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Determinants of Global Palm Oil Demand: A Gravity Approach

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Abstract

This paper reviews the determinants of global palm oil trade using the gravity model. This model helps to explain how the shift in demand for palm oil has affected trade flows among trading partners. We decompose the effects of growth in the regional markets, location, and the reduction in the palm oil price relative to other edible oils, on palm oil exports. We find that standard variables suggested by the gravity literature, such as the growth of GDP, GDP per capita, and location, are indeed important determinants of palm oil trade. Given the preceding results, we simulate whether the economic growth of Indonesia's trading partners can explain the growth in palm oil export demand from Indonesia. The simulation results for top ten Indonesia's trading partners suggest that the growth of palm oil imports is a great deal higher than the growth of income for all countries.

Introduction

Palm oil (PO) is a type of vegetable oil derived from oil palm (*Elaeis guineensis* Jacq.) fresh fruit bunch (FFB). Oil palm cultivation is found in tropical areas of Africa, South America, and South East (SE) Asia. The history of oil palm cultivation and trade began in Africa and was associated with the slave trade in the 16th century. However, the modern development of the PO industry in Africa has lacked behind SE Asia, particularly Indonesia and Malaysia, the two largest PO producers globally.

The vast growth in global PO demand is undeniable. In fact, PO is one of the fastest growing perennial crops in the world (Koh & Wilcove, 2008). However, the industrialisation of PO was only prominent after the 1980s. The global PO trade has increased more than five-fold from 1990 to 2015, or from 8.3 million tonnes to 45.1 million tonnes (USDA-FAS, 2016).

However, PO industry development is also one of the most controversial global problems, as it is argued to be one of the major sources of deforestation, particularly in biodiversity-rich countries like Indonesia and Malaysia. In 2013, the total area of global oil palm plantation was 18.1 million hectares, increased from 6.1 million hectares in 2013 (FAOstat, 2015).

The largest share of global PO demand comes from Asian countries, with India and China being the largest and second largest importers of PO. Together they account for more than 33 percent of the global PO export market. But, does the growth in these two markets account for the growth in Indonesia's PO exports?

To answer this question, we employ the gravity model. This model will help to explain how the shift in demand for PO has affected trade flows among trading partners. We will examine the effects of growth in the regional markets, location, and the reduction in PO price relative to other edible oils on PO exports. The second aim of this paper is to examine the role of income growth in top 10 Indonesia's palm oil importers, particularly China and India in determining PO demand from Indonesia.

In the global edible oil market, PO is the most important traded vegetable oil, with import growth of 7 percent annually between 1990 and 2015. PO import shares of total vegetable oil imports have increased substantially, from around 41 percent in 1990 to around 64 percent in 2014. Meanwhile, import shares of soybean oil have gradually decreased from around 17 percent to around 14 percent over the same period.

Indonesia and Malaysia dominate the PO export market. Their combined export share is around 90 percent of the world's total demand. Since 2008, Indonesia has surpassed Malaysia in PO exports. In 1980, Indonesia's export share was only 6 percent, while Malaysia was 72 percent. Whereas in 2014, Indonesia's export share was 54 percent and Malaysia's was 37 percent. A significant growth in Indonesian PO exports

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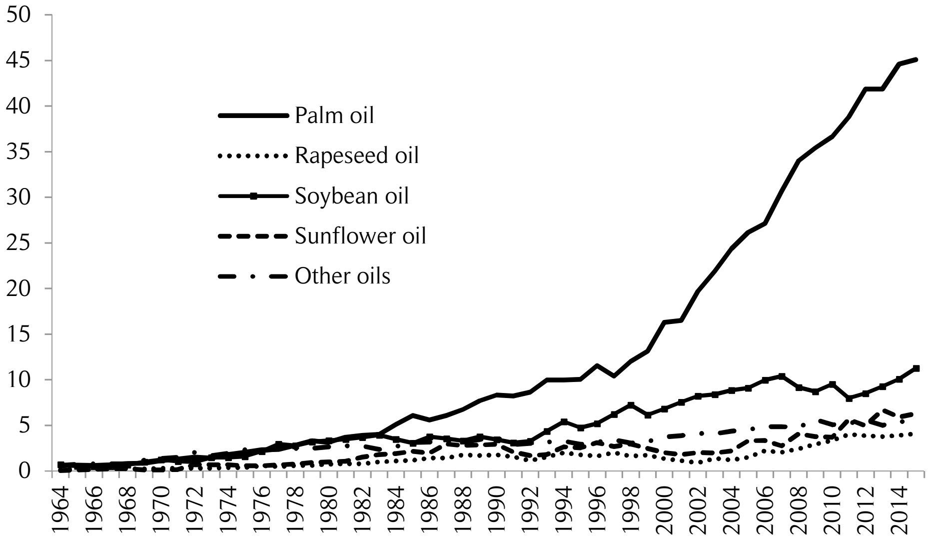
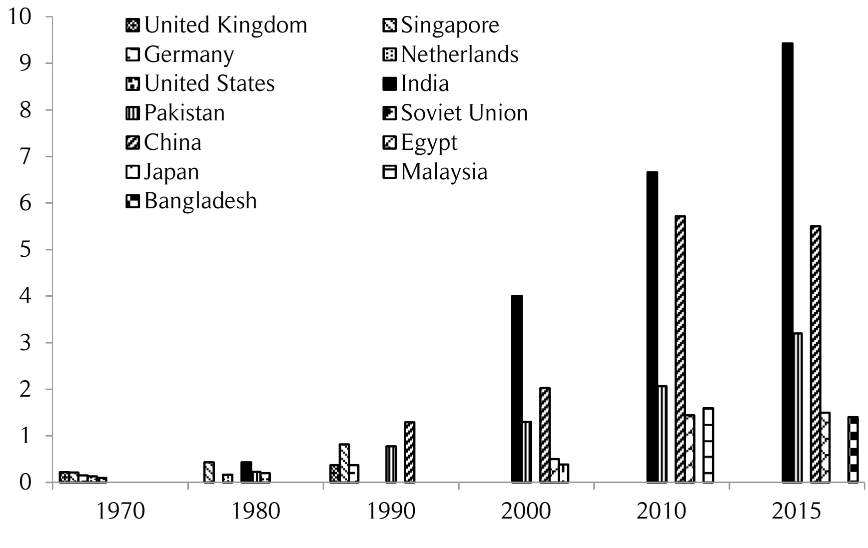
occurred after 1990. Meanwhile, the export share for the rest of the world has remained constant at around 10 percent since 2000.



Source: USDA-FAS (2016).

Figure 1. Major Vegetable Oil Imports, 1964–2015 (Million MT)

Figure 2 shows that there has been a major shift in the largest PO import countries since 1970. In 1970, PO imports were dominated by European countries, including the UK, Germany, and the Netherlands. Between 1980 and 1990, several European countries, including the Netherlands, Germany, the UK and the former Soviet Union, still played an important role in the PO market. After that, the market shifted to Asian countries.



Source: USDA-FAS (2016).

