Journal of Korea Trade Vol. 25, No. 8, December 2021, 25-44
https://doi.org/10.35611/jkt.2021.25.8.25
ISSN 1229-828X

Imported Intermediate Goods and Economic Growth

Kyung-Min Kim†
Department of Economics and Finance, Keimyung University, South Korea

JKT 25(8)

Received 18 October 2021
Revised 3 December 2021
Accepted 10 December 2021

Abstract

Purpose – This research aims to provide empirical evidence that highlights the importance of imported intermediate goods in long-term economic growth. To this end, this paper develops an index that measures the productivity gains associated with a country's intermediate goods imports using highly disaggregated trade data.

Design/methodology – The basic hypothesis is that countries sourcing higher-productivity (or higher-quality) inputs from developed economies derive a larger benefit from foreign R&D. To explore this hypothesis, standard cross-country growth regressions are performed using the highly disaggregated data from the United Nations (UN) Commodity Trade Statistics Database (COMTRADE). To address the endogeneity issue, I apply an instrumental variable (IV) approach.

Findings – The results of this study demonstrate that the index predicts subsequent economic growth in middle- and low-income countries. This finding is consistent with previous studies that have argued that developing countries can achieve substantial productivity gains by importing intermediate inputs from developed countries. By contrast, there is no evidence of a significant association between the index and economic growth in high-income countries.

Originality/value – This paper contributes to our understanding of the causal relationship between international trade and economic growth. From an economic policy perspective, the results suggest that developing countries with limited technology endowment can boost growth from input-tariff liberalization.

Keywords: Cross-national Analysis, Economic Growth, Imported Intermediate Goods, Productivity Gains
JEL Classifications: F14, F43, O47

1. Introduction

Trade liberalization has been a key component of policy advice to promote sustainable economic growth to developing economies. Economists have long postulated that trade openness has a positive impact on economic growth, on average, although the effect differs between countries (Balassa, 1965; Feder, 1983; Esfahani, 1991; Stiglitz, 2007; Irwin, 2019). And yet there is still debate about the transmission channel through which trade affects growth.

This paper focuses on the relationship between imported intermediate goods and long-term economic growth. Endogenous growth models link increases in productivity that are due to the use of new intermediate inputs to long-term economic growth (Ethier, 1982; Rivera-Batiz and Romer, 1991; Aghion and Howitt, 1992; Grossman and Helpman, 1994). These models emphasize that importing intermediate goods that embody research and development (R&D) from advanced countries can be a significant source of productivity and

† **First and Corresponding author:** kyungmin@kmu.ac.kr

growth. For example, Grossman and Helpman (1991) construct a two-country model of quality competition during the product life cycle with endogenous innovation and imitation. In their model, the South entrepreneurs can attain technological progress by learning the production processes developed in the North via international trade.

This research aims to provide empirical evidence that highlights the importance of imported intermediate goods in long-term economic growth based on the aforementioned studies. The basic hypothesis is that countries sourcing higher-productivity (or higher-quality) inputs from developed economies derive a larger benefit from foreign R&D. To explore this hypothesis, standard cross-country growth regressions are performed using the highly disaggregated data from the United Nations (UN) Commodity Trade Statistics Database (COMTRADE). To address the endogeneity issue, I apply an instrumental variable (IV) approach. In particular, this article pays greater attention to the results for the subsamples of developed and developing countries (more precisely, high-income countries and middle- and low-income countries). This is because there is a plausible a priori expectation that gains from imported inputs will be greater in developing countries. For example, Broda, Greenfield, and Weinstein (2017) find that the impact of new imported varieties on productivity is larger in developing countries.

The novelty of the current approach is that it creatively develops an index of "the productivity gains from imported intermediate goods" for each country. This methodology is inspired by Hausmann, Hwang, and Rodrik (2007), who compile an index measuring "the income level of a country's exports" and verify that it predicts subsequent economic growth. Here, the index is constructed through the following steps. To begin with, intermediate goods are ranked in terms of their implied productivity. This measure (which I call PRODY) is generated by taking the weighted average of the per capita GDPs of the exporting countries for each intermediate good. Further, previous literature tells us that product quality may vary markedly across countries within products (Schott, 2004; Hummels and Klenow, 2005; Khandelwal, 2010). Thus for each intermediate good, PRODY is assumed to increase as an exporting country's income and revealed comparative advantage (RCA) rise unlike Hausmann, Hwang, and Rodrik (2007). Then the index (which I call IMPY) that corresponds to the productivity gains from imported intermediate goods is constructed by taking the weighted average of PRODY for each country. Although the IMPY index can be easily constructed using commodity trade data, it provides useful information when assessing the role of imported intermediate goods in economic growth. The methodology in this paper is distinctively different from my previous publication (Kim, 2019) in that the sophistication of imported inputs is differentiated not only by product but also by source country. In other words, this paper explicitly emphasizes that the quality of imported inputs may vary significantly by country of origin based on prior literature.

Empirical results, using cross-country data for the period 2004-2018, confirm that IMPY shows different patterns in predicting subsequent economic growth depending on the subsample. Although IMPY has a positive and statistically significant impact on economic growth in developing countries, this relationship is not observed in developed countries. These results are robust to a number of alternative specifications. This finding is consistent with Coe, Helpman, and Hoffmaister (1997) who have shown that total factor productivity in developing countries is positively associated with R&D in their industrial country trade partners.

The policy implications of the paper are clear. Imports can serve as a channel for economic growth in developing countries because these economies can take advantage of foreign technology and knowledge by importing intermediate goods. Consequently, input-tariff liberalization may be particularly beneficial for less developed countries that seek to close the technological gap with advanced countries.

