'Do Changes in Exchange Rate Impact Car Export Volume?'

Kevin Schaminée
436325

Supervisor: Felix Ward

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Abstract

This paper examines the influence of exchange rate changes on car export volume. Additionally, it researches the mechanism of the import effect where exchange rates cause price changes in imported intermediate goods used in car production lines. This study uses a first difference regression approach. This research finds that increased exchange rates do decrease car export volume. However, this is only the case for developed countries. Increased exchange rate risk causes car export volumes to decline for all countries. Lastly, there appears to be an import effect for developed countries. However, this effect is not driven by changes in exchange rates but by another factor.

1. Introduction

There are 195 countries in the world today. Many of those countries have their own currency, and some even have multiple currencies within one country. As of 2020, the United Nations have recognized 180 different currencies around the world. Globalization and its impact on international trade have led to countries, companies and customers also using other countries' currencies. The Bretton Woods Agreement in 1944 implemented a gold standard (Mikesell, R. F., 1994). This agreement resulted in a fixed exchange rate between foreign currencies and the dollar. However, with the collapse of this agreement in 1973 the major currencies in the world engaged in a system were exchange rates floated freely (Garber, P. M., 1993). Exporting multinationals were now facing exchange rate risk. This could lead to unexpected costs, especially for firms active in the foreign market as their end product could turn out to be too expensive for the foreign market, when facing an appreciation in their home currency. Yet a higher valued currency leaves companies that use a lot of imported goods room to produce their end product cheaper. A devaluation leads to opposite results. When imports become more expensive, exporting firms will be able to be more competitive on the foreign market.

Overall, there are pros and cons about having an overvalued or an undervalued currency . This raises the question whether it is more beneficial to have an overvalued or an undervalued currency. A famous example of this is the Chinese Yuan. The United States have accused China of interfering in the value of the Yuan for over a decade now (Wei, L.,2015). China floating down their own Yuan gives Chinese exporting firms a competitive advantage in the foreign market. While the rest of the world tries to tackle these problems with import tariffs, it is not promoting free trade. Ultimately, this leads to a lower overall welfare for the world.

The car market is one of the most globalized and competitive markets in the world. Many major car companies operate worldwide. This ranges from buying components in one country to selling their end product in another country (Humphrey, J., 2000). Because of their wide variety of products and many destination countries car companies face a relatively large degree of exchange rate risk. Therefore, a study researching whether car companies are affected by floating exchange rates could be interesting. The home bias effect might influence the results for the domestic market (Wolf, H. C., 2000). Some consumers tend to prefer domestic products over foreign products and

could therefore show a lower price elasticity. Therefore, focusing on the car export industry could give more striking results. Consequently, the main question will be:

'Do changes in exchange rate impact car export volume?'

Alongside the impact of exchange rate fluctuations on car export volume other variables potentially influencing car export volume will be examined. Among those are GDP, export price of cars and import effect. This research analyzes data from the period 2000 to 2018. In total 19 countries are included. Together, these countries account for a sizeable portion of the car industry export. By using a first difference regression the impact of the variables on export prices of cars are examined. Finally, this study will look at differences in response to the variables between developing and developed countries.

This study finds that increased exchange rate risk reduces car export volume. However, this effect is only noticed with a one year lag. Additionally, an increased exchange rate relative to the U.S. dollar reduces the car export volume for developed countries. Developing countries do not see a reduction in their car export volume with a higher value of their currency. This paper finds that there is some sort of import effect for developed countries. However, this effect is not explained by changes in exchange rates. The real driver of this effect remains unclear. Finally, this study finds that an increase in export prices of cars results in a higher car export volume. The magnitude of this effect is larger for developing countries.

The paper proceeds as follows. Section 2 includes a review of previous literature and develops the hypotheses. Section 3 describes the methodology used and sample selection. Section 4 discusses the regression analyses performed. Section 5 contains the conclusion, limitations, and recommendations for future research.

2. Literature Review and Hypothesis Development

2.1 Exchange Rate Volatility Increases Export Volume

A lot of empirical research has been done regarding exchange rate volatility on exports. Much less research has yielded results of exchange rate changes within the automobile sector. Aseery and

Peel investigate whether exchange rate volatility has an impact on export at all. They find that real exchange rate level has a significant impact on exports, with a negative sign (Asseery, A., & Peel, D. A., 1991). A research on China, one of the biggest growing exporters for decades, shows that exchange rate appreciation reduces export growth. This holds for both non-processed and processed exports (Ahmed, S., 2009). This is an interesting finding, especially for processed exports as import can play an important role in these products. Nevertheless, this study shows that processed good exports are also affected by exchange rate changes. Another study that takes import content into account shows that exported goods with high import content are not adversely affected by exchange rate appreciation as lower import prices reduce the cost of export (Abeysinghe, T., & Yeok, T. L., 1998). This is an interesting result as the car industry is flooded with components coming from different markets with different currencies. Low developing countries show similar effects to developed countries, the negative relation between export and exchange rate holds both in the short and long run (Arize, A. C., Malindretos, J., & Kasibhatla, K. M., 2003).

2.2 Exchange Rate Volatility Decreases Export Volume

Much research shows a negative relationship between export volume and exchange rate volatility. However, there are several papers with opposing results. A paper from 2007 focusing on the export from Taiwan to the United States shows that only agricultural trade flows are affected by changes in exchange rate volatility, other sectors do not show any effect (Wang, K. L., & Barrett, C. B., 2007). The authors mention this might be due to the use of less restrictive modelling assumptions. In line with this paper, another research studies the effect of exchange rate volatility on export growth with similar results. Only 3 out of 33 regressions support that exchange rate volatility hinders export growth (Bailey, M. J., Tavlas, G. S., & Ulan, M., 1987). A third paper including firm structure showed that a firm with both a fixed capital stock and a risk-neutral behavior can capitalize from exchange rate uncertainties and increase exports (Caballero, R. J., & Corbo, V.,1989). However, the same authors produced another paper in the same year concluding that a 5 percent increase in the annual standard deviation of the real exchange rate reduces exports by 2 to 30 percent in the short run, with effects being even bigger in the long run (Caballero, R. J., & Corbo, V., 1989). A wide study researching the period from 1889 to 1999 shows that exchange rate volatility did not have an effect on British exports to the United States. Another finding is that there is no evidence that exchange rate regimes had any impact on exports (Aristotelous, K., 2001).