Figure 2. Top Five Palm Oil Imports, 1970–2015 (Million Metric Tonnes)

Recently, the largest market for global PO is Asia. Data from USDA-FAS (2016) shows that, in 2015, four out of the top five PO importers are located in Asia: India, China, Pakistan and Bangladesh. Since early 2000, India and China have been the largest importers of PO. India absorbed around 21 percent and China 12 percent of global PO imports in 2015. Another top importer is Egypt. These top five countries alone were responsible for more than 46 percent of global PO demand in 2015.

Strong population and economic growth is likely to increase demand for PO in many Asian countries, particularly India and China. Population growth will increase the total demand for PO, while economic growth will increase the average edible oil consumption, particularly since the average consumption in both countries is far below the world average. We estimated the annual per capita consumption of major vegetable oils for selected countries based on total domestic consumption from USDA data and total population data from World Bank. The results are available in Table 1.

Table 1. Per Capita Consumption of Major Vegetable Oils, 1990–2010 (kg/year)

Country	1990	2000	2010
China	5.74	10.71	20.92
India	5.75	10.55	12.92
Indonesia	11.75	19.97	32.92
US	28.69	25.38	38.12
World	11.05	14.95	22.10

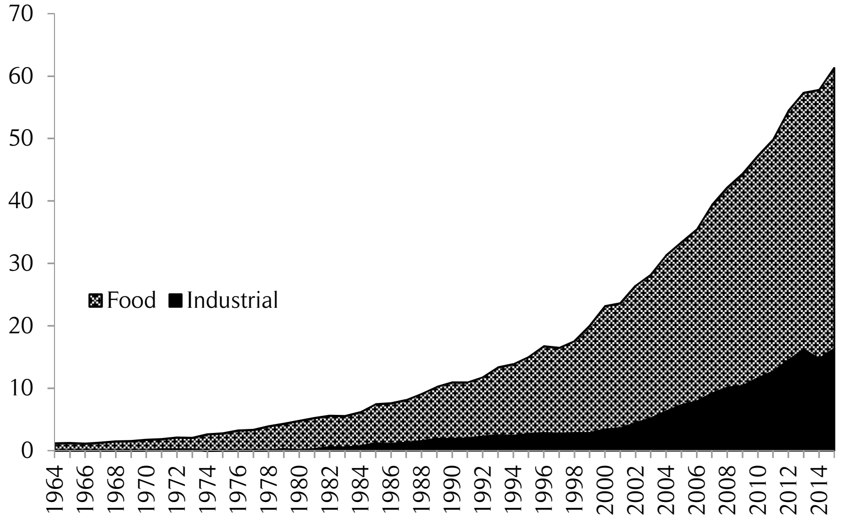
Source: (USDA-FAS, 2016) and (Word Bank, 2016).
Note: per capita consumption is author's calculation.

Major vegetable oils include coconut oil, cottonseed oil, olive oil, palm oil, palm kernel oil, groundnut oil, rapeseed oil, soybean oil and sunflower oil. Note that this estimation indicates the per capita of total domestic consumption. It does not separate oils for food and industrial consumption

Table 1 shows that per capita vegetable oil consumption has increased over time. The increase was particularly large in China with per capita consumption increasing almost four-fold during 1990–2010. Though not as significant as China, growth of per capita consumption in India is still considered high, more than doubling during the same period. However, these figures are still below the world average and below the Western average (for example, if compared with per capita consumption in the US). High per capita consumption in Indonesia might be misleading as it represents not only the actual consumption of PO, but also the PO processing industries in Indonesia.

Palm oil is predominantly served as edible oil. However, it can also be used for industrial purposes. Figure 3 shows the global consumption of PO for food and industrial uses. The figure shows that total consumption of PO increased more than five-fold between 1990 and 2015, from 11 million MT in 1990 to 61 million MT in 2015. However, the growth rate of industrial PO exceeded that for edible PO. During the same period, PO used for non-food industry grew by more than 700 percent, from 1.9 million MT to 16.3 million MT, while PO used for food increased by 400 percent, from 9 million MT to 45 million MT. In 1980, almost 100 percent of PO was served as food. In 2015, this had decreased to 73 percent.

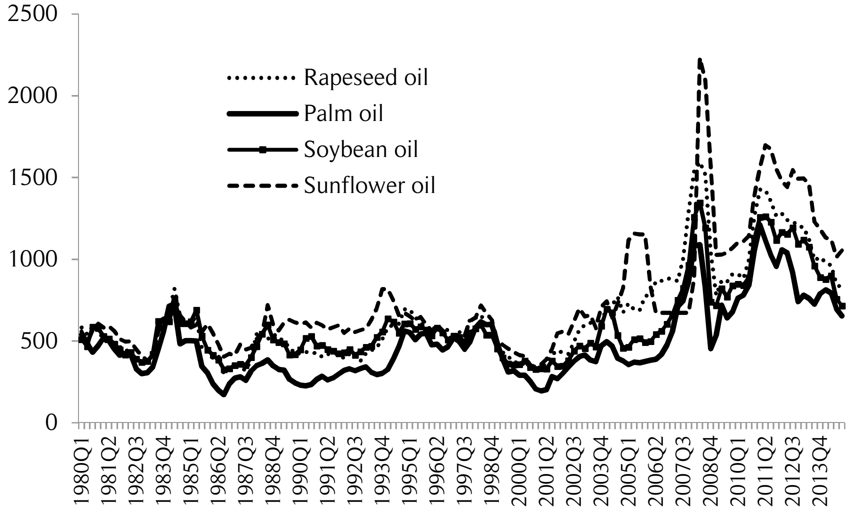
Though this figure does not mention in detail what the industrial purposes are, many believe that this is strongly correlated with the growing increase of the biodiesel industry, especially in European countries (Lam *et al.*, 2009, Lam *et al.*, 2009, Murphy, 2009). According to Mitchel (2008), biodiesel was responsible for approximately one-third of the increase in vegetable oil consumption in 2004–2007. In the early 19th century Europe, PO was predominantly used for soap, candles and heating (Henderson & Osborne, 2000). Nowadays, according to Gerasimchuk and Koh (2013), biodiesel feedstock in Europe increased by 365 percent from 2006 to 2012, equivalent to an increase from 0.4 million MT to 1.9 million MT, and an increase of 40 percent for electricity and heat generation from 0.4 million MT to 0.6 million MT. For comparison, the use of PO for other purposes, mainly food, increased by 6 percent (Gerasimchuk and Koh, 2013). This is important, since Europe is the largest producer of biodiesel (Tan *et al.*, 2009, Zhou and Thomson, 2009). There is also a growing interest in biodiesel production in Asian countries, especially PO-based biodiesel in Indonesia and Malaysia (Mekhilef, Siga and Saidur, 2011, Santosa, 2008, Wirawan and Tambunan, 2006, Zhou and Thomson, 2009).



Source: (USDA-FAS, 2016).

Figure 3. Global Palm Oil Consumption for Food and Industrial Uses, 1964–2015 (Million MT)

One important reason for PO's growing popularity appears to be price. Compared with other vegetable oils, PO has the lowest price. Although the gap in price between PO and soybeans, its closest substitute, is not large, PO prices have been consistently below soybean prices over the past decades. The average price of PO was around 17 percent less expensive than soybean oil in 2010–2014, as shown in Figure 4. Being the least expensive edible oil is another reason for PO to gain the largest share of the market in Asia. Future demand is also expected to increase, particularly in some developing Asian countries, such as India, China, and Pakistan.



