. It means that our hypothesis is empirically meaningful.

Table 4:

GRANGER-CAUSE TESTS

	High- tech export	**P-value**
$\overline{\mathbf{W}}$	3.396	-
$\overline{\mathbf{Z}}$	31.611	0.000
$\widetilde{\mathbf{Z}}$	13.301	0.000

Source: Empirical results

Table 5 displays the estimated results regarding the impact of untapped potential on ASEAN countries' high-tech exports (Equation 1). Following Doanh and Heo (2018), we conduct a sensitivity test by adding new variables to the model, one by one. As observed, the coefficients' signs are stable across five models, meaning that our models are not sensitive to adding new variables. The p-values of both Sargan and AR(2) tests are insignificant, confirming that our instruments are valid and there is no second-order serial correlation in the first-differenced residuals. Hence, we can conclude that the system-GMM estimator is efficient.

Table 5:

DETERMINANTS OF ASEAN COUNTRIES' HIGH-TECH EXPORTS

Explanatory variables		**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
$lnEH_{ij,t-1}$		0.702**	0.712**	0.715**	0.714**	0.613**
		(0.031)	(0.042)	(0.030)	(0.030)	(0.046)
$HC_{i,t}$		0.516**	0.399**	0.334**	0.349**	0.145*
		(0.083)	(0.100)	(0.068)	(0.069)	(0.066)
$R\&D_{i,t}$			0.0528	0.066**	0.068**	0.040*
			(0.028)	(0.021)	(0.021)	(0.020)
$TF_{j,t}$				0.020**	0.020**	0.016**
				(0.002)	(0.002)	(0.002)
$IS_{ij,t}$					0.305*	0.294*
					(0.150)	(0.149)
$lnEP_{ij,t-1}$						0.250**
						(0.058)
Constant		1.905**	2.121**	0.667**	0.352	-0.367
		(0.163)	(0.299)	(0.170)	(0.226)	(0.262)
Number of Obs		3480	3480	3480	3480	3480
AR(2)	Z	-1.54	-1.89	-1.48	-1.48	-1.79
	Pr>z	0.125	0.059	0.138	0.138	0.073
Sargan	Chi(2)	5.00	3.09	4.78	4.66	3.41
	Prob> chi2	0.082	0.213	0.092	0.097	0.182

Source: Empirical results

Notes: Standard errors are in parentheses.

Significance at the 0.01 (**) and 0.05 (*) levels.

According to Table 5, all coefficients are positive and statistically significant, at least at 0.05 level. *Firstly*, the estimated result for the variable $lnEH_{ij,t-1}$ indicates substantial effects of dynamic nature in high-tech exports in the long run. *Secondly*, ASEAN countries tend to export more to their trading partners with similar institutional quality. This finding is consistent with that of Anderson and Marcouiller (2002) and Feenstra, Hong, Ma, and Spencer (2013). *Thirdly*, higher trade freedom levels in importing countries are robustly associated with a greater

volume of ASEAN countries' high-tech exports to these importing countries. This result supports the view of Riley and Miller (2015). *Fourthly*, the estimated results for the variables $HC_{i,t}$ (human capital) and $R\&D_{i,t}$ (R&D capability) confirm the critical role of ASEAN countries' supply competencies in tapping the untapped potential. This finding is in line with the endogenous growth theories, which argue that higher human capital (Mehrara et al., 2017) and higher levels of R&D, technology, and innovation (Anguelov, 2014; Cortright, 2001) improve the quality and productivity that ultimately leads to a higher level of high-tech exports.

Notably, the coefficient of the variable $lnEP_{ij,t-1}$ is positive and statistically significant at the 0.01 level. This finding suggests that our hypothesis is empirically meaningful. Markets with high untapped potential are ideal destinations because there are rooms for ASEAN countries to develop new products and increase their high-tech exports to these markets. As already explained, untapped potential means that actual exports fall short of the maximum level a country can export, signifying plenty of possibility for export growth. Thus, in theory, ASEAN countries should tap all their untapped potential in the next year. However, the untapped potential does not naturally translate into actual performance in reality. The reason is that ASEAN countries' supply competencies are not excellent enough to produce high-quality and diversified products to meet the customers' needs, especially those in high-income countries. Besides, ASEAN countries have not yet removed trade resistances, including trade barriers and impediments due to institutional differences between ASEAN countries and their partner countries.

Since the impact of untapped potential on high-tech exports depends on supply competencies and bilateral linkage, we incorporate several interaction effects. Table 6 shows the empirical results on the interaction effects. Again, all models satisfy both Sargan and AR(2) tests.