2.3 Research on Cars and Exchanges Rate

Research on the effect of exchange rate volatility on the car market also shows different results. First, a study from 1990 shows that exchange rate changes are not passed on to car prices (Kirman, A., & Schueller, N., 1990). A different paper states that changes in exchange rate and production costs do not affect export prices. They add, car exporters follow prices set by domestic producers (Ginsburgh, V., & Vanhamme, G., 1989). Another study that focused on the impact of exchange rate fluctuations and profit margins over the period 1971 to 2002 shows that there is a positive association between exchange rate changes and mark-up adjustments (Requena-Silvente, F., & Walker, J., 2007). Results from a paper focusing on price convergence in the European car market shows that exchange rate changes significantly contributed to price dispersion over time across countries (Gil-Pareja, S., & Sosvilla-Rivero, S, 2008). Consequently, this price dispersion can have an influence on export volume. A study focusing on the exporting rivalry between Korea and China shows that the won appreciation period has enhanced Korean firms' export competitiveness compared to Japanese firms. Meaning that in this case the import effect dominated the export effect. However, Japanese automobile firms did not lose export competitiveness due to a relative decline of domestic production costs (Sato, K., Shimizu, J., Shrestha, N., & Zhang, S., 2013).

2.4 Added Value to previous Literature

Previous papers on the impact of exchange rate volatility on the car market show mixed results. These papers seek answers to explain the difference in prices within the worldwide car market, which would have a direct impact on car export volume. They give mixed results, suggesting exchange rates do or do not provide an explanation for these differences in price. However, these papers merely suggest exchange rates as possible drivers for these price differences and none of these papers focus directly on the impact of exchange rate volatility on car market export volume. This paper fills that gap and studies whether exchange rate volatility does have an effect on car export volume. By using an export demand equation model, accounting for other parameters influencing car export, the exact impact of exchange rate volatility on car export volume will be measured.

2.5 Hypothesis Development

There are many events that influence trade flows. Some show only a minor impact, whereas others turn out to have a huge impact. To tackle this issue and answer our main question: '*Do changes in exchange rates impact car export volume?'* some hypotheses have to be constructed.

Before getting to our main hypothesis on the impact of exchange rate on car export volume, we first look at some other control variables. These control variables may contribute to changes in car export volume. The first control variable to consider is GDP of importing countries. When a country's GDP increases, it is known to become more actively involved in global trade (Freund, C., 2009). Additionally, buying a car is something you can't afford to do every day. Increasing a country's wealth might enable people to buy a car who weren't able to buy one previously. Considering this, I expect the following regarding GDP:

H1a: Export volume of cars will increase following an increase of an importing country's GDP.

Another control variable of why a country or company is able to export a product is its price. Simply said, no matter how good a product is, when it is too expensive no one will buy it. Vice versa, a mediocre product that is extremely cheap may still sell well. At first glance, it seems very convincing that an increase in the export price of cars will lead to a decline in sales numbers. However, when considering annual inflation, increased wages and other factors, jumping to this conclusion seems shortsighted. Possibly, one may consider a price increase as paying for an improved product. The question is, will the price increase be too large, causing customers to look for alternatives instead. Obviously, with the ever increasing number of cars worldwide I do not think this has been the case. Therefore, the export price of cars will probably not negatively impact the export volume of cars. Following this:

H1b: An increase in the export price of cars will lead to an increased export volume of cars

Previous studies have shown that there is some sort of import effect in global trade. The import effect implies that as a country's imports become cheaper, the exports become more expensive. Consequently, export products with a lot of imported components may show different results to

sales numbers when exchange rate changes come into play. Cars contain many different components from many different countries. Therefore, the existence of an import effect within the car industry is a definite possibility. Measuring the possible existence of the import effect within the car industry has never been done before. Therefore, it is difficult to predict results. For the import effect to have a positive effect on car volume sales it would require that the import numerator will outweigh the export denominator (Towbin, P., & Weber, S., 2013). I potentially think this could be the case, as car components are smaller product lines, which could adapt quicker to changes in exchange rates than the rigid car prices. Following:

H1c: Import effect will increase car export volume as decreased prices of car components will outweigh increased export costs

The impact of exchange rate changes and volatility is closely linked to the import effect and export prices of cars. The main difference, both the import effect and export prices of cars show price changes due to changes in the production line. Exchange rate changes only change the amount a customer is paying, or a company is receiving without changing anything to the product. Previously mentioned academic results show to have mixed feedback on the impact of exchange rate changes on the volume of car trades. Therefore, based on previous studies, it is difficult to predict the impact of exchange rate fluctuations in this study. In fact, even the sign of the co-efficient is up for debate as previous literature has shown a positive and negative co-efficient on trade volume. Nevertheless, I expect increased exchange rates and volatility to show a negative effect on car export volume:

H1d: Increased exchange rates and increased exchange volatility will decrease car export volume

Lastly, exchange rate volatility in developing countries is known to cause more rumblings in their economies than in developed countries (Esquivel, G., & Larraín B, F., 2002). Therefore, fluctuations and increased exchange rate volatility in developing countries might show greater impact to car export volume:

H1e: Developing countries' car industries will be more exposed to exchange rate fluctuations than developed countries.