Source: (IMF, 2015), (UNCTADstat, 2015), and (Word Bank, 2015).
Note: Quarterly averages are author's calculations.

Figure 4. Major Vegetable Oil Quarterly Prices, 1980–2014 (US$)

The price of PO and other vegetable oils has fluctuated considerably since 2005. The PO price, like other commodity prices, experienced a significant increase during 2006 to 2008, but fell to its lowest level in the first half of 2009 and increased again after that. The decrease in PO price in 2008 was caused by a decrease in demand following the global financial crisis. Many also believe that this price decrease was related to the decrease in petroleum prices, as vegetable oils, including PO, were used as raw materials for biodiesel. Further research concerning vegetable oils and energy markets can be found in Abdel and Arshad (2008), Peri and Baldi (2010), Priyati and Tyers (2016), Sanders, Balagtas and Gruere (2014), and Yu *et al.* (2006).

The main possible factors explaining why PO prices are very competitive are lower production costs and higher yields compared with other major vegetable oils. Unlike other oils, such as soybean, rapeseed or sunflower oil, which are annual crops, oil palms are a perennial crop with year-round harvesting. Palm oil incurs less production costs and less labour costs, since oil palm plantations are mostly found in countries like Indonesia and Malaysia where lower wages are paid to workers (Murphy, 2009a). According to Carter *et al.* (2007), the average production cost of PO in 2004–2005 was slightly above US$200, compared with more than US$300 for sunflower and soybean oils and more than US$500 for rapeseed oil.

Yield-wise, PO also appeared to have the highest productivity per ha compared with other vegetable oils. With an average yield of nearly 4 MT/hectare/year excluding palm kernel oil (PKO) which is also derived from oil palm fruits, the PO was more productive than other oils, which had a productivity of less than 0.5 MT/hectare/year (Johnston *et al.*, 2009 and Murphy, 2009a).

Methods

The gravity model

Palm oil is generally shipped in bulk, because the unit price is relatively low. Asia is the most important market for Indonesian PO. In 2010, almost 70 percent of Indonesian PO was exported to Asian countries, with the largest and second largest being India (32 percent) and China (13 percent). In this case, proximity might be an important factor to determine the flow of PO trades. The fact that Indonesia and Malaysia are close to these large and rapidly growing markets may help explain the rapid growth in their PO exports. This is an interesting hypothesis that will form the basis of our gravity model.

The role of distance in international trade is commonly investigated by the gravity model. The traditional gravity model was introduced by Tinbergen (1962). He proposed that trade between two countries is determined in part by their sizes and distance. Size determines the volume of demand and distance explains the transportation cost.

The gravity model has been empirically successful in explaining international trade flows. The theoretical foundations of the gravity model have been discussed by Anderson (1979), Bergstrand (1985), Bergstrand (1989), and Deardorff (1998). This model is mainly employed for general trade, with an emphasis on trade agreements or free trade zones. Only a few specific commodities have been investigated using the gravity model. A few examples of the gravity model being employed with a specific emphasis in agricultural good trades are Lambert and Grant (2008), Hatab, Romstad and Huo (2010), Olper and Raimondi (2008), and Sarker and Jayasinghe (2007).

In its simplest form, the gravity equation can be written as:

$$M_{jit} = \alpha_0 Y_{it}^{\alpha_1} Y_{jt}^{\alpha_2} Dist_{ij}^{\alpha_3} \tag{1}$$

Where M_{jit} determines imports of country j to country i in year t, Y_{it} and Y_{jt} determine GDP of country i and j, and $Dist_{ij}$ is the distance between i and j. In our gravity model specification, we include several additional variables, such as per capita income of both country *i* and country *j* (*PY*), the relative price of PO over soybean oil (*RP*), importer-specific importer dummy variable (*D*), and interaction dummies for their incomes (*DY*). Taking the logarithms, the gravity model specification can be written as:

$$\begin{aligned} \ln M_{jit} = {} & \alpha_0 + \alpha_1 \ln Y_{it} + \alpha_2 \ln Y_{jt} + \alpha_3 \ln Dist_{ij} + \alpha_4 \ln PY_{it} + \alpha_4 \ln PY_{jt} + \alpha_5 RP_t \\ & + \alpha_6 D_{jt} + \alpha_7 D \ln Y_{jt} + \varepsilon_t \end{aligned} \tag{2}$$

Where, Y_{it} is the GDP of exporter countries and Y_{jt} is the GDP of importer countries. Both exporters' and importers' GDPs are used to represent supply and demand factors, respectively (Egger & Pfaffermayr, 2003). Therefore, we expect both α_1 and α_2 to have positive signs. The distance between exporter and importer countries is represented by $Dist_{ij}$. Distance is used as a proxy for transport cost to export goods from one country to another. The greater the distance between two countries, the higher the transport cost, which also means the trade flow between those two countries will be lesser. So, the expected sign of α_3 is negative.

We also add per capita income growth of both exporter and importer countries and the relative price of PO over its closest substitute, soybean oil. Where, PY_{it} is per capita GDP of exporter countries, and PY_{jt} is per capita GDP of importer countries. The positive and statistically significant coefficient of exporter per capita income (α_4) suggests that the good is capital intensive, otherwise it is labour-intensive. For importer countries, positive and statistically significant per capita GDP (α_5) suggests that the good is luxurious; otherwise it is a necessity (Bergstrand, 1989).

The first five variables are standard properties in the gravity model. To capture the substitution between PO and soybean oil, we have added relative price of PO over soybean oil $\left(RP_{(\frac{PO}{SBO})t}\right)$. We assume people will shift from palm oil to soybean oil when the price of palm oil increases, and vice versa. Therefore, we expect a negative sign of α_5.

We also introduce the importer-specific effect; therefore, we add dummy variables for India and China as the countries of interest (D_{jt}). Additionally, we also include the interaction dummies of their incomes, which equals the multiplication of importer dummy and the log of income ($D_{jt} \ln Y_{jt}$) . Since we only have two dummies (China and India), there will be only two interaction dummies ($D_{CHN} \ln Y_{CHNt}$) and ($D_{IND} \ln Y_{INDt}$), as they are the two most important importers of PO from Indonesia and Malaysia, which imported around 33 percent of global PO in 2010.

Data

Throughout this paper, we will use Standard International Trade Classification (SITC) revision-3. Under this classification, PO is coded as 4222, while its disaggregated products, crude PO (CPO) and refined PO (RPO) are under 42221 and 42229 classifications, respectively. Palm kernel oil (PKO/4224), another product derived from oil palm fruit, is beyond the scope of this paper, since it is sold in different markets and used in different industries.

The model is estimated using annual import data reported by almost all countries (some are excluded because of the lack of data) importing PO that originated in Indonesia and Malaysia. The model only covers imports from Indonesia and Malaysia because they represent around 90 percent of global PO trade. The analysis will be carried out using SITC classification: 4222 for PO, 42221 for CPO, and 42229 for RPO. The imported country lists are in Appendix A1.