This paper is related to several strands in the existing literature. First, this paper adds to empirical evidence of the causal link between imports and economic growth. For example, Lee (1995) observes that the ratio of imported to domestically produced capital goods has a significant positive impact on economic growth. Keller (2004) argues that intermediate input imports are an important channel of technology diffusion. Lim and McNelis (2016) confirm that both trade and financial openness can achieve improvements in income growth once a country gets through a critical threshold in capital intensity and in the use of imported intermediate goods. While these studies deal with quantitative measures of imports, this article concentrates mainly on the importance of qualitative measures of imports. In other words, the present paper points out that the sophistication of imported inputs, namely what a country imports and from where it imports, matters for economic growth.

Second, recent trade literature has extensively investigated the impact of imported inputs on firm productivity. Empirical studies have shown that a greater access to foreign inputs has improved firm productivity in some developing countries (Amiti and Konings, 2007; Kasahara and Rodrigue, 2008; Topalova and Khandelwal, 2011; Halpern, Koren, and Szeidl, 2015; Fieler, Eslava, and Xu, 2018). It is likely that firm-level productivity gains lead to overall productivity growth (Coe, Helpman, and Hoffmaister, 1997; Hagemejer, 2018). This may be due to technology spillovers among firms and/or industries and the reallocation of market shares to more productive firms. Microeconomic research at the firm-level has the advantage of identifying causation and isolating the effects of trade openness, but cannot be confidently generalized across countries. Thus, this study contributes to the literature by providing new cross-country empirical evidence about the effects of imported inputs on productivity and economic growth.

The remainder of this paper is organized as follows: Section 2 provides an overview of the empirical methods to construct IMPY. Section 3 presents the empirical findings. Section 4 concludes.

2. Empirical Analysis

2.1. Construction of IMPY

To begin with, I construct an index called $PRODY_k$ following Hausmann, Hwang, and Rodrik (2007). $PRODY_k$ represents the implied productivity level (proxied by income level) associated with a given intermediate good k. This index is computed by taking a weighted average of the per capita GDPs of countries exporting that product as follows:

$$PRODY_k = \sum_i \frac{(X_{ik}/X_i)}{\sum_i (X_{ik}/X_i)} Y_i = \sum_i w_{ik} Y_i \quad (1)$$

where X_{ik} denotes country i's export value in intermediate good k, X_i is the total exports of country i, and Y_i represents the per capita GDP of country i. The numerator of the weight, X_{ik}/X_i, is the share of the intermediate good in the country's total export value. The denominator of the weight, $\sum_i X_{ik}/X_i$, sums up the shares across all the countries exporting the intermediate good. Thus, the index stands for the weighted average of per capita GDPs, where the weights (w_{ik}) are determined by the RCA.[1] This index gives greater weight to countries with higher value-shares of the corresponding intermediate good in their own overall export baskets. This methodology thus ensures that the ranking of goods is not distorted by country size.[2]

On the other hand, previous studies have established that richer countries export higher quality goods (Schott, 2004; Hummels and Klenow, 2005; Khandelwal, 2010). In addition, Khandelwal (2010) formulates that higher quality is assigned to varieties with higher market shares conditional on price. Consider the example of watch movements in the 6-digit Harmonized System (HS) product category 910820. In 2018, Switzerland and China were, respectively, the world's largest and fourth-largest exporters of that product. The calculated $PRODY_k$ value of product 910820 is \$57,246. However, there is no doubt that the Swiss luxury watch industry has maintained its position as market leader for long periods of time. Therefore, we anticipate that Swiss watch movements are of a much higher quality than those made in China.

In this regard, for each intermediate good, I compile a differentiated productivity level that corresponds to a specific exporting country. The current method seems to be a kind of rule of thumb, but it does not require special data beyond what is readily available in disaggregated trade data. First, $PRODY_k$ is assumed to be the lowest productivity level that corresponds to the poorest country among the exporting countries for a given product. Thus, $PRODY_k$ can be interpreted as a reference value. Next, country-specific productivity is presumed to increase along with a country's income and RCA according to the aforementioned literature. More precisely, an incremental factor (α_{ik}) is defined as the variation of $PRODY_k$ when we substitute the poorest country's income (Y_L) for a given country's income (Y_i).

$$\alpha_{ik} = PRODY_k - [\textstyle\sum_{l \neq i} w_{lk} Y_l + w_{ik} Y_L] = w_{ik}(Y_i - Y_L) \quad (2)$$

Roughly speaking, α_{ik} measures how much a given country contributes to $PRODY_k$ relative to the poorest country. It is worth noting that α_{ik} depends not only on a country's income but also on its RCA. This approach thus does not rule out the possibility that low- or middle-income countries may export higher productivity varieties within products. One concern is that α_{ik} may be too large when the richest countries have high RCA values. Hence, the maximum productivity level is limited to the richest country's income (Y_H) by the intrinsic logic of the $PRODY$ index construction.[3] Finally, the implied productivity level associated with intermediate good k exported from country i equals the following:

$$PRODY_{ik} = min[PRODY_k + \alpha_{ik}, Y_H] \quad (3)$$

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[1] Because each weight lies between 0 and 1, the weight is different from Balassa's (1965) well-known RCA index.

[2] See Hausmann, Hwang, and Rodrik (2007) for a detailed explanation of the rationale for the current weighting scheme.

[3] The upper-bound restriction is rather scarcely applied to our actual data. The proportion is only 0.0002% (22 of 90,609 total observations).