3. Methodology and Data

3.1 Research Methodology

3.1.1 Model 1

The research method used will be similar to previous studies of exchange rate volatility on export volume. The model will be a standard export demand equation. The dependent variable will be the export volume of cars in U.S. dollars. The independent variables will consist of the importing country's income (GDP), the export price of cars, the exchange rate level in foreign currency relative to the U.S. dollar, a measure of exchange rate risk and a measure that captures the import effect. This is in line with previous studies such as Doğanlar, M., (2002), Awokuse, T. O., & Yuan, Y. (2006) and Chowdhury, A. R. (1993). When using a first difference regression in formula form this will be:

$$\Delta ln(X_{it}) = \beta_1 \Delta\, ln(Y_{it}) + \beta_2\, \Delta ln(P_{it}) + \beta_3\, \Delta ln(EX_{it}) + \beta_4\, \Delta ln(V_{it}) + \beta_5 \Delta\, ln(IMP_{it}) + \beta_6 \Delta\, ln(EX_{it}) * \Delta\, ln(IMP_{it}) + \varepsilon_{it} \quad (1)$$

Where X_{it} shows the export volume of car manufacturers, Y_{it} represents importing countries' income in U.S. dollars (β_1 is the income elasticity). This is included because a reduction of importing countries' income can affect car import volume despite there not being any fluctuations in the exchange rate. The importing countries' GDP is measured as follows. First, for each exporting country in the sample a baseline of export destinations is established for the year 2010[1]. Subsequently, this ratio is multiplied by the GDP of the importing country. For example, in 2010 France exported 16.5% of its cars to Germany, 7.7% to Belgium, 7.1% to Italy etc. These ratios are then multiplied by the corresponding importing countries' GDP.

Following, P_{it} represents the export price of cars where β_2 is the price elasticity of demand for cars. An increase in the export price for cars cannot only be clarified by exchange rate volatility, but also by other factors such as increased wages or marketing expenses. EX_{it} measures the exchange rate level in foreign currency relative to the U.S. dollar. Exchange rate movements change relative prices of goods. This can have an effect on export demand. β_3 is the exchange rate

[1] This data is retrieved from the EOC database.

elasticity. V_{it} measures exchange rate risk. There are no clear variables in the economic theory on exchange rate risk. The choice of measuring this has been done following Thursby and Thursby (1985). They follow an absolute percentage change in exchange rate levels. In formula form:

$$V_1 = \frac{|u_t - u_{t-1}|}{u_{t-1}} \tag{2}$$

Where u is the current exchange rate and t refers to time. The automobile industry has relatively long periods between purchase and delivery of goods. Therefore, it was decided to work with annual data on exchange rate levels.

Lastly, IMP_{it} measures the import effect. This parameter has not been included in previously mentioned studies. However, because the automobile industry gathers many components (e.g., raw materials or intermediate goods) from all around the world before the end product is exported, this measurement will capture the import effect it has on the end product's relative price. Ideally, IMP_{it} is based on goods that are imported and ultimately used for the end product of the car. However, there is no specific data available on this. Therefore, a proxy will be used to account for the import effect. In formula form this proxy will be:

$$IMP = \frac{IG_{it}}{GDP_{it}} \tag{3}$$

Where IG represents the value of intermediate goods imported. GDP represents the income of a country. A relatively high number of imports will lead to a high IMP, suggesting that a larger part of the car is built with components coming from abroad. Logically, a lower IMP might suggest that the country has a large amount of intermediate goods available within the country itself. Consequently, this will make it likely that the car components come from its own domestic industry.

3.1.2 Model 2

Model 1 pictures an ideal world, where fluctuations in input immediately change output prices. However, in the car world rigid prices could be a possible issue for the approach that has been

chosen (Carlton, D. W., 1986). Usually, car manufacturers set a fixed price for a model car and this price does not fluctuate from day to day due to the current exchange rate. However, steep changes in exchanges rates could change the behavior of car manufacturers within the market, influencing sales and exports. For example, reduced advertisements, limited production to certain areas, etc. could be the result of a steeply fluctuating exchange rate. The same can be said for other control variables in the model. For example, does an increase in GDP immediately increase the demand for cars? Alternatively, it could be that a customer needs time before he or she realizes there is extra money to spend. Likewise, similar lagged responses could occur for the import effect and the export prices of cars.

To account for this potential flaw a second model, very similar to the first one, captures these problems. By using an ARDL model for optimum lag selection the ideal lag composition of model 2 is established. This is a one period lag for GDP and exchange rate risk. As a result of capturing said lags, the model allows for delayed responses in the GDP and exchange rate risk variable. In other words, model 2 allows for a change in export volume of cars in year t to be explained by GDP and exchange rate risk fluctuations in year t-1. In formula form:

$$\Delta ln(X_{it}) = \beta_1 \Delta \ln(Y_{it-1}) + \beta_2 \Delta \ln(P_{it}) + \beta_3 \Delta \ln(EX_{it-1}) + \beta_4 \Delta \ln(V_{it-1}) + \beta_5 \Delta \ln(IMP_{it}) + \beta_6 \Delta ln(EX_{it}) * \Delta ln(IMP_{it}) \varepsilon_{it} \quad (4)$$

Empirically, a one period lag can be used with annual data as most car manufacturers produce new models every one to two years. With their total line up existing out of multiple models' annual data provides a good analysis.

3.2 Data

3.2.1 Data Collection

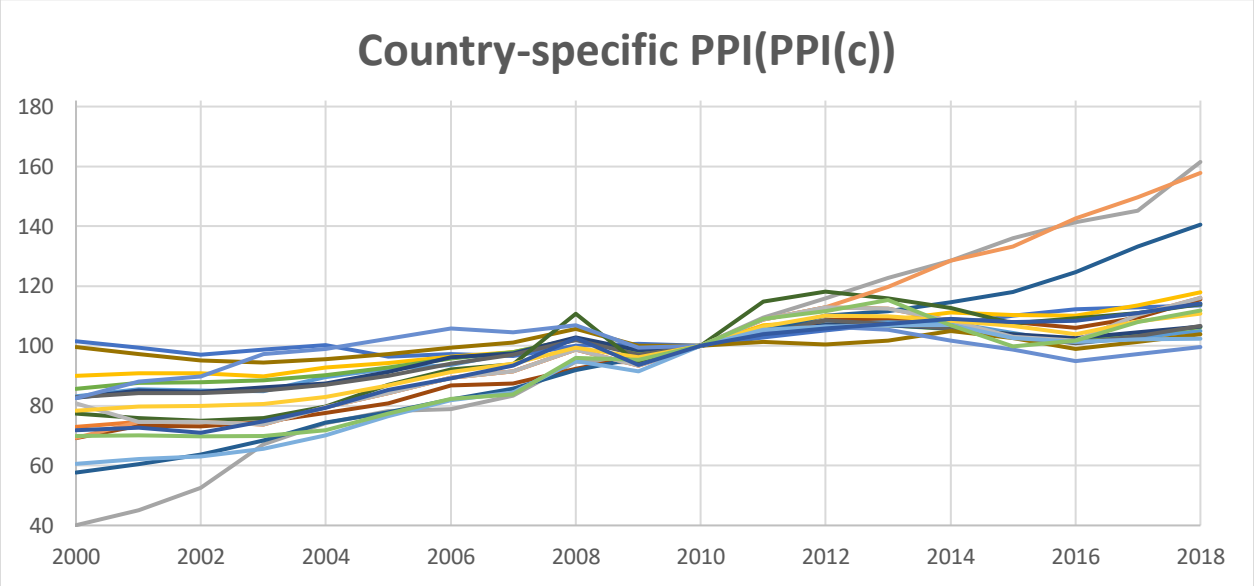
Several sources of data are used. First, data for export volume on cars is found in the EOC database. Second, for Y_{it} the GDP will be retrieved from the world bank database in U.S. dollars. Third, there is no data available that shows the exact export price of cars per country. Therefore a proxy is