Table 2. Summary of Variables and Data Sources

m_{jit}	:	import of country j from country j measured in US$ (2000) constant price, data for export and import are obtained from UN-COMTRADE (http://wits.worldbank.org/wits/) and deflated by US import price indices obtained from US Bureau of Labour Statistics database (http://www.bls.gov/data/#prices).
y_{it}	:	constant GDP of country i, data obtained from World Development Indicator (WDI), The World Bank (http://data.worldbank.org/data-catalog/world-development-indicators)
y_{jt}	:	constant GDP of country j, data obtained from WDI
py_{it}	:	constant GDP per capita of country i, data obtained from WDI
py_{jt}	:	constant GDP per capita of country j, data obtained from WDI
$dist_{ij}$	:	distance between i dan j, obtained from Mayer and Zignago (2011) available at French Institute for Research on International Economy (CEPII) database, (http://www.cepii.fr/anglaisgraph/bdd/distances.htm)
$rp_{(PO/SBO)t}$	:	relative price of palm oil over soybean oil to capture the substitution effect between palm oil and soybean oil, data obtained from the World Bank commodity markets (pink sheet) (http://econ.worldbank.org/).
d_{IND}	:	dummy for India, 1=India, otherwise=0
d_{CHN}	:	dummy for China, 1=China, otherwise=0
$d_{IND}y_{jt}$	:	Interaction dummy for India, $d_{IND}y_{jt} = d_{IND} * y_{jt}$
$d_{CHN}y_{jt}$	:	Interaction dummy for China, $d_{CHN}y_{jt} = d_{CHN} * y_{jt}$
i	:	exporter countries (Indonesia and Malaysia)
j	:	importer countries (all countries[#])

Note: [#] some countries are omitted because of data limitations.

We focus on the period between 1999 and 2011. We have chosen the starting year of 1999 because in 1998 the Indonesian government banned PO exports for several months as a result of the depreciation of the Rupiah following the Asian financial crisis in 1997. We use PO import data of country j from both Indonesia and Malaysia obtained from the United Nations Commodity Trade Statistics Database (UN-COMTRADE). Since the import data is in current value, we deflate it by the US import indices taken from the US Bureau of Labour

Statistics. The GDP and per capita GDP are in constant 2000 US dollars obtained from WDI, available from the World Bank website. Other variables and data sources are summarised in Table 2.

Results and Discussions

We estimate the gravity model on PO trade using panel data of two exporter countries (Indonesia and Malaysia) and 157 importer countries, over the period of 1999–2011. We include time fixed effects in model 2, model 3 and model 4 as in Egger and Pfaffermayr (2003) and Matyas (1997). Importer effect comes as importer-specific effects for India and China. However, since there are only two exporter countries included in this analysis, we exclude exporter fixed effects. The analysis will be carried out using ordinary least squares (OLS) and Poisson pseudo-maximum-likelihood (PPML). The first is a standard method used in the majority of gravity models in the relevant literature, and the latter is an alternative proposed by Silva and Tenreyro (2006). They argue that PPML estimation can be used to deal with zero trade problems and is found to be consistent even in the presence of heteroskedasticity (Silva & Tenreyro, 2006).

Table 3. Gravity Equation Estimates: Palm Oil (SITC 4222)

Variable	OLS				PPML			
	Model				Model			
	1	2#	3#	4#	1	2#	3#	4#
LnGDP:								
• exporter (Y_{it})	1.42***	−0.42	−0.40	−0.41	1.97***	3.03	3.01	3.00
	(0.21)	(2.33)	(2.33)	(2.33)	(0.22)	(2.09)	(1.99)	(2.01)
• importer (Y_{jt})	1.14***	1.14***	1.12***	1.12***	0.93***	0.93***	0.78***	0.79***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.04)	(0.04)
LnGDP per capita:								
• exporter (PY_{it})	0.87***	0.19	0.20	0.20	0.79***	1.19	1.20	1.19
	(0.09)	(0.86)	(0.86)	(0.86)	(0.09)	(0.77)	(0.74)	(0.75)
• importer (PY_{jt})	−0.80***	−0.80***	−0.78***	−0.78***	−0.67***	−0.67***	−0.49***	−0.49***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)	(0.06)
Ln distance ($Dist_{ij}$)	−0.77***	−0.78***	−0.76***	−0.76***	−0.62***	−0.62***	−0.61***	−0.61***
	(0.10)	(0.10)	(0.10)	(0.10)	(0.07)	(0.07)	(0.07)	(0.07)
Ln relative price	−0.89	0	0	0	−0.83	1.63	1.60	1.67
($RP_{(PO/SBO)t}$)	(0.09)				(0.68)	(7.55)	(7.22)	(7.21)
Dummy:								
• India (D_{IND})	–	–	0.75***	11.38	–	–	0.78***	3.99
			(0.27)	(9.27)			(0.25)	(7.99)
• China (D_{CHN})	–	–	0.48***	−9.13***	–	–	0.62***	−3.58
			(0.19)	(2.36)			(0.18)	(3.28)
Interaction dummy:								
• $D_{IND}*ln\ Y_{IND}$	–	–	–	−0.79	–	–	–	−0.24
				(0.70)				(0.60)
• $D_{CHN}*lnY_{CHN}$	–	–	–	0.66***	–	–	–	20.29
				(0.16)				(0.23)
constant	−14.72***	11.68	11.36	11.38	−19.38***	−35.17	−34.95	−34.71
	(3.23)	(33.83)	(33.83)	(33.85)	(3.12)	(31.05)	(29.59)	(29.88)
N	2537	2537	2537	2537	3668	3668	3668	3668
R^2	0.42	0.43	0.43	0.43	0.64	0.65	0.67	0.66
F-statistic	317.21	114.00	411.93	682.89				
RMSE	2.30	2.30	2.29	2.30				
Log pseudo-likelihood					−8.91e+07	−8.79e+07	−8.58e+07	−8.56e+07

Note: dependent variables are import values in natural logarithms (ln) for OLS and in levels for PPML. Figures in parentheses are robust standard errors.
#includes time fixed effect.Individual time fixed effect is not reported.
*** indicates that a coefficient is significant at the 1% level and **significant at the 5% level.

Table 3 presents the OLS panel and the alternative results from PPML for PO. Overall, the results of OLS and PPML are consistent with the general results in the gravity literature. That is, on average all the significant income coefficients are close to unity. The distance coefficients are between −0.78 and −0.61. In both tables, the first column (model 1) shows the model without time fixed effects; while all other three columns (models 2, 3 and 4) show the results with time fixed effects. The R^2 ranges between 0.42 and 0.43 for OLS and higher for PPML between 0.64 and 0.67. This means that PPML generally performs better than OLS. Also in line with Silva and Tenreyro (2006), we found that the coefficient of most variables were lower in PPML compared with OLS.

The main result is that importers' GDP and GDP per capita variables are estimated to be strongly significant ($p<0.01$), and this is consistent across models. The importer's GDP coefficients for PO reported in Table 3 all have positive signs and are all close to unity. For PPML, importers' GDP coefficients are slightly smaller than OLS results, ranging from 0.78 to 0.93.