Using the aforementioned example of watch movements, Switzerland has the highest $PRODY_{ik}$ value of $87,434. The second- and third-highest countries in terms of $PRODY_{ik}$ are, respectively, Hong Kong ($67,696) and Japan ($62,431). By contrast, China's $PRODY_{ik}$ is the lowest, $57,246.

To my knowledge, no previous study has developed a similar index except Veeramani (2009). But the approach in this paper is considerably different from his work. He constructs $PRODY_{ik}$ by simply multiplying each country's per capita GDP by the Balassa index. Thus, for each country, he ranks traded goods according to their RCA values. However, there are several problematic aspects that need to be addressed with regard to his methodology. First, it ignores the fact that a country's hierarchy in goods in terms of their implied productivity does not depend entirely on its RCA. For example, suppose that the bicycle industry is relatively more competitive than the automobile industry in India. Can we conclude that Indian bicycles, as products, have a higher productivity than Indian cars? Second, a country's level of income may determine its export basket regardless of its RCA measures. Hummels and Klenow (2005) show that developed countries export not only more goods but also a wider variety of goods. So if we evaluate the implied productivity according to each country's income and RCA, we cannot avoid underestimation and/or overestimation problems. In 2018, the US per capita GDP (PPP, constant 2017 international dollars) was $61,544, which made the US approximately four times as rich as China ($15,243). Suppose that China's RCA is 10 times higher than the US in pencils. Can it then be concluded that Chinese pencils have a 2.5 times higher productivity than pencils made in the US? In actuality, numerous poor countries show high $PRODY_{ik}$ values in Veeramani (2009) because their RCA values are too high at times.[4]

Eventually, the productivity gains associated with country j's imported intermediate goods basket is defined by the following:

$$IMPY_j = \sum_k \sum_i \left(\frac{M_{ijk}}{M_j}\right) PRODY_{ik} \tag{4}$$

where M_{ijk} is country j's import value from country i in intermediate good k and M_j represents the total value of imported intermediate goods of country j. Therefore, $IMPY_j$ represents a weighted average of $PRODY_{ik}$ for country j, where the weights correspond to the value shares of the products in the country's total imports of intermediate goods.

2.2. Data and methods

Trade data are obtained from the UN COMTRADE at the 6-digit level Harmonized System (HS6) for the years 2002–2018. The HS6 codes were introduced in 1988 and were revised periodically in 1996, 2002, 2007, 2012, and 2017. Thus, it is difficult to collect consistent data over a long period of time. However, we cannot acquire a sufficient number of observations if our time span is too short. This study uses the multilateral export and bilateral import data as classified by HS 2002. The export and import values are measured in current US dollars.

Following Hausmann, Hwang, and Rodrik (2007), the PRODY measure is constructed for a fixed sample of countries for the years 2015–2017 to avoid sampling bias.[5] It is likely that

[4] Each weight lies between 0 and 1 herein, but the Balassa index does not have an upper limit.

[5] The current methodology attempts to use the most recent data. However, the number of countries that

non-reporting is highly correlated with income, so constructing PRODY using a different country sample every year could cause serious bias. As a result, PRODY is calculated for a sample of 144 countries based on export data and the real per capita GDP data for the 2015–2017 period. The real per capita GDP data are collected from the World Development Indicators database. These data are in constant 2017 international dollars. This study will present most of its results with PPP-adjusted measures of PRODY. However, the PRODY measure is also calculated using GDP at market exchange rates to investigate robustness. I exclude observations wherein the US consumer price index (CPI)-deflated annual export value is below $10,000 in 2015 US dollars. This is because some small countries' RCA indices might be overestimated when such observations are included.

Subsequently, the IMPY measure is constructed for the years 2002–2018 using the average PRODY from 2015–2017. Extremely small countries may rely more heavily on only a few countries for their imports or show a high degree of commodity concentration of imports. Therefore, I exclude small countries with a population of less than 1 million in 2019.[6] The number of countries for which IMPY indices are calculated differs from year to year. Table 1 shows the country coverage between 2002 and 2018. The total number of countries for which IMPY is calculated ranges from 74 to 131.

Intermediate goods are chosen according to the classifications used by the Broad Economic Categories (BEC) of the UN Conference on Trade and Development. I use the HS–BEC concordance provided by the World Integrated Trade Solution (WITS) to identify intermediate goods from the COMTRADE data. The BEC codes and definitions for intermediate goods here are shown in Table 2.

Table 1. Country Coverage of IMPY

Year	No. of countries	Year	No. of Countries	Year	No. of Countries
2002	74	2008	125	2014	131
2003	92	2009	124	2015	128
2004	104	2010	131	2016	126
2005	112	2011	130	2017	127
2006	117	2012	129	2018	114
2007	124	2013	131		

reported trade data for 2018 is relatively small compared to those during 2015–2017, as shown in Table 1.

[6] The following 58 countries (or dominions) are excluded:
Aruba, Andorra, American Samoa, Antigua and Barbuda, Bahamas, Belize, Bermuda, Barbados, Brunei Darussalam, Bhutan, Channel Islands, Comoros, Cabo Verde, Curacao, Cayman Islands, Djibouti, Dominica, Fiji, Faroe Islands, Micronesia, Fed. Sts., Gibraltar, Grenada, Greenland, Guam, Guyana, Isle of Man, Iceland, Kiribati, St. Kitts and Nevis, St. Lucia, Liechtenstein, Luxembourg, Macao, St. Martin (French part), Monaco, Maldives, Marshall Islands, Malta, Montenegro, Northern Mariana Islands, New Caledonia, Nauru, Palau, French Polynesia, Solomon Islands, San Marino, Sao Tome and Principe, Suriname, Sint Maarten (Dutch part), Seychelles, Turks and Caicos Islands, Tonga, Tuvalu, St. Vincent and the Grenadines, British Virgin Islands, Virgin Islands (U.S.), Vanuatu, Samoa