Table 6:

THE EFFECTS OF UNTAPPED POTENTIAL ON ASEAN COUNTRIES' HIGH-TECH EXPORTS

Explanatory variables		**Model 6**	**Model 7**	**Model 8**	**Model 9**
$lnEH_{ij,t-1}$		0.653**	0.764**	0.647**	0.653**
		(0.032)	(0.041)	(0.036)	(0.036)
$IS_{ij,t}$		0.073*	0.120**	0.072*	0.187**
		(0.033)	(0.032)	(0.036)	(0.028)
$TF_{j,t}$		0.013**	0.009**	0.019**	0.012**
		(0.002)	(0.002)	(0.004)	(0.002)
$HC_{i,t}$		0.289**	0.250**	0.158	0.173
		(0.065)	(0.092)	(0.095)	(0.092)
$R\&D_{i,t}$		0.059**	0.092**	0.062**	0.060**
		(0.018)	(0.025)	(0.018)	(0.019)
$lnEP_{ij,t-1} \times HC_{i,t}$		0.065**			
		(0.021)			
$lnEP_{ij,t-1} \times R\&D_{i,t}$			0.013*		
			(0.006)		
$lnEP_{ij,t-1} \times TF_{j,t}$				0.002**	
				(0.001)	
$lnEP_{ij,t-1} \times IS_{ij,t}$					0.039*
					(0.016)
Constant		-2.659**	-2.591**	-2.776**	-2.781**
		(0.391)	(0.557)	(0.382)	(0.384)
Number of Obs		3480	3480	3480	3480
AR(2)	Z	-1.59	-1.54	-1.60	-1.58
	Pr>z	0.113	0.123	0.110	0.115
Sargan	Chi(2)	4.05	1.96	6.38	6.84
	Prob> chi2	0.256	0.376	0.094	0.077

Source: Empirical results

Notes: Standard errors are in parentheses. Significance at the 0.01 (**) and 0.05 (*) levels.

As the results indicate, all estimated coefficients' signs are positive and highly significant. This finding means that the relative importance of untapped potential to actual high-tech export performance depends on ASEAN countries' supply competencies and bilateral linkage. Given that technological products depend

upon science and technology (Sandu & Bogdan, 2014) and human capital (Tebaldi, 2011), more outstanding supply competencies would help ASEAN countries produce high-quality and diversified products for the untapped markets. Moreover, a higher level of institutional similarity and a lower level of trade barriers are vital factors that facilitate bilateral trade. Indeed, effective institutions and liberalized trade policy would reduce bilateral trade costs. To elucidate the differential impact of untapped potential on high-tech exports, we divide ASEAN countries' trading partners into low, middle, and high-income countries. The empirical results are in Table 7.

Table 7:

THE EFFECTS OF UNTAPPED POTENTIAL ON ASEAN COUNTRIES' HIGH-TECH EXPORTS TO TRADING PARTNERS GROUPED BY THEIR INCOME LEVELS

Explanatory variables	**High-income$_{j,t}$**	**Middle-income$_{j,t}$**	**Low-income$_{j,t}$**
$lnEP_{ij,t-1} \times HC_{i,t}$	0.379**	0.137*	0.189**
	(0.140)	(0.061)	(0.070)
$lnEP_{ij,t-1} \times R\&D_{i,t}$	0.125**	0.026**	0.014*
	(0.058)	(0.007)	(0.007)
$lnEP_{ij,t-1} \times TF_{j,t}$	0.010**	0.101*	0.283*
	(0.003)	(0.048)	(0.100)
$lnEP_{ij,t-1} \times IS_{ij,t}$	0.047**	0.387*	0.619**
	(0.015)	(0.197)	(0.135)

Source: Empirical results

Notes: Standard errors are in parentheses.

Significance at the 0.01 (**) and 0.05 (*) levels.

As shown in Table 7, all interaction variables' coefficients are positively and statistically significant, at least at 0.05 level. Regardless of which group of countries ASEAN exports to, the impact of untapped potential on ASEAN countries' high-tech exports depends on their supply competencies and bilateral linkage. Our findings are consistent with several previous studies, which demonstrated that human capital (Mehrara et al., 2017; Tebaldi, 2011), higher R&D intensity (Sezer, 2018; Ying et al., 2014), trade barriers (Kinzius et al., 2019; Seyoum & Ramirez, 2019), and institutional similarity (Bojnec & Fertő, 2009; Liu et al., 2020) affect exports.