established. Using both the Production Price Index (PPI) for the vehicle industry (vi) worldwide and the general PPI per country (c). In formula form[2]:

$$P_{it} = \sqrt{PPI(vi) * PPI(c)} \tag{5}$$

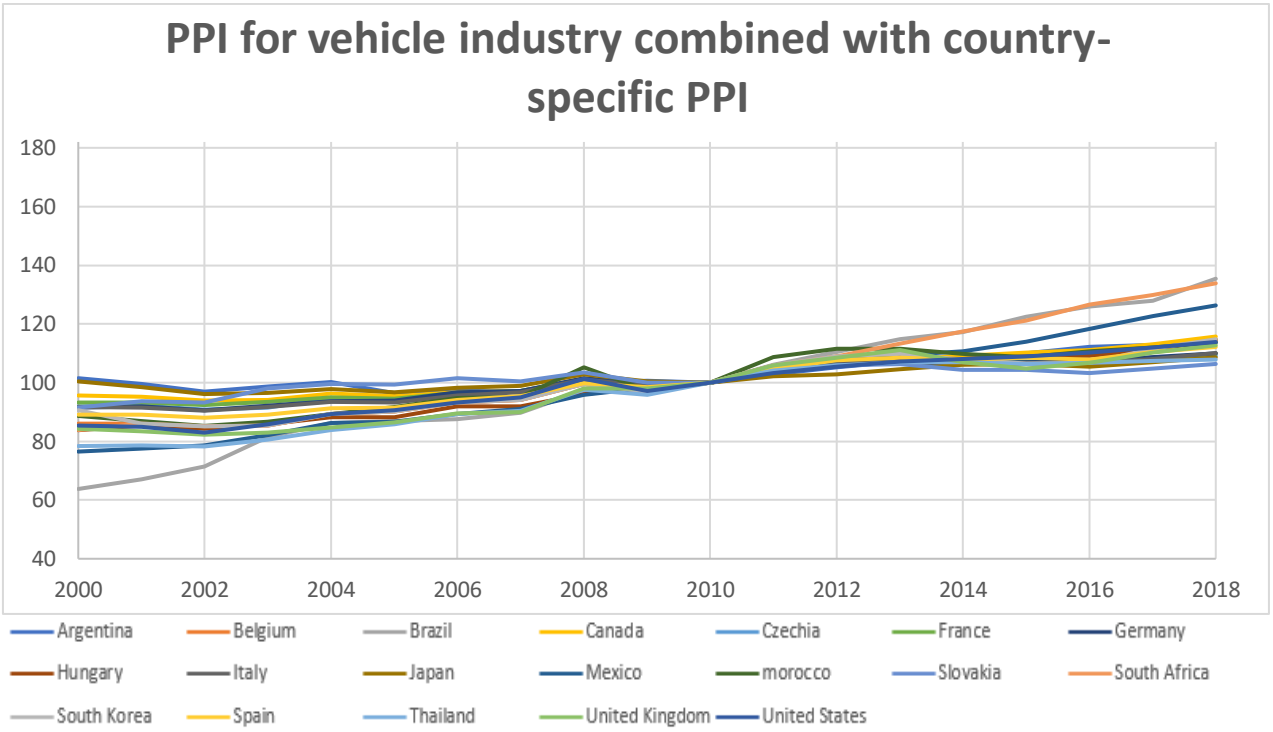
If a specific country shows deviating PPI movement in the vehicle industry this will likely be neutralized by including the country-specific PPI (Figure 1). This means that any major bias will be mitigated[3]. Fourth, both exchange rate levels and risk are obtained from the International Monetary Fund database. Lastly, data on both imported and exported intermediate goods will be retrieved from WITS Worldbank.

Figure 1: Shows differences in country specific PPI relative to country-specific PPI combined with vehicle industry PPI. The graph including both PPIs shows that for most countries the inclusion of PPI for vehicle industry results in a more conservative proxy for P_{it}.



[2] All production price indices in the sample have 2015 as value 100. Formula is divided by 100 to simplify estimation results into percentages.