Table 2. BEC Codes to Identify Intermediate Goods

Code	Definition
111	Food and beverages, primary, mainly for industry
121	Food and beverages, processed, mainly for industry
21	Industrial supplies not elsewhere specified, primary
22	Industrial supplies not elsewhere specified, processed
31	Fuels and lubricants, primary
322	Fuels and lubricants, processed (other than motor spirit)
42	Parts and accessories of capital goods (except transport equipment)
53	Parts and accessories of transport equipment

Furthermore, this study assumes that the implied productivity within products differs across countries. I thus exclude homogeneous goods, which are by definition not differentiated by quality, according to the product classifications suggested by Rauch (1999).[7]

Table 3 presents some descriptive statistics on $PRODY_k$ using both PPP-adjusted GDP and GDP at market exchange rates. The income level associated with intermediate goods varies widely from \$1,654 to \$104,055 on the basis of PPP-adjusted GDP. This reflects the fact that countries specialize in different sets of goods on the basis of their income levels.

Table 3. Descriptive Statistics for Mean $PRODY_k$ over 2015-2017 (2017 International Dollars)

Variable	No. of observations	Mean	SD	Minimum	Maximum
PPP-adjusted GDP	1,438	28,969	12,561	1,654	104,055
GDP at market exchange rates	1,438	22,706	12,542	736	100,174

Table 4 shows the five intermediate goods with the smallest and largest values of $PRODY_k$. As might be expected, intermediate goods with low $PRODY_k$ values are the main export items of poor countries: 410622 (Burundi), 540834 (Gambia), 560729 (Afghanistan, Uganda), 630510 (Nepal), and 410621 (Uganda and Nepal). By contrast, the top five intermediate goods with the highest values for $PRODY_k$ hold a significant share of Luxembourg's exports. Luxembourg records the highest level of GDP per capita in the sample of exporting countries.

Fig. 1 depicts the time trends for IMPY for some Asian and Latin American countries. Among the Asian countries included (China, India, Korea, and Thailand), China and Korea have the highest IMPY values. These two countries experienced a temporary decline in IMPY

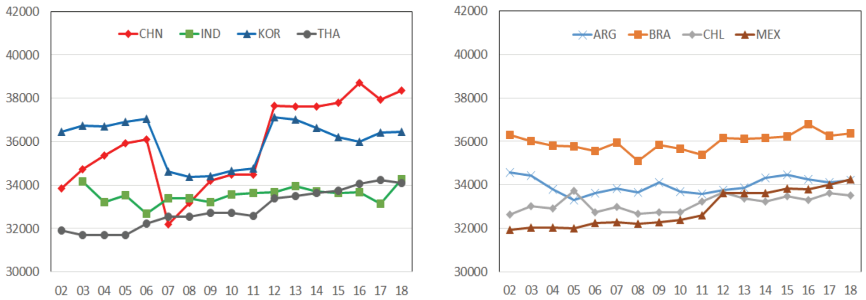
[7] Rauch classifies 4-digit SITC sectors into three categories: homogeneous sectors, reference-priced sectors, and differentiated sectors. He proposes two different categories to create his classification, namely, "liberal" and "conservative." The conservative category was chosen because it is more stringent in classifying homogeneous goods. To match the HS6 codes to the SITC 4-digit codes (Revision 2), I use the SITC–HS concordance provided by WITS and exclude non-unique mappings.

during the global financial crisis, possibly owing to their high degree of vertical specialization in exports. Interestingly, China's IMPY now surpasses that of Korea and exceeds those of other Asian and Latin American developing countries. Brazil has the highest IMPY level among the Latin American countries, but its IMPY has shown a stagnant trend over time. Both Mexico and Thailand have displayed relatively steady upward trends.

Table 4. Largest and Smallest $PRODY_k$ Values (2017 International Dollars)

	Product	Product Description	Mean $PRODY_k$
Smallest	410622	Tanned or crust skins of goats (dry)	1,654
	540834	Woven fabric with wool or fine animal hair	2,164
	560729	Twine, cordage, ropes and cables	3,544
	630510	Sacks and bags Of jute or of other textile	3,583
	410621	Tanned or crust skins of goats (wet)	3,685
Largest	590290	Tire cord fabric of viscose rayon	104,055
	721633	H sections of a height of 80 mm or more	99,032
	730110	Sheet piling of iron or steel	94,665
	721632	I sections of a height of 80 mm or more	79,777
	590220	Tire cord fabric of polyesters	78,541

Fig. 1. IMPY over Time for Some Selected Economies



(a) (b)

Table 5 shows the countries with the lowest and highest IMPY values for 2018. The gap between the lowest and highest IMPY levels seems somewhat smaller than expected. This is mainly because even poor countries may require high-quality foreign intermediate goods for their most advanced sectors. The top five countries with the largest values for IMPY are small, rich European economies (Belgium, Switzerland, and Ireland) and Asian city-states (Singapore and Hong Kong). Conversely, the countries with the lowest IMPYs include three Sub-Saharan African countries (Gambia, Togo, and Eswatini) as well as Nicaragua and Cambodia.