The elasticity reported for GDP per capita of importer countries was found to be negative and significant for PO both from OLS and PPML results. These results are also in line with Sarker and Jayasinghe (2007) who found that importer's GDP per capita was negatively correlated for oilseeds and vegetables in the European market. Our results suggest that PO imports will decrease by between 0.78 percent and 0.8 percent with every 1 percent per capita income increase when using OLS, and 0.49 percent and 0.67 percent when using PPML.

Our findings also prove that the bilateral distances between trading partners are negatively correlated in PO trade. The elasticities of distances are around −0.8 for OLS and around −0.6 for PPML. As mentioned earlier, PO imports used in this analysis come from Indonesia and Malaysia only, where almost 90 percent of global PO originates. For both countries, China and India constitute the most important importers of PO. In fact, in 2011, both China and India absorbed around 40 percent of total PO from Indonesia and Malaysia. The growth of both countries could be an important determinant of PO demand.

Table 4. Gravity Equation Estimates: Crude Palm Oil (SITC 42221)

Variable	OLS				PPML			
	Model				Model			
	1	2#	3#	4#	1	2#	3#	4#
LnGDP:								
• exporter (Y_{it})	1.82***	3.13	3.12	2.94	2.92***	5.10	5.09*	5.08*
	(0.36)	(3.93)	(3.90)	(3.91)	(0.44)	(3.75)	(2.82)	(2.81)
• importer (Y_{jt})	0.88***	0.88***	0.88***	0.88***	0.82***	0.82***	0.67***	0.67***
	(0.06)	(0.06)	(0.07)	(0.07)	(0.05)	(0.05)	(0.04)	(0.05)
LnGDP per capita:								
• exporter (PY_{it})	−0.09	0.39	0.39	0.32	0.47***	1.30	1.32	1.31
	(0.15)	(1.45)	(1.44)	(1.44)	(0.15)	(1.39)	(1.07)	(1.06)
• importer (PY_{jt})	−0.74***	−0.74***	−0.72***	−0.72***	−0.68***	−0.68***	−0.40***	−0.40***
	(0.07)	(0.07)	(0.08)	(0.08)	(0.09)	(0.09)	(0.08)	(0.08)
Ln distance ($Dist_{ij}$)	−0.56***	−0.56***	−0.55***	−0.55***	−0.79***	−0.79***	−0.78***	−0.78***
	(0.15)	(0.15)	(0.16)	(0.16)	(0.12)	(0.12)	(0.11)	(0.11)
Ln relative price	0.26	0	0	0	−1.44	6.46	6.52	6.89
($RP_{(PO/SBO)t}$)	(0.97)				(1.19)	(14.75)	(9.38)	(9.25)
Dummy:								
• India (D_{IND})		–	1.80**	−21.41**	–	–	1.68***	−4.62
			(0.39)	(9.95)			(0.25)	(6.09)
• China (D_{CHN})		–	−1.61***	−45.19***	–	–	−1.09***	−9.15
			(0.52)	(12.55)			(0.30)	(9.34)
Interaction dummy:								
• D_{IND}*$ln\ Y_{IND}$		–	–	1.73**		–	–	0.46
				(0.735)				(0.45)
• D_{CHN}*lnY_{CHN}		–	–	3.01***		–	–	0.55
				(0.86)				(0.64)
Constant	−12.53**	−31.53	−31.52	−28.78	−26.59***	−58.83	−59.54	−59.34
	(5.38)	(56.77)	(56.43)	(56.49)	(6.16)	(55.85)	(42.09)	(41.88)
N	1398	1398	1398	1398	3668	3668	3668	3668
R^2	0.24	0.24	0.25	0.25	0.33	0.34	0.74	0.74
F-statistic	58.35	21.51	59.23	130.93		–		
RMSE	2.82	2.83	2.81	2.81				
Log pseudo-likelihood					−6.88e+07	6.81e+07	−5.74e+07	−5.73e+07

Note: dependent variables are import values in natural logarithms (ln) for OLS and in levels for PPML.
Figures in parentheses are robust standard errors.
#includes time fixed effect.Individual time fixed effect is not reported.
*** indicates that a coefficient is significant at the 1% level and **significant at the 5% level.

To capture the importance of China and India, we included country specific effects for China and India as dummy variables in model 3 and model 4. In model 3, we found that both dummies for India and China are significant. The coefficients of Indian dummies for PO are 0.75 for OLS and 0.78 for PPML; for China, the dummy coefficients are 0.48 for OLS and 0.62 for PPML. Overall, India has a bigger impact on PO trade than China. The OLS results suggest that India imports 2.12 (exp(0.75)) times more PO than non-India and non-China countries, and China imports 1.57 (exp(0.48)) times more PO than non-China and non-India countries.

We also repeat similar methodologies for disaggregated PO, namely CPO and RPO. The results can be observed in Table 4 and Table 5. In general, the coefficients and signs are expected to be not very different from PO. Since CPO is less expensive and bulkier than RPO, we expect that the distance coefficients will be higher in CPO than in RPO, importer's GDP will be higher in RPO, and importer's GDP per capita will be less negative in RPO. Based on the results, we can say that overall those hypotheses held. Distance coefficients were found to be more than 0.2 points higher in CPO than in RPO in PPML analysis, although they do not vary much in OLS. Importers' GDP elasticities are mostly found to be more than 1 in RPO and consistently less than 1 for CPO. Importers' GDP per capita elasticities were found to be consistently less negative for RPO in OLS results.

Table 5. Gravity Equation Estimates: Refined Palm Oil (SITC 42229)

Variable	OLS				PPML			
	Model				Model			
	1	2#	3#	4#	1	2#	3#	4#
Ln GDP:								
• exporter (Y_{it})	1.25***	−1.03	−1.00	−0.98	1.44***	0.61	0.59	0.56
	(0.22)	(2.39)	(2.38)	(2.38)	(0.23)	(2.18)	(1.55)	(1.51)
• importer (Y_{jt})	1.04***	1.04***	1.00***	1.00***	1.00***	1.00***	0.86***	0.86***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
LnGDP per capita:								
• exporter (PY_{it})	0.97***	0.12	0.13	0.14	0.98***	0.67	0.67	0.66
	(0.10)	(0.89)	(0.89)	(0.89)	(0.11)	(0.81)	(0.59)	(0.57)
• importer (PY_{jt})	−0.65***	−0.66***	−0.61***	−0.61***	−0.67***	−0.67***	−0.55***	−0.56***
	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)	(0.07)	(0.07)
Ln distance ($Dist_{ij}$)	−0.56***	−0.56***	−0.53***	−0.53***	−0.53***	−0.53***	−0.51***	−0.50***
	(0.10)	(0.10)	(0.10)	(0.10)	(0.07)	(0.07)	(0.07)	(0.07)
Ln relative price ($RP_{(PO/SBO)t}$)	−0.96	0	0	0	−0.61	−3.50	−3.59	−3.42
	(0.60)				(0.82)	(8.46)	(5.78)	(5.62)
Dummy:								
• India (D_{IND})		–	0.67**	29.42***		–	−0.16	29.16***
			(0.33)	(10.90)			(0.31)	(8.95)
• China (D_{CHN})		–	1.63***	−7.16***		–	0.86***	−4.95*
			(0.19)	(2.38)			(0.20)	(2.607)
Interaction dummy:								
• $D_{IND}*Y_j$		–	–	−2.14***		–	–	−2.18***
				(0.82)				(0.67)
• $D_{CHN}*Y_j$		–	–	0.61***		–	–	0.39**
				(0.16)				(0.18)
constant	−16.06***	16.78	16.19	15.95	−16.57***	−4.40	−3.73	−3.29
	(3.41)	(34.74)	(34.67)	(34.71)	(3.53)	(32.48)	(23.24)	(22.57)
N	2386	2386	2386	2386	3668	3668	3668	3668
R^2	0.38	0.39	0.39	0.39	0.65	0.67	0.82	0.84
RMSE	273.36	98.41	476.56	704.04				
Log pseudo-likelihood					−5.63e+07	−5.50e+07	−5.09e+07	−4.96e+07