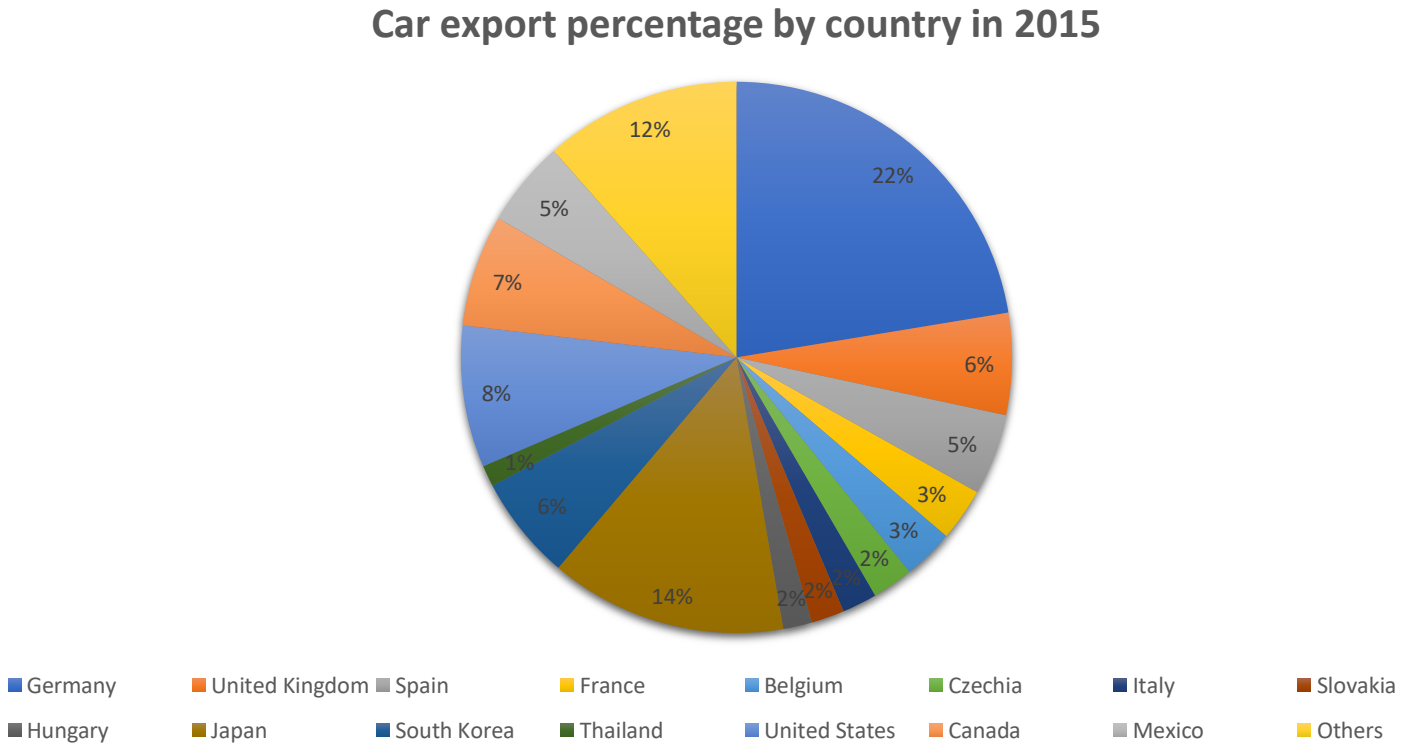
[3] Producer Price Index for Argentina is not available for the sample size period. In addition, immense inflation in Argentina will likely not show representable movements for the car industry. Therefore, it has been chosen to use the general PPI for the vehicle industry for Argentina.



3.2.2 Sample Selection

The car industry is dominated by only a dozen manufacturers. However, because these manufacturers have factories all over the world, many countries export cars around the world. Nevertheless, only several countries account for the majority of exported cars (OECD, 2018)

Figure 2: Shows car export percentage by country for the year 2015. From OECD database.



The figure above shows that 15 countries account for 88% of all car exports. Therefore, it has been chosen to only include the export volume from these countries. However, to account for possible differences between developing and developed countries, a number of other countries are added. Developed countries dominate the list of biggest car exporters. To get a bigger sample on developing countries Brazil and Argentina (0.5% and 0.29% of car export respectively) are added and South Africa and Morocco (0.88% and 0.4% respectively). In total, this means that car exports of 19 countries, on 5 different continents, with 14 different currencies are analyzed[4]. The period examined ranges from 2000 to 2018.

3.2.3 Descriptive Statistics

Table 1 shows the descriptive statistics of the entire sample size. The entire sample size includes 361 observations. The mean of the independent variable, export volume is 23.132. Other meaningful statistics shown in table 1 are the mean of the GDP, export price of cars, exchange rate, import effect, exchange rate risk, and the multiplier EX_IMP. Respectively those are 28.537, 4.598, 1.669, -9.735, -0.07, and -15.718.

Table 1: Descriptive statistics of variables used in Model 1.

Variable	Obs	Mean	Std. Dev.	Min	Max
log EV	361	23.132	1.845	13.33	25.821
log GDP	361	28.537	.895	26.734	30.655
log EPC	361	4.598	.106	4.155	4.908
log ERate	361	1.669	2.193	-.695	7.19
log IE	361	-9.735	.913	-12.218	-7.964
log ERisk	361	-.007	.119	-.517	.53
log EX IMP	361	-15.718	20.031	-59.387	7.081

When comparing the different characteristics between developed and developing countries we get a few interesting results (table 2 and table 3)[5]. Comparing the export volume, we see that the mean of developed countries is higher compared to developing countries. Similar statistics are seen for the variable GDP. This is in line with expectations. Developed countries are usually seen as richer (higher GDP) and are more actively participating in trade (higher export volume for cars). Following this, the export price of cars shows similar numbers between developing and developed countries. In other words, the production price of cars has shown similar patterns over the period

[4] Note that the car exports from these countries do not only go to the other countries analyzed, but all over the world.

[5] The descriptive statistics used in model 2 can be viewed in the Table 4, 5 and 6 in the Appendix.

2000-2018. Theoretically this makes sense. If some countries were able to produce much cheaper cars, we would expect car manufacturers to capitalize on this opportunity. Consequently, this would show in the export volume for countries with a low EPC. The import effect variables show a lower mean in developed countries relative to developing countries. This implies that developed countries are more export oriented than developing countries in the sample size. Lastly, the exchange rate and exchange rate risk show lower numbers for developed countries. Because the data is analyzed in log form this means that developing countries' currencies are shown to be more volatile over the period 2000-2018.[6] Developed countries are generally known to have more stable currencies. Therefore, this statistic is in line with the predictions.

Table 2: Descriptive statistics of developed countries for variables used in model 1.

Variable	Obs	Mean	Std. Dev.	Min	Max
log EV	247	23.866	1.002	21.234	25.821
log GDP	247	28.608	.821	27.142	30.655
log EPC	247	4.6	.082	4.41	4.751
log ERate	247	1.444	2.546	-.695	7.19
log IE	247	-9.604	.816	-11.315	-7.964
log ERisk	247	-.016	.115	-.517	.319
log EX IMP	247	-13.205	23.133	-59.387	7.081

Table 3: Descriptive statistics of developing countries for variables used in model 1.