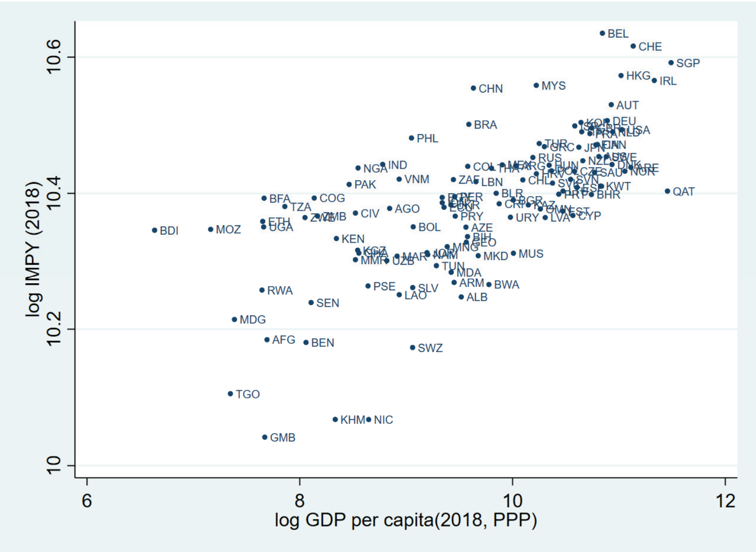
Table 5. Smallest and Largest IMPY (2017 International Dollars)

Smallest Countries	IMPY	Largest Counties	IMPY
Gambia	22,966	Belgium	41,570
Nicaragua	23,566	Switzerland	40,792
Cambodia	23,570	Singapore	39,812
Togo	24,477	Hong Kong	39,064
Eswatini	26,191	Ireland	38,784

2.3. Determinants of IMPY

Fig. 2 shows a scatterplot of IMPY against per capita GDP. There is a clear positive correlation between these two variables. This is consistent with Hallack (2006), who finds that rich countries are more likely to import from countries that produce high-quality goods. The positive association is also in accordance with the Linder hypothesis: countries trade more with trading partners at a similar level of development. This concept was proposed by Linder (1961) and Murphy and Shleifer (1997).

Fig. 2. Relationship between Per Capita GDP and IMPY (2018)



Let us now examine the determinants of IMPY using cross-national data. Table 6 reports that IMPY has a positive and statistically significant relationship with per capita GDP. Both human capital and the rule of law index do not seem to be strongly associated with IMPY once we control for per capita GDP. The rule of law index represents the institutional quality of a country, but IMPY appears to have no significant links to country-specific institutional characteristics. Population is strongly and positively related to IMPY, whereas land area has a negative but insignificant association with IMPY. Large countries, in terms of population or GDP, tend to trade more products (Hummels and Klenow, 2005; Baldwin and Harrigan, 2011). By contrast, countries with larger land area tend to have a lower share of imported inputs into production because they are likely to have relatively abundant natural resources (Campa and Goldberg, 2006). The last column of Table 6 is included to investigate the validity of the instrumental variables for IMPY, as will be explained later. It is well known that landlocked countries trade less due to their high transportation costs. However, some developed countries (such as Austria, Switzerland, and Luxembourg) have successfully participated in international trade despite being landlocked. Thus, I augment a dummy variable for the landlocked status of developing countries.[8] This dummy variable yields a significantly negative coefficient, as expected.

Table 6. Determinants of IMPY

	Dependent variable: ln$IMPY$ in 2017			
	(1)	(2)	(3)	(4)
log GDP per capita	0.065***	0.068***	0.069***	
	(0.006)	(0.011)	(0.009)	
log human capital		0.001	0.003	
		(0.041)	(0.034)	
log rule of law		-0.008	-0.005	
		(0.016)	(0.017)	
log population			0.035***	0.028***
			(0.005)	(0.007)
log land area			-0.005	-0.008
			(0.004)	(0.007)
Landlocked dummy				-0.070***
				(0.016)
Constant	9.758***	9.763***	9.704***	10.410***
	(0.067)	(0.073)	(0.091)	(0.078)
Observations	127	118	118	127
R^2	0.453	0.473	0.633	0.177

Notes: 1. Robust standard errors in parentheses.
2. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively.

3. IMPY and Economic Growth

3.1. Baseline cross-national analysis

I now examine the relationship between IMPY and economic growth using a cross-national analysis. The baseline time horizon selected is 2004–2018. As shown in Table 1, the

[8] The list of 32 countries can be downloaded on the UNCTAD website:
Afghanistan, Armenia, Azerbaijan, Bhutan, Bolivia, Botswana, Burkina Faso, Burundi, Central African Republic, Chad, Eswatini, Ethiopia, Kazakhstan, Kyrgyzstan, Laos, Lesotho, Macedonia, Malawi, Mali, Mongolia, Nepal, Niger, Paraguay, Moldova, Rwanda, South Sudan, Tajikistan, Turkmenistan, Uganda, Uzbekistan, Zambia, Zimbabwe.

maximum time span is 2002–2018. However, this leaves us with a considerably small sample of only 74 countries. Therefore, this study focuses on a shorter time horizon between 2004 and 2018, which has sufficient observations.

Following Lee (1995), Hausmann, Hwang, and Rodrik (2007), and Barro (2003), a regression model using cross-country data is specified as follows:

$$GY_j = \alpha + \beta IMPY_j + \gamma I_j + \varepsilon_j, \tag{5}$$

where GY_j is the average annual growth rate of per capita income over the sample period except during the global financial crisis of 2008–2009, and I_j is a set of important explanatory variables. That is to say, the average annual growth rate is regressed on initial values of IMPY and other explanatory variables for each regression. The relevant variables in I_j include the initial per capita GDPs, human capital, capital–labor ratio, a rule of law index, and trade openness (defined as exports plus imports divided by GDP) as suggested by Barro (2003).[9]

IMPY is plausibly correlated with omitted variables that are closely related to economic growth. Therefore, an IV specification is employed. In accordance with the previous literature, I use population, land area, and landlocked dummies as instruments for IMPY.[10] It is expected that country size and geographic characteristics are exogenous with respect to IMPY values and economic growth.[11]

Finally, IMPY may work differently in countries at different levels of economic development. Hence, the sample countries are divided into two subgroups: high-income countries and middle- and low-income countries as per the World Bank's income classification.