Regarding ASEAN countries' high-tech exports to high-income countries, the coefficients of the variable $lnEP_{ij,t-1}\times HC_{i,t}$ is the highest, followed by those of variables $lnEP_{ij,t-1}\times R\&D_{i,t}$, $lnEP_{ij,t-1}\times IS_{ij,t}$, and $lnEP_{ij,t-1}\times TF_{j,t}$. It means that ASEAN countries' human capital and R&D capability are the most important factors affecting the relationship between untapped potential and high-tech exports. This finding is completely reasonable because high-tech goods are both human capital (Tebaldi, 2011) and R&D-intensive (Sandu & Bogdan, 2014). Except for Singapore, the remaining ASEAN countries in our sample are in the middle-income group with a modest level of human capital and R&D capability. Therefore, it is important to improve human capital and R&D capability to produce goods that are qualified enough for high-income countries. Meanwhile, high-income importing countries often have a low level of trade barriers and outstanding institutional quality, facilitating a smooth trade flow. That is why trade resistances are not as important as supply competencies when exporting to high-income economies.

In the case of ASEAN countries' high-tech exports to low-income countries, the coefficient of the variable $lnEP_{ij,t-1}\times IS_{ij,t}$ is the highest, followed by those of $lnEP_{ij,t-1}\times TF_{j,t}$, $lnEP_{ij,t-1}\times HC_{i,t}$, and $lnEP_{ij,t-1}\times R\&D_{j,t}$. It means that importing countries' trade barriers and the institutional similarity between ASEAN countries and the importing countries are the most important. This result makes good sense because low-income countries often have untransparent trade barriers. Besides, their institutional quality is often low and differs significantly from ASEAN countries, creating certain impediments to trade flows. Meanwhile, consumers in low-income countries generally do not have strict product requirements. ASEAN countries' supply competencies fully allow them to produce high-tech goods that meet low-income countries' quality requirements. That is why supply competencies are not as important as bilateral linkage when exporting to low-income economies.

In regard to ASEAN countries' high-tech exports to middle-income countries, the coefficient of the variable $lnEP_{ij,t-1}\times IS_{ij,t}$ is the highest, followed by those of $lnEP_{ij,t-1}\times HC_{i,t}$, $lnEP_{ij,t-1}\times TF_{j,t}$, and $lnEP_{ij,t-1}\times R\&D_{j,t}$. It means that institutional similarity is the most important factor in helping ASEAN countries tap the untapped potential. Our finding is plausible because there is still a certain institutional difference between ASEAN and middle-income countries. The reason is that many middle-income countries are in the upper-middle-income group, whereas many ASEAN countries are in the lower-middle-income group. While upper-middle-income countries have made intensive efforts to improve their institutional quality, many lower-middle-income countries still have weak institutions. Compared with middle-income countries, ASEAN countries have invested significantly in human capital and R&D in recent years. Therefore, the quality and variety of high-tech products of ASEAN countries can meet customers' needs in this group of countries. That is why R&D capability is less important than institutional similarity in helping ASEAN countries tap the untapped potential.

5. CONCLUSIONS

This paper examines the impact of untapped potential on ASEAN countries' high-tech exports to the ROW for the 2006-2016 period. Our innovative contribution is to shed new light on the relationship between the untapped potential in the previous year and high-tech exports in the current year. Besides, we incorporate several interaction effects into our analysis to determine if the impact of untapped potential on high-tech exports depends on ASEAN countries' supply competencies and bilateral linkage. Using a system GMM estimator, we discover the following meaningful results.

Firstly, the untapped potential in the last year is an essential signal that ASEAN countries can increase their exports to untapped markets. *Secondly*, the untapped potential does not naturally translate into high-tech export performance. Whether ASEAN countries can fully tap the untapped potential or not depends heavily on ASEAN countries' supply competencies (human capital and R&D capability) and bilateral linkage (trade barriers and institutional similarity). *Thirdly*, supply competencies are the most important when ASEAN countries export high-tech goods to high-income countries. In contrast, the bilateral linkage is crucial when ASEAN countries ship high-tech products to low-income countries.