Variable	Obs	Mean	Std. Dev.	Min	Max
log EV	114	21.541	2.221	13.33	24.649
log GDP	114	28.382	1.023	26.734	30.302
log EPC	114	4.595	.145	4.155	4.908
log ERate	114	2.157	.924	-.001	3.789
log IE	114	-10.018	1.043	-12.218	-8.528
log ERisk	114	.013	.127	-.419	.53
log EX IMP	114	-21.162	8.348	-33.853	.005

3.2.4 Correlation Analysis and Stationarity of Data

To avoid multicollinearity in the data a correlation analysis has been executed. From the results in table 7 we can ascertain that no regressors are strictly correlated undermining any of the results from the models.[7] Table 8 and 9 in the appendix show similar correlation analyses for the sample divided into developed and developing countries.

[6] Exchange rate risk is measured as log(1+ERisk). Consequently, higher values of the variable ERisk correspond with higher exchange rate risk.

[7] There is a high correlation between log_EX_IMP and log_ ERate. However, this does not cause multicollinearity issues as the standard errors of the interaction term co-efficient do not show a large increase in value.

Table 7: Correlation analysis for multicollinearity in data

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) log_GDP	1.000					
(2) log_EPC	0.346	1.000				
(3) log_ERate	0.337	-0.021	1.000			
(4) log_IE	-0.192	0.043	0.323	1.000		
(5) log_ERisk	0.071	0.215	0.015	-0.013	1.000	
(6) log_EX_IMP	-0.344	0.015	-0.992	-0.240	-0.015	1.000

A major problem in panel data is non-stationary data. To test the sample size for any non-stationary variables a Levin-Lin-Chu unit-root test has been performed. The results show that no regressors are stationary.[8] This means that the data can be modeled without having any form of trends, cycles or random walks.

4. Results

4.1 First Difference Regression Results

Table 10 presents regression estimates on export volume of cars. Column 1 represents the results for model 1 and column 2 represents the results for model 2. Row 1 measures the effect of GDP on export volume. A one percent increase in GDP in a certain year corresponds to a .975% increase in the export volume of cars of that specific country in model 1. Results show that this association is significant at the 1% level. When applying the results of model 1 to reality we could conclude that an increase in income results in more cars being exported. A potential driver for this could be that increased welfare leads to an increased demand for cars. Consequently, this will increase the export volume of cars as not all cars come from the domestic market. Nevertheless, when controlling for a one period lag of GDP, we see a deviating result. Model 2 shows that there is a negative relationship of -.039% between GDP and car export volume. However, this result appears to be insignificant. In contrast with model 1 this suggests that GDP is no real driver in variations in car export volume.

Row 2 reveals that the export price of cars also shows a positive association with the export volume of cars. A one percent increase in export price of cars results in an increase in export volume of 0.712%. For Model 1 the export price of cars is insignificant. Model 2 shows similar results to model 1, where the export price of cars still shows a strong positive relation with car export volume

[8] All individual unit-root tests can be found in the Appendix under the header Unit-root tests.

numbers. In fact, by adding lags to the model this effect has become even stronger at 1.977%. Additionally, this finding is significant at the 1% level. Theoretically, this could be interpreted in the wrong way when suggesting that ever-increasing car prices would still increase export figures. The proxy used to calculate the export price of cars uses the production price of cars. Previous literature states that car prices are formed by production cost with a constant mark-up. These two factors determine the export price of a car. Following, when looking for possible reasons explaining this positive relation between car export price and car export volume we come to several potential answers. First, the export price of cars is reported in U.S. dollars. Inflation will lead to an upward bias of the EPC co-efficient as money in period t is worth more than money in period $t + 1$ Second, over the sample period the average person may have changed his views on owning a car. This means that they might be willing to buy a more expensive car. Or people that previously didn't own a car may be willing to buy one now.

Row 3 for model 1 states that a one percent increase in the import effect results in the export volume of cars going up by 0.477%. An increase in the import effect is caused by a relative increase in intermediate imported goods of a country's total GDP. Typically, a relative increase in imports is instigated by higher valued currency. Other factors could be increased production costs such as higher domestic wages. As a result, firms prefer importing over dealing within the domestic market. This result is significant at the 1% level. Additionally, model 2 also shows a significant relationship (0.598%) for the import effect. A positive relationship of the import effect could be caused by car manufacturers exploring new markets for cheaper car components. Consequently, cheaper car components will reduce the production price, meaning that they can offer their cars at a lower price or have a higher profit margin. Ultimately, this will increase the car export volume.

From row 4 there appears to be a positive effect between exchange rate and export volume. A one percent increase in the exchange rate relative to the U.S. dollar leads to a 0.426% increase in car export volume. This is in contradiction with economic theory. Economic theory suggests that an increase in exchange rate results in lower export numbers. Yet, this result shows to be insignificant. Model 2 shows similar results to model 1, where a one percent increase in exchange rate causes a 0.334% increase in car export volume. Logically, it would make more sense that an increase in exchange rate would cause customers to turn to another car market, consequently reducing car

export volume. However, both models come with little statistical significance and these results should be taken lightly.

Row 5 measures the effect of exchange rate risk on car export volume. Model 1 indicates that an increased exchange rate risk enhances car export volume (0.82%). However, this comes with little statistical meaning. By adding a lag in Model 2 the results change drastically. Model 2 shows a negative effect of exchange rate risk on car export volume. Moreover, this effect appears to be significant at the 1% level. When assuming risk-neutral behavior this finding makes complete sense, as a customer would rather buy a car from a country that has a stable currency than from a country that does not have this. Especially when looking at companies buying cars at mass (e.g., lease companies) exchange rate risk might influence their buying strategy. This finding is in line with hypothesis H1d.

Lastly, row 6 shows the results of the interaction term between exchange rate and the import effect. Previously, the import effect showed a significant positive sign. When multiplying this with the exchange rate we can show how much of the import effect is caused by changes in exchange rate. Model 1 and model 2 both show insignificant results. From this, we can conclude that the import effect is likely not caused by exchange rate changes but by another factor. There could be many reasons for increased imports other than exchange rates changes. Examples of this could be technical development, changes in labor force etc.