Table 7 shows the estimation results. The first-stage F-statistics indicate that the instruments are not weak. Hansen's J tests cannot reject the null hypothesis that the instruments are valid. We cannot observe a statistically significant impact of IMPY on economic growth for either the full sample or the subsample of high-income countries. By contrast, IMPY enters with a positive coefficient that is statistically significant for the subsample of middle- and low-income countries. The estimated coefficient for the subsample of developing countries is relatively large. The results imply that a 10% increase in IMPY accelerates economic growth by 1 percentage point.

Moreover, the empirical results generally support the conditional convergence hypothesis, which implies that countries with low initial per capita incomes grow faster after controlling for other determinants of long-run economic growth. Human capital has a statistically significant and positive effect on economic growth, while the capital–labor ratio and institutional quality do not enter the equation in a significantly manner. The effect of trade openness on economic growth is significant for both the full sample and the subsample of high-income countries.

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9 Barro (2003) includes trade openness as an explanatory variable in the growth equation. However, we cannot neglect the potential endogeneity of trade. See for example, Dowrick and Golley (2004).

10 By definition, the dummy for landlocked developing countries is excluded from the subsample of high-income countries.

11 We cannot neglect the impact of country size on growth. However, Rose (2006) denies a positive effect of country population on economic growth. In light of this finding, Hausmann, Hwang, and Rodrik (2007) consider country size an appropriate IV in their cross-national growth regression. In addition, Frankel and Rose (2002) perform a sensitivity analysis for the results of Frankel and Romer (1999) and show that the main conclusion is robust to the inclusion of geographical and institutional variables in the growth equation.

Table 7. Baseline Cross-national Growth Regressions: IV (2004-2018)

	Dependent variable: average annual growth rate of GDP per capita over 2004-2018					
	All		High income		Middle & low income	
	(1)	(2)	(3)	(4)	(5)	(6)
log GDP per capita	-0.008**	-0.020**	-0.028***	-0.012	-0.009**	-0.022*
	(0.004)	(0.009)	(0.010)	(0.013)	(0.004)	(0.012)
log IMPY	0.061	0.081	0.100	-0.110	0.112**	0.120**
	(0.058)	(0.050)	(0.164)	(0.107)	(0.052)	(0.049)
log human capital		0.042***		0.038***		0.046***
		(0.010)		(0.012)		(0.015)
log capital-labor ratio		-0.001		-0.012		0.001
		(0.005)		(0.006)		(0.006)
log rule of law		0.002		-0.001		0.004
		(0.004)		(0.006)		(0.004)
Trade openness		0.007**		0.016***		-0.007
		(0.003)		(0.002)		(0.013)
Constant	-0.522	-0.676	-0.724	1.228	-1.046**	-1.059**
	(0.570)	(0.473)	(1.617)	(1.029)	(0.509)	(0.451)
1st stage F-statistics	10.06	10.44	3.63	2.48	13.83	12.77
Hansen J-statistics (p-value)	0.30	0.99	0.09	0.29	0.18	0.69
Observations	102	96	43	42	59	54

Notes: 1. Robust standard errors in parentheses.
2. The instruments are log population, log land area and landlocked dummy for developing countries.
3. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively.

3.2. Robustness checks

Several robustness exercises are employed to check the sensitivity of the results. The first check re-runs the cross-national regressions using GDP at market exchange rates. In Table 8, the first-stage F-statistics are rather small for the subsample of high-income countries. However, F tests based on the full sample and the subsample of middle- and low-income countries indicate that the instruments are jointly significant in the first stage. All the IV specifications pass Hansen's overidentifying restrictions test. Focusing on the subsample of developing countries, the coefficients for IMPY are still significant, and their magnitudes are similar to those in our baseline model. All other regression results are in line with the previous baseline results shown in Table 7.

Table 8. Robustness: Cross-national Growth Regressions: IV (2004-2018)

	Dependent variable: average annual growth rate of GDP per capita (at market exchange rates) over 2004-2018					
	All		High income		Middle & low income	
	(1)	(2)	(3)	(4)	(5)	(6)
log GDP per capita	-0.007**	-0.023***	-0.014	0.000	-0.008**	-0.028***
	(0.003)	(0.006)	(0.010)	(0.015)	(0.003)	(0.010)
log IMPY	0.053	0.089*	0.017	-0.203	0.097**	0.124**
	(0.055)	(0.051)	(0.229)	(0.154)	(0.047)	(0.054)
log human capital		0.045***		0.052***		0.044***
		(0.010)		(0.016)		(0.014)
log capital-labor ratio		0.004		-0.014*		0.008
		(0.005)		(0.007)		(0.007)
log rule of law		0.006*		-0.007		0.006
		(0.003)		(0.016)		(0.004)
Trade openness		0.007***		0.014***		0.002
		(0.002)		(0.003)		(0.016)
Constant	-0.446	-0.734	-0.003	2.027	-0.886*	-1.021**
	(0.532)	(0.481)	(2.233)	(1.475)	(0.463)	(0.491)
1st stage F-statistics	7.23	6.10	0.81	1.21	12.80	7.51
Hansen J-statistics (p-value)	0.39	0.81	0.26	0.56	0.32	0.92
Observations	102	96	43	42	59	54

Notes: 1. Robust standard errors in parentheses.
2. The instruments are log population, log land area and landlocked dummy for developing countries.
3. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively.