Note: dependent variables are import values in natural logarithms (ln) for OLS and in levels for PPML.
Figures in parentheses are robust standard errors.
#includes time fixed effect. Individual time fixed effect is not reported.
*** indicates that a coefficient is significant at the 1% level and **significant at the 5% level.

Additionally, we also include models with country fixed effects both for exporters and importers and some additional dummy variables such as land border and common language, as shown in Table 6. The results are also consistent with general results in gravity model. However, we find that the coefficients of both importer's GDP and GDP per capita are consistently higher than model without country fixed effects. The elasticities of distances are also found to be a lot higher in models with country fixed effects. These results applied across all types of palm oil.

In all models across all disaggregated PO products, we found that importers' GDP was consistently significant. Therefore, we conclude that the growth of GDP has been a significant factor in explaining Indonesia's PO expansion.

Table 6. Gravity Equation Estimates: OLS Results with Country Fixed Effects and Additional Dummies

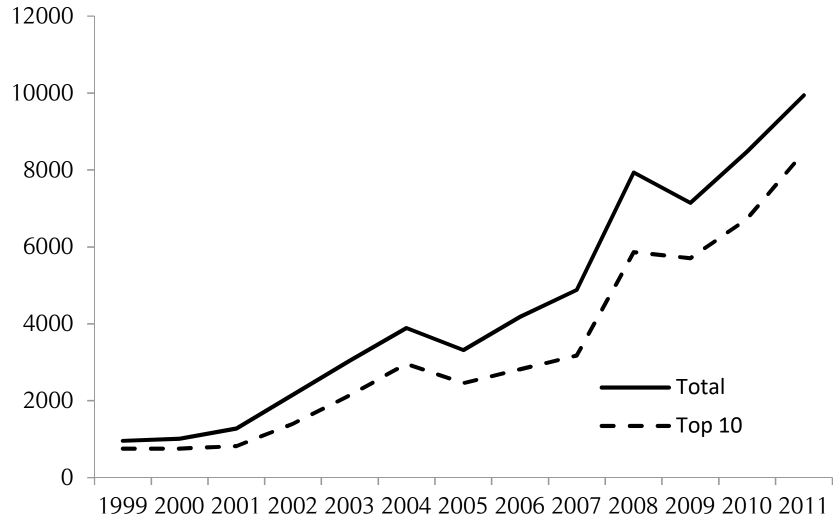
Variable	PO		CPO		RPO	
Ln GDP:						
• exporter (Y_i)	0.71**	-1.76	1.00*	-3.57	1.10***	0.64
	(0.05)	(0.22)	(0.08)	(0.14)	(0.00)	(0.7)
• importer (Y_j)	2.64***	4.43***	1.81***	1.53	2.13***	3.64***
	(0.00)	(0.00)	(0.00)	(0.27)	(0.00)	(0.00)
LnGDP per capita:						
• exporter (PY_i)		3.12		6.40*		0.23
		(0.13)		(0.06)		(0.92)
• importer (PY_j)		-2.03***		0.46		-1.75**
		(0.00)		(0.77)		(0.01)
Ln(dist)	-1.57**	-1.59**	-2.01	-1.96	-2.11***	-2.11***
	(0.04)	(0.04)	(0.14)	(0.15)	(0.01)	(0.01)
Ln relative price	-1.11**	-1.28***	-	-1.89**	-	-0.93*
($RP_{PO/SBO}$)	(0.02)	(0.01)		(0.15)		(0.08)
Dummy:						
• border	1.74**	1.77**	-0.61	-0.41	2.06***	2.07***
	(0.02)	(0.0.02)	(0.76)	(0.84)	(0.00)	(0.00)
• common language	0.83**	0.82**	1.07	1.00	0.52	0.53
	(0.04)	(0.04)	(0.16)	(0.18)	(0.15)	(0.14)
Constant	-59.81***	-57.11***	-37.97***	18.47	-46.51***	-60.51***
	(0.00)	(0.01)	(0.01)	(0.63)	(0.00)	(0.01)
Exporter fixed effect	yes	yes	yes	yes	yes	Yes
Importer fixed effect	yes	yes	yes	yes	yes	yes
n	2537	2537	1398	1398	2386	2386
R^2	0.73	0.73	0.69	0.70	0.69	0.69

Note: dependent variables are import values in natural logarithms (ln).
Figures in parentheses are probabilities.
*** indicates that a coefficient is significant at the 1% level, **significant at the 5% level and *significant at 10% level.

Mostly backed by descriptive data, many papers mention the importance of India and China in determining global PO demand, such as Corley (2009) and Koh and Wilcove (2007). This comes from the fact that China and India alone are responsible for 40 percent of PO imports originating in Indonesia and Malaysia. Given the preceding results, a relevant question is whether the growth of Indonesia's trading partners can explain the growth in PO export demand. In particular, there has been rapid growth in China and India, which are the two of Indonesia's largest trading partners. To what extent does the growth of income of Indonesia's trading partners explain the boom in Indonesia's PO export demand? The estimated model 4 from PPML analysis for PO (Table 3) is used for simulating PO imports from Indonesia for the period 2000–201. We only include the significant coefficients for the simulations. The importer's GDP coefficient in this model is 0.79, meaning that a 1 percent increase in importer's GDP may lead to 0.79 percent of PO import from Indonesia.

For simplicity, we selected Indonesia's top 10 PO importers only. The selection is based on import data from 2011. Total imports from these countries accounted for 73 percent of total PO exports from Indonesia. India had the largest share, with nearly 40 percent, followed by China, with almost 20 percent. The total Indonesian PO imported by the top 10 countries can be plotted in Figure 5. We use the estimated coefficients for importer GDP (GDP_j) and importer's GDP per capita ($PGDP_j$) to estimate the share of PO trade for each top 10 country.

The simulated shares of PO imports from Indonesia to the top 10 countries based on importer GDP (GDP_j) and importer's per capita GDP ($PGDP_j$) for the period 2000–2011 are reported in Figures 6 (all top 10), Figure 7 (China), and Figure 8 (India). More complete simulation results are reported in Appendix A2.



Source: UN-COMTRADE (WITS, 2015).