Overall, model 1 and model 2 show very similar results for export price of cars, import effect, exchange rate changes, and the interaction term. Contrarily, the variables GDP and exchange rate risk show completely different results. Furthermore, model 2 adds more statistical significance to the results.

Table 10: First difference regression on export volume of cars. Column 1 represents the results for model 1. Column 2 represents the results for model 2. Variables with ^{L1} include one period lags used in model 2. The results show co-efficient of regressors and standard errors within parentheses. Significance is indicated at 1%, 5% and 10% by *, **, * respectively.**

	(1) log_EV	(2) log_EV
log_GDP^{L1}	.975***	-.039
	(.220)	(.041)
log_EPC	0.712	1.977***
	(.614)	(.562)
log_IE	.477***	.598***
	(.169)	(.170)
log_ERate	.426	.334
	(.512)	(.526)
log_ERisk^{L1}	.082	-.205***
	(.107)	(.0939)
log_EX_IMP	.070	.070
	(.049)	(.051)
Observations	342	341
R^2	.181	.179

4.2 Differences in development

Table 11 presents regression estimates for model 1 and model 2. Columns 1 and 3 represent the results for developed countries. Columns 2 and 4 represent the results for developing countries. Column 1 and column 2 show the results for a first difference regression for model 1. Results for model 2 are found in columns 3 and 4.

When distinguishing between developing and developed countries we find many interesting results. First, row 1 states that the GDP estimator has a positive effect for both developed and developing countries in model 1. The co-efficient for developing countries is higher, but this is only marginally. These results are in line with our full sample size analysis. Model 2 shows more interesting results. Namely, by adding lags the GDP co-efficient becomes negative. This is also in line with the full sample analysis. However, for model 2 developing countries' GDP co-efficient becomes significant. When developing countries' trade partners get richer, they tend to trade less with developing countries. A potential driver for this could be that developed countries participate more in global trade whereas developing countries trade relatively more with nearby countries. Consequently, when nearby countries get richer they might engage more in global trade with other

developed countries. As a result, developing countries' export volume might dwindle because of this. This would also explain why developed countries see no significant effect to GDP changes.

Model 1 row 2 indicates that there is a negative relationship between export price of cars for developed countries and a positive relationship for developing countries. However, these results appear to be insignificant. More interesting are the results from model 2. Export price of cars shows positive effects on export volume of cars for both developed and developing countries. This is significant at the 1% and 5% level respectively. Where developed countries show a co-efficient of 1.032, developing countries show a much higher co-efficient of 2.292%. A potential explanation for this difference could be that initial production prices in developing countries could be lower. Wages and production facilities will generally be cheaper than in developed countries. With developing countries becoming more involved in global trade over time, this could partially explain a more positive relationship between export price of cars and export volume of cars for developing countries.

Row 3 shows a negative relationship between import effect and car export volume for developing countries (columns 2 and 4). A negative import effect co-efficient implies that an increase in the ratio intermediate imported goods divided by a countries' GDP decreases car export volume. In other words, when the car industry uses relatively more imported components in its production process, the export volume of cars tends to go down. For developing countries this finding comes with no significance. Contrary to the findings of developing countries, developed countries show a positive significant effect of the import effect (0.768% and 0.856% for model 1 and model 2 respectively). This suggests that a higher number of imported components increases car export volume for developed countries. This raises the question why developed countries see a positive import effect and developing countries see no import effect. A potential driver for this could be that developed countries have access to more and other markets which developing countries have no access to. Consequently, car manufacturers in developed countries may be able to capitalize on opportunities causing this import effect, whereas a lack of information and market access means that developing countries are unable to capitalize on this.

Row 4 shows how exchange rate changes affect car export volume. In our full sample analysis there was a slight positive effect with no statistical significance. After splitting up our sample we find very interesting results. With developed countries we see a negative effect of exchange rate changes on car export volume. This is significant at the 1% level for both model 1 and model 2. This result implies that an increase in exchange rate reduces car export volume. This is in line with economic theory. A higher valued currency makes your product less interesting for countries that use other currencies, as they pay more for the same product. Additionally, countries with the same currency may be able to import similar products from other countries at reduced cost. When looking at developing countries we find complete opposite results. We find a positive significant effect between exchange rate changes and car export volume. This result implies that developing countries can increase their car export volume while their currency rises in value. A potential explanation for this could be that lower production costs (wages, facilities, etc.) enable developing countries to compete with developed countries despite seeing an higher valued currency. Another explanation could be that over time more car manufacturers have set up factories in developing countries due to their lower production costs. Consequently, this will lead to higher car exports.

Row 5 presents the impact of exchange rate risk on car export volume. For model 1 both developed and developing countries show a slight positive relationship with car export volume. However, this effect appears to be insignificant. The results found in model 2 are more interesting. Developed countries show a negative relationship between exchange rate risk and car export volume. This effect is significant at the 1% level. A negative co-efficient indicates that car export volume decreases with increased exchange rate risk exposure. This is in line with economic theory showing that people are risk-averse. Similar findings are found for developing countries. However, this effect appears to be insignificant.

Lastly, row 6 shows the results of the interaction term. First, for developed countries we find a slight negative co-efficient with little statistical meaning. Interestingly, we found a high import effect for developed countries. The results of the interaction term show that a high import effect is not caused by changes in exchange rates but by other factors. Second, the interaction term for developing countries shows interesting results. Initially, the import effect showed no significant effect for developing countries. However, by multiplying this term with exchange rate changes we

find a significant positive effect between the interaction term and car export volume for developing countries. This suggests that exchange rate changes do have an impact on the import effect for developing countries. However, other factors influencing the import effect estimator make it such that the total import effect shows no statistical meaning for developing countries.