The next set of robustness checks re-runs the baseline specification using alternative measures of IMPY. I now construct an IMPY measure based on the PRODY for the year 2004. This sensitivity check is performed in Table 9, considering the possibility that a country's RCA may vary over decades. Both the first-stage F-statistics and the J-statistics inform us that our instruments are appropriate. IMPY still enters significantly only in middle- and low-income countries while the other results remain qualitatively unchanged.

The next robustness check uses the IMPY measure including capital goods. Krueger (1983) argues that imported capital goods are usually required to foster a new domestic industry. Lee (1995) shows that cheaper foreign capital goods increase the efficiency of capital accumulation and thus have a positive impact on economic growth in developing countries. Considering these arguments, I re-calculate IMPY by adding imported capital goods with the BEC codes of 41 (capital goods except for transport equipment) and 521 (industrial transport equipment). Table 10 demonstrates that the results are robust to the inclusion of capital goods. Once again, the positive association between IMPY and growth is significant only in the subsample of middle- and low-income countries. All the test statistics indicate that the IVs are valid.

Table 9. Robustness: Cross-national Growth Regressions: IV (2004-2018)

	Dependent variable: average annual growth rate of GDP per capita over 2004-2018					
	All		High income		Middle & low income	
	(1)	(2)	(3)	(4)	(5)	(6)
log GDP per capita	-0.009**	-0.019**	-0.031***	-0.016	-0.009**	-0.021*
	(0.004)	(0.008)	(0.011)	(0.011)	(0.004)	(0.011)
log IMPY	0.057	0.073*	0.116	-0.059	0.097**	0.106***
(PRODY, 2004)	(0.048)	(0.038)	(0.131)	(0.065)	(0.043)	(0.034)
log human capital		0.044***		0.031***		0.049***
		(0.009)		(0.008)		(0.013)
log capital-labor ratio		-0.001		-0.009		0.000
		(0.004)		(0.007)		(0.005)
log rule of law		0.001		0.001		0.003
		(0.004)		(0.005)		(0.004)
Trade openness		0.006**		0.015***		-0.012
		(0.003)		(0.002)		(0.010)
Constant	-0.474	-0.599*	-0.853	0.747	-0.880**	-0.907***
	(0.459)	(0.343)	(1.254)	(0.645)	(0.412)	(0.293)
1st stage F-statistics	11.83	12.25	4.42	5.58	20.38	13.08
Hansen J-statistics (p-value)	0.31	0.98	0.15	0.14	0.12	0.68
Observations	101	95	43	42	58	53

Notes: 1. Robust standard errors in parentheses.
2. The instruments are log population, log land area and landlocked dummy for developing countries.
3. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively.

Finally, I augment a panel regression as a complementary robustness check. The standard cross-sectional regressions may suffer from possible omitted variables bias as Druckenmiller and Hsiang (2018) point out. The use of panel data allows us to control for time-invariant unobserved heterogeneity. Because HS6-digit product information in the COMTRADE does not provide data across a sufficient time span, I use the bilateral disaggregated export data for the United States.

Restricting the source country sample to only US seems to be problematic. This approach proceeds under the assumption that countries' imports from US reflect their imports from the rest of world. However, this assumption is partially justified since the United States is the world's second largest exporter and covers a wide range of products ranging from primary raw materials to high-tech intermediate goods. Nevertheless, we need to cautiously interpret panel estimation results since we cannot check the consistency of the two data series for earlier years.

Table 10. Robustness: Cross-national Growth Regressions: IV (2004-2018)

	Dependent variable: average annual growth rate of GDP per capita over 2004-2018					
	All		High income		Middle & low income	
	(1)	(2)	(3)	(4)	(5)	(6)
log GDP per capita	-0.008**	-0.016**	-0.026***	-0.018*	-0.009**	-0.018*
	(0.003)	(0.007)	(0.007)	(0.009)	(0.004)	(0.010)
log IMPY	0.068	0.085	0.086	-0.125	0.130**	0.131**
(+capital goods)	(0.060)	(0.053)	(0.148)	(0.110)	(0.054)	(0.052)
log human capital		0.037***		0.041***		0.038**
		(0.010)		(0.013)		(0.015)
log capital-labor ratio		-0.003		-0.008		0.000
		(0.005)		(0.007)		(0.006)
log rule of law		0.001		0.001		0.002
		(0.003)		(0.004)		(0.004)
Trade openness		0.008***		0.015***		-0.004
		(0.003)		(0.002)		(0.013)
Constant	-0.597	-0.759	-0.598	1.439	-1.223**	-1.204**
	(0.600)	(0.538)	(1.480)	(1.120)	(0.531)	(0.511)
1st stage F-statistics	14.33	14.42	4.67	3.03	21.00	22.25
Hansen J-statistics (p-value)	0.30	0.98	0.09	0.35	0.19	0.71
Observations	102	96	43	42	59	54

Notes: 1. Robust standard errors in parentheses.
2. The instruments are log population, log land area and landlocked dummy for developing countries.
3. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively.

Hausmann, Hwang, and Rodrik (2007) use 4-digit standard international trade classifications (SITC rev. 2) to construct the panel dataset during 1962-2000. However, I prefer to make use of more disaggregated data because within-product quality differentiation can be accurately estimated at the finest level of product aggregation available (Khandelwal, 2010).