Figure 5. Indonesia's Palm Oil Exports, 1999–2011 (Million US$)

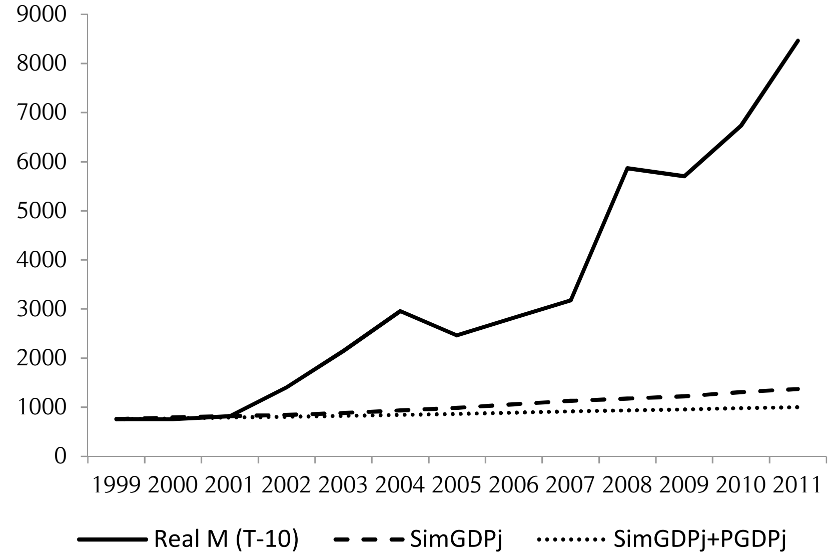


Figure 6. Palm Oil Real Import and Import Simulation for the Top 10 Countries (Million US$)

Overall, we find that GDP_j and the combination of GDP_j and $PGDP_j$ explain very little of the rapid growth in PO export demand from Indonesia. For instance, over the sample period, China's GDP grew by 131 percent, while the growth of China's PO imports from Indonesia was more than 800 percent. For India, the growth of GDP was 95 percent, while the actual growth of PO imports from Indonesia was more than 1000 percent.

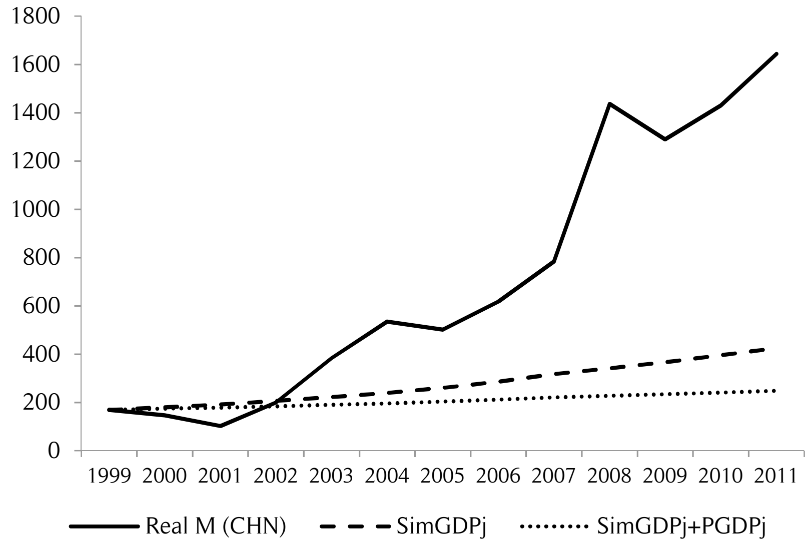


Figure 7. Palm Oil Real Import and Import Simulation for China (Million US$).

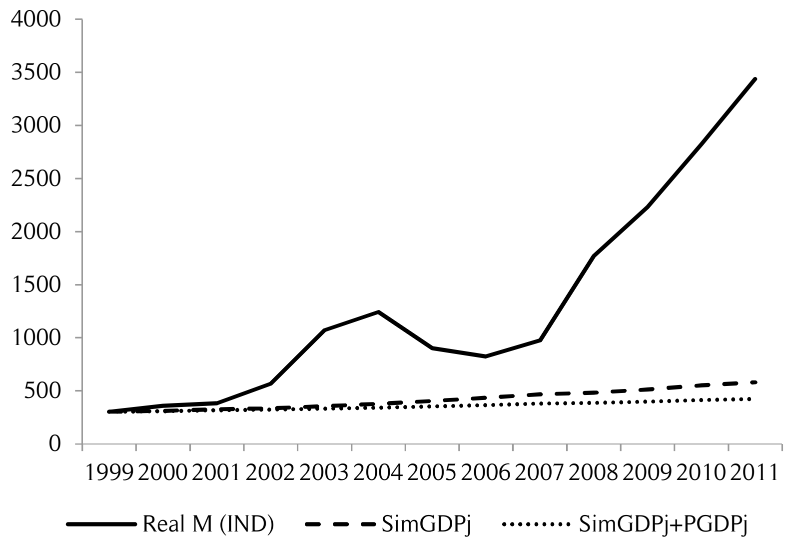


Figure 8. Palm Oil Real Import and Import Simulation for India (Million US$).

Figure 6 shows that, consistent with results for China and India, the actual PO imports from Indonesia to all countries are far more than the simulated PO imports explained by importer's GDP and importer per capita GDP. For example, the actual PO import to the top 10 countries was US$8.5 billion compared with only US$1.8 billion as projected by the growth in GDP (see Appendix A2).

These results suggest that income growth alone cannot be used to explain the boom in PO export demand. There are possibly other variables that explain the vast increase in global PO demand, including changing preferences, diversification in end uses and import tariff reduction, but those variables are not included in this research.

Conclusion

Global vegetable oil demand has increased very rapidly in the last decade, with PO now being the most produced vegetable oil, displacing soybean oil in 2007. Indonesia and Malaysia are the largest producers and exporters of PO, capturing a combined market share of around 90% in 2014.

In this paper, we employ gravity equations to observe the trade in palm oil market with only Indonesia and Malaysia as exporters and all other countries as their importers. The gravity model is widely used to investigate the role of distance and economic growth in international trade flows.

The results suggest that PO trade follows the general results in gravity literature. We find that importer GDP and importer per capita GDP variables are consistently significant in all models in both OLS and PPML used in this study. Our findings also prove that the bilateral distances between trading partners are negatively correlated in PO trades. However, we are unable to confirm the importance of relative price between palm oil and soybean oil in determining palm oil trade flows.

Given the large growth in China and India's GDP and their proximity to Indonesia and Malaysia, we also examine the impact of China and India in the model. We find that both dummies for China and India are positively correlated.

Furthermore, we do a simulation using the samples of top ten imported countries of Indonesia's palm oil. We, particularly, observe how the economic growth of importer countries affect the flow of palm oil trade. The simulation result for top ten Indonesia's trading partners suggest that the simulated palm oil trades explained by importer GDPs account for only 15 percent in average when compared to the actual trade flows. This result is also applied for China and India which both GDPs explain only 25 percent and 17 percent of their actual palm oil imports. There are possibly other variables that explain the vast increase in global PO demand, including changing preferences, diversification in end uses and import tariff reduction, but those variables are not included in this research.