Based on the empirical findings, we propose several solutions for ASEAN countries to tap their untapped potentials. *Firstly*, ASEAN countries and their trading partners need to remove trade resistances gradually. In achieving this goal, it is necessary to implement free trade agreements and undertake appropriate measures to reduce the institutional differences between ASEAN countries and their trading partners. At the same time, ASEAN countries must enhance their enterprises' institutional adaptability when trading abroad. As suggested by Shen and Tsai (2016), motivated and capable local leadership, openness to new policy ideas, and state capacity for policy implementation are crucial success factors. *Secondly*, to increase the supply competencies, ASEAN countries should design appropriate policies to improve their human capital and strengthen R&D capability. Enhancing human capital requires ASEAN countries to speed up the GDP growth, attract FDI, invest in education and health, and reform institutions. In developing R&D capability, ASEAN countries must increase government effectiveness, improve the rule of law and regularity quality, encourage competition incentives, promote university-enterprise R&D collaboration, support enterprises in R&D alliances, and strengthen intellectual property rights. Simultaneously, they need to enable the commercialization of scientific and technological products.

APPENDICES

Appendix 1:

CATEGORICAL PCA PATTERN MATRIX WITH ITEM LOADINGS OF > 0.5 FOR A FOUR-COMPONENT WITH VARIMAX ROTATION

Variables	$R\&D_{i,t}$
$R\&D_{i,t}$	
Quality of scientific research institutions	0.990
Company spending on R&D	0.962
University-industry collaboration in R&D	0.916
Availability of scientists and engineers	0.899
Eigenvalue	***3.553***
KMO- test	**0.808**
Cronbach alpha (α)	**0.961**

Source: Empirical results

Appendix 2:

THE ESTIMATED RESULTS OF THE STOCHASTIC FRONTIER GRAVITY MODEL

Dependent variable: ($lnEH_{ij,t}$)	**Coef.**	**Std. Err.**	**P > |z|**
Constant	20.351	0.416	0.000
$lnGDP_{i,t}$	0.339	0.049	0.000
$lnGDP_{j,t}$	1.292	0.023	0.000
$lnPOP_{i,t}$	-0.622	0.023	0.000
$lnPOP_{j,t}$	-0.225	0.024	0.000
$lnDIST_{ij}$	-1.653	0.035	0.000
$Landlocked_{j}$	-0.133	0.105	0.206
$Colony_{ij}$	0.032	0.189	0.867
$Language_{ij}$	0.288	0.105	0.006
$Border_{ij}$	0.124	0.187	0.507
Mu	-179.55	167.171	0.283
Dependent variable: Ua			
Constant	5.311	0.913	0.000
Dependent variable: Va			
Constant	0.381	0.049	0.000
Observation	3828		
Log-likelihood	-7231.098		
Mean technical efficiency	0.473		

Source: Empirical results

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NEISKORIŠTENI POTENCIJAL I VISOKOTEHNOLOŠKA TRGOVINA: SLUČAJ IZVOZA ZEMALJA ASEAN-6

Sažetak

Ova studija ima za cilj kvantificirati utjecaj neiskorištenog izvoznog potencijala na visokotehnološki izvoz zemalja ASEAN-6 za razdoblje 2006.-2016. Naš inovativni aspekt baca novo svjetlo na odnos između neiskorištenog izvoznog potencijala u prethodnoj godini i izvoznih rezultata u tekućoj godini. Koristeći sustav GMM procjenitelja, pronašli smo nekoliko značajnih rezultata. Prvo, neiskorišteni izvozni potencijal u prošloj godini ima pozitivan učinak na visokotehnološki izvoz zemalja ASEAN-6 u tekućoj godini. Drugo, učinak neiskorištenog izvoznog potencijala na visokotehnološki izvoz zemalja ASEAN-6 ovisi o opskrbnim kompetencijama (ljudski kapital i sposobnost istraživanja i razvoja u zemljama ASEAN-6) i bilateralnoj povezanosti (trgovinske prepreke zemalja uvoznica i institucionalna sličnost između zemlje ASEAN-6 i zemlje uvoznice). Treće, kompetencije u opskrbi su najvažnije kada zemlje ASEAN-6 izvoze robu visoke tehnologije u zemlje s visokim dohotkom. Nasuprot tome, bilateralna veza je najvažnija kada zemlje ASEAN-6 isporučuju visokotehnološke proizvode u zemlje s niskim prihodima. Mjere za poboljšanje ljudskog kapitala, nadogradnju istraživačkih i razvojnih sposobnosti, promicanje liberalizacije trgovine i smanjenje institucionalne udaljenosti s trgovinskim partnerima, lijek su za zemlje ASEAN-6 da iskoriste neiskorišteni potencijal.

Ključne riječi: Neiskorišteni potencijal, izvoz visoke tehnologije, ASEAN, kompetencije u opskrbi, bilateralna povezanost.