The data are obtained from Peter Schott's International Economics Resource Page. They record US exports by destination country and year from 1991 to 2017 according to the HS 10-digit codes. After aggregating the HS information to the 6-digit level, an IMPY measure is constructed for each country based on the average PRODY of intermediate goods exported from US during 2015-2017. Because each country's imports from US may vary considerably from year to year, three-year moving averages of IMPY are employed to mitigate excessive volatility. The correlation coefficient between the baseline IMPY and the current IMPY measure is in the range 0.96-0.98 depending on the year during the period 2002-2017.

I group data into non-overlapping 5-year intervals (1991-1995, 1996-2000, 2001-2005, 2006-2012 excluding the period of the global financial crisis 2008-2009, 2013-2017). Three different estimation methods are applied : IV, IV with fixed effects for countries, and the system GMM. All equations include period dummies. A dummy for landlocked status of developing countries was excluded to introduce country fixed effects.

Table 11 contanis regression results. The instrumental variables pass the overidentification test except for columns (2) and (3). The GMM setup exhibits no second-order correlation except for column (6). The estimated coefficient on IMPY is significantly positive in the IV and GMM estimations for both the full sample and the subsample of middle- and low-income countries. The coefficient values in the GMM model are relatively small compared to those in the both cross-sectional and panel IV estimations. On the other hand, the fixed effect results tell us that IMPY does not affect the subsequent growth significantly once we control for unobserved time-invariant country characteristics. This is perhaps because most countries have very stable IMPY values over time. I take comfort in the fact that human capital and trade openness turns out mostly insignificant in the fixed effects model for similar reasons unlike the IV and GMM estimations. We need to keep in mind that fixed effects may soak up most of the explanatory power of some slowly changing independent variables as Beck (2001) points out. Furthermore, Fukase (2010) asserts that "the System GMM estimator improves substantially the estimate of the impact of education on growth relative to the models which focus on within-country changes in education, adding information on cross-country variation in education levels."

4. Concluding Remarks

This paper proposes an analytical framework linking the type of intermediate goods a country imports to its economic growth. In contrast to the previous literature, this article emphasizes the qualitative characteristic of imported inputs. More precisely, this study defines an index capturing the productivity gains from imported inputs to test empirically the effect of imported inputs on growth. The cross-country growth regression shows that developing countries importing more sophisticated intermediate goods achieve subsequent higher growth. This result implies that what countries import matters with regard to the growth effect of trade. By contrast, there is no evidence of a significant association between the index and subsequent growth in developed countries.

This paper contributes to our understanding of the causal relationship between international trade and economic growth. From an economic policy perspective, the results suggest that developing countries with limited technology endowment can boost growth from input-tariff liberalization. Nevertheless, the analysis in this paper has several limitations. First, this paper does not explicitly analyze the underlying mechanism that causes an interesting pattern of asymmetry in the growth effect of imported inputs. Second, Amiti and Konings (2007) propose that the increased availability of imported intermediate goods can raise productivity via learning, variety, and quality effects. Although the current results are consistent with the literature, we cannot say with confidence which, if any, of these channels leads to higher productivity and economic growth. The answer to these questions awaits future research.

Table 11. Robustness: Panel Growth Regressions (1991-2017 except for the Period 2008-2009, 5-Year Panels)

	All			High income			Middle & low income		
	IV	FE	GMM	IV	FE	GMM	IV	FE	GMM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
log GDP per capita	-0.016***	-0.035***	-0.013***	-0.023***	-0.033***	-0.031***	-0.017***	-0.035***	-0.010***
	(0.002)	(0.007)	(0.002)	(0.004)	(0.007)	(0.003)	(0.004)	(0.009)	(0.003)
log IMPY	0.096 **	0.007	0.044**	-0.085*	0.063	0.021	0.168***	-0.032	0.043*
	(0.042)	(0.075)	(0.021)	(0.049)	(0.151)	(0.036)	(0.053)	(0.047)	(0.025)
log human capital	0.039***	0.027	0.037***	0.025***	-0.023	0.019**	0.022*	-0.029	0.031***
	(0.009)	(0.022)	(0.006)	(0.007)	(0.022)	(0.009)	(0.013)	(0.030)	(0.008)
Trade openness	0.004*	0.003	0.004*	0.010***	-0.001	0.007***	0.017	0.029**	0.001
	(0.002)	(0.005)	(0.002)	(0.002)	(0.006)	(0.001)	(0.013)	(0.011)	(0.011)
Constant	-0.872	0.226	-0.345	1.120**	-0.267	0.090	-1.601***	0.638	-0.353
	(0.422)	(0.793)	(0.215)	(0.476)	(1.571)	(0.363)	(0.538)	(0.516)	(0.250)
Hansen J-statistics (p-value)	0.27	0.04	0.01	0.38	0.46	0.25	0.42	0.42	0.07
2nd-order serial correlation (p-value)			0.54			0.04			0.56
Observations	607	607	606	207	207	207	400	400	399

Notes: 1. Robust standard errors in parentheses.

2. All equations include period dummies. Fixed effects (FE) include dummies for countries. GMM is the Blundell-Bond System-GMM estimator.

3. All equations include period dummies. The instruments are log population and log land area

4. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively.

Appendix

Table A1. Data

Variables	Data Source
HS6 world trade data	UN COMTRADE (WITS)
Per capita GDP	World Bank's World Development Indicators (WDI)
Human capital	Penn World Table (version 9.0)
Rule of law	World Bank's World Development Indicators (WDI)
Population	World Bank's World Development Indicators (WDI)
Land area	World Bank's World Development Indicators (WDI)
Landlocked dummy	UNCTAD website
Capital-labor ratio	Penn World Table (version 9.0)
Trade openness	Penn World Table (version 9.0)
HS10 US trade data	Peter Schott's International Economics Resource Page

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