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APPENDICES

Appendix A1. List of Indonesia and Malaysia Trading Partners on Palm Oil Trades

Albania	Georgia	Nicaragua
United Arab Emirates	Ghana	Netherlands
Argentina	Guinea	Norway
Armenia	Gambia*	Nepal
Antigua and Barbuda**	Greece	New Zealand
Australia	Guatemala	Oman
Austria	Guyana**	Pakistan
Azerbaijan	Hong Kong, China	Panama
Burundi	Honduras**	Peru
Belgium	Croatia	Philippines
Benin	Hungary	Papua New Guinea
Burkina Faso	Indonesia**	Poland
Bangladesh	India	Portugal
Bulgaria	Ireland	Qatar**
Bahrain**	Iran, Islamic Rep.	Romania
Bosnia and Herzegovina	Iraq**	Russian Federation
Belarus	Israel	Rwanda
Brazil	Italy	Saudi Arabia
Barbados**	Jamaica	Sudan
Brunei	Jordan	Senegal
Bhutan	Japan	Serbia
Botswana**	Kazakhstan	Singapore
Central African Republic	Kenya	Solomon Island
Canada	Kyrgyz Republic	El Salvador
Switzerland	Cambodia	Suriname
Chile	Kiribati**	Slovak Republic
China	Korea, Rep.	Slovenia
Cote d'Ivoire	Kuwait	Sweden
Cameroon	Lebanon	Seychelles**
Congo, Rep.	Libya**	Syrian Arab Republic
Colombia	Saint Lucia**	Togo
Comoros	Sri Lanka	Thailand
Cape Verde**	Lithuania	East Timor*
Costa Rica**	Luxembourg**	Tonga*
Cyprus	Latvia	Trinidad and Tobago
Czech Republic	Macao	Tunisia
Germany	Morocco	Turkey
Djibouti	Moldova	Tanzania
Dominica**	Madagascar	Uganda
Denmark	Maldives**	Ukraine
Dominican Rep.**	Mexico	Uruguay
Algeria	Macedonia, FYR	United States
Ecuador	Mali	St. Vincent and the Grenadines*
Egypt, Arab Rep.	Malta**	Venezuela
Eritrea**	Mongolia	Vietnam
Spain	Mozambique	Vanuatu
Estonia	Mauritania	Samoa
Ethiopia (excludes Eritrea)	Mauritius	Yemen
Finland	Malawi	South Africa
Fiji	Malaysia*	Zambia
France	Namibia	Zimbabwe
Gabon	Niger	
United Kingdom	Nigeria	

Note: *trade with Indonesia only. **trade with Malaysia only.

Appendix A2. Simulation Results (Million US$)

	CHN	DEU	EGY	IND	ITA	MYS	NLD	PAK	RUS	TZA	Total
Real data											
2000	146.84	74.02	11.06	357.88	7.22	9.54	102.91	4.29	10.52	30.62	754.90
2001	102.39	84.75	10.16	381.86	13.77	19.13	110.61	26.59	25.33	42.66	817.25
2002	199.89	116.53	6.81	568.32	11.59	115.45	182.45	108.45	43.53	52.31	1405.33
2003	384.11	111.96	1.73	1069.20	25.84	143.77	189.75	101.76	51.30	66.05	2145.47
2004	535.29	156.63	44.21	1242.50	60.39	336.91	233.15	226.43	54.84	68.94	2959.29
2005	501.43	148.67	33.44	902.56	66.38	134.52	219.46	288.59	98.36	68.94	2462.34
2006	618.73	155.47	178.68	824.34	77.63	224.22	226.98	309.43	96.81	106.87	2819.15
2007	783.16	237.96	74.23	974.75	85.75	196.28	304.36	345.78	90.07	79.31	3171.66
2008	1437.37	406.57	388.47	1770.77	314.63	463.21	571.92	383.81	94.56	33.92	5865.25
2009	1290.31	293.04	211.83	2229.89	395.05	545.85	490.15	112.89	81.16	56.17	5706.34
2010	1430.67	373.11	161.18	2823.77	421.00	780.54	434.60	31.01	210.33	65.35	6731.57
2011	1643.66	262.79	323.69	3436.91	394.70	1237.86	518.50	152.96	333.96	159.72	8464.75
Simulation: GDPj											
2000	185.17	57.54	7.31	316.50	22.43	74.05	123.86	4.86	8.58	2.72	803.02
2001	202.47	58.52	7.60	334.07	22.90	74.48	126.53	4.97	9.07	2.91	843.52
2002	223.22	58.52	7.80	348.73	23.02	78.99	126.64	5.15	9.55	3.14	884.76
2003	248.36	58.28	8.08	379.90	23.00	84.13	127.12	5.43	10.34	3.38	948.02
2004	276.62	59.04	8.45	413.45	23.45	90.55	130.30	5.88	11.17	3.68	1022.60
2005	311.86	59.49	8.88	456.68	23.70	95.97	133.29	6.39	11.97	3.99	1112.22
2006	356.55	61.96	9.56	504.32	24.28	102.28	138.37	6.83	13.07	4.29	1221.51
2007	413.72	64.23	10.32	560.00	24.74	109.73	144.46	7.27	14.33	4.63	1353.43
2008	458.45	65.01	11.16	584.46	24.42	115.66	147.38	7.40	15.17	5.02	1434.12
2009	505.94	61.29	11.74	638.65	22.92	113.54	141.56	7.70	13.85	5.36	1522.55
2010	565.23	63.83	12.42	707.35	23.38	122.73	144.24	8.05	14.52	5.79	1667.54
2011	624.42	65.97	12.67	761.88	23.50	129.81	146.14	8.27	15.22	6.20	1794.08
Simulation: GDPj+PGDPj											
2000	195.67	58.85	7.51	322.00	23.06	77.67	126.94	4.93	9.24	2.77	828.64
2001	226.00	60.47	7.91	348.42	23.87	77.03	130.85	5.04	10.18	3.04	892.81
2002	264.72	60.40	8.15	370.09	24.02	83.62	130.39	5.27	11.15	3.39	961.21
2003	314.96	59.95	8.53	422.74	23.85	91.47	130.74	5.69	12.80	3.77	1074.49
2004	375.43	61.29	9.07	482.19	24.45	101.94	135.98	6.42	14.66	4.27	1215.70
2005	456.65	62.11	9.72	564.13	24.74	110.80	141.06	7.29	16.54	4.78	1397.83
2006	568.63	66.61	10.86	659.90	25.67	121.67	150.11	8.05	19.27	5.30	1636.08
2007	725.89	70.88	12.20	779.31	26.35	135.25	161.21	8.82	22.56	5.91	1948.39
2008	858.38	72.46	13.72	828.64	25.62	145.97	166.28	8.96	24.89	6.62	2151.54
2009	1008.19	65.69	14.76	952.63	22.90	139.70	154.66	9.45	21.32	7.23	2396.54
2010	1208.67	70.46	16.02	1120.74	23.61	157.43	159.03	10.07	23.09	8.04	2797.16
2011	1422.35	74.56	16.35	1257.73	23.71	171.00	161.98	10.38	25.01	8.83	3171.89