Table 11: First difference regression on export volume of cars. Columns 1 and 2 represent the results for model 1. Columns 3 and 4 represent the results for model 2. Results for developed countries can be found in columns 1 and 3. Results for developing countries can be found in columns 2 and 4. Variables with ^{L1} include one period lags used in model 2. The results show co-efficients of regressors and standard errors are stated within parentheses. Significance is indicated at 1%, 5% and 10% by *, **, * respectively.**

	(1) log_EV	(2) log_EV	(3) log_EV	(4) log_EV
log_GDP^{L1}	0.929***	.984***	-.011	-.227**
	(.160)	(.488)	(.023)	(.121)
log_EPC	-.449	1.221	1.032***	2.292**
	(.461)	(1.328)	(.425)	(1.223)
log_IE	.768***	-.372	.856***	-.051
	(.104)	(.519)	(.109)	(.515)
log_ERate	-.560***	4.576***	-.624***	3.888**
	(.283)	(2.004)	(.295)	(2.074)
log_ERisk^{L1}	.111	.165	-.210***	-.203
	(.072)	(.286)	(.061)	(.241)
log_EX_IMP	-.023	.471***	-.025	.420***
	(.029)	(.192)	(.029)	(.197)
Observations	234	108	233	107

5. Conclusion

This study analyzes the effect of exchange rate changes on car export volume and what other factors impact car export volume. The study uses data from 19 different countries on 5 continents over the period 2000 to 2018. Two different regressions are formed and measured. One picturing an ideal world where price changes are integrated immediately, the other accounting for lagged responses of the estimators due to a rigid car market. These regressions are executed in the form of a first difference regression. Consequently, a second first difference regression is estimated to account for differences between developing and developed countries.

Table 12: All results of regressions conducted in this research. Results show co-efficient for each estimator of car export volume. Log_GDP^{L1} and log_ERisk^{L1} indicate that these variables come with a one period lag in model 2. Significance is indicated at 1%, 5% and 10% by *, **, * respectively.**

	Model 1			Model 2		
	Full sample	Developed	Developing	Full sample	Developed	Developing
(1) log_GDP^{L1}	.975***	0.929***	.984***	-.039	-.011	-.227**
(2) log_EPC	0.712	-.449	1.221	1.977***	1.032***	2.292**
(3) log_IE	.477***	.768***	-.372	.598***	.856***	-.051
(4) log_ERate	.426	-.560***	4.576***	.334	-.624***	3.888**
(5) log_ERisk^{L1}	.082	.111	.165	-.205***	-.210***	-.203
(6) log_EX_IMP	.070	-.023	.471***	.070	-.025	.420***

Table 12 provides a short summary of all the results acquired in this study. Answering the hypothesis in order: first, model 1 shows that GDP seems to have a significant positive influence on car export volume. However, model 2 shows deviating results suggesting that GDP has no real significant impact on car export volume. Therefore, H1a is rejected. Second, an increase in the export price of cars will lead to an increased export volume of cars. Both model 1 and model 2 support this hypothesis. The impact appears to be even bigger when controlling for lagged inputs (roughly 2% in model 2 versus 0.7% in model 1). Additionally, we see that car exports for developing countries incraease more than car exports of developed countries when there is an increase in the export price of cars. Third, the import effect appears to show a positive relationship with export volume. Especially with developed countries the import effect appears to be significant. However, when looking at the interaction term we see that little of the import effect is explained by changes in exchange rate. Therefore, H1c is rejected. Fourth, where exchange rate changes appear to have no decisive effect on car export volume, enhanced exchange rate risk reduces car export volume. Consequently, hypothesis H1d is partly rejected. Lastly, changes in exchange rates influence car export differently depending on a country's state of development. Mainly developed countries see a reduction in car exports with an increase in their exchange rate. Contrarily, an higher valued home currency in a developing country seems to not hinder car exports at all. This may be caused by car manufacturers moving production facilities to lower-wage countries in the last few decades. Increased exchange rate risk reduces car export volume no matter what state of development a country is in. This effect appears to be no bigger for developing countries. In conclusion, hypothesis H1e does not hold.

This research has several limitations. First of all, multiple proxies have been used. For example, the import effect has been measured using intermediate goods over the entire industry. While it is likely this generally follows the same trend as intermediate goods used in the car industry it isn't the ideal situation. The same holds for the proxy for export price of cars. Ideally, you would like to get the average export price per car. However, this is not available. Even if this data was available, countries could switch production to more expensive cars, undermining the intention of the variable 'EPC'. Hence, production price indices were chosen to account for this variable. With constant mark-ups on the production price this should lead to relatively close approximations of the export price of cars. Nevertheless, for this proxy generalized production price indices were used which could undermine the results of the acquired results. Second, this study uses annual exchange rate data. Therefore, the volatility of a currency may not show in the data. Consequently, this will underestimate the exchange rate volatility which may lead to a downward bias of the exchange rate risk co-efficient.

Multiple recommendations can be made for future research. First, it is important to resolve the limitations mentioned above. This may be difficult as some of the data is simply not available to this date. Nevertheless, there may be proxies that approach the real values more than the proxies used. Second, despite the rigid car market it would be interesting to see results based on quarterly data rather than annual data. Especially for exchange rate volatility this may yield interesting results. Lastly, it would be interesting to see further research on the import effect. This doesn't necessarily have to be within the car industry, but from this research it appears that there is some sort of import effect. However, its precise influence on price changes remains quite unclear.

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APPENDIX

Table 4: Ddescriptive statistics of variables used in model 2.

Variable	Obs	Mean	Std. Dev.	Min	Max
log EV	361	23.132	1.845	13.33	25.821
log GDP L1	360	28.535	.895	26.734	30.655
log EPC	361	4.598	.106	4.155	4.908
log ERate	361	1.669	2.193	-.695	7.19
log IE	361	-9.735	.913	-12.218	-7.964
log ERisk L1	360	-.007	.12	-.517	.53
log EX IMP	361	-15.718	20.031	-59.387	7.081

Table 5: Ddescriptive statistics of developed countries for variables used in model 2.

Variable	Obs	Mean	Std. Dev.	Min	Max
log EV	247	23.866	1.002	21.234	25.821
log GDP L1	246	28.607	.822	27.142	30.655
log EPC	247	4.6	.082	4.41	4.751
log ERate	247	1.444	2.546	-.695	7.19
log IE	247	-9.604	.816	-11.315	-7.964
log ERisk L1	246	-.016	.115	-.517	.319
log EX IMP	247	-13.205	23.133	-59.387	7.081

Table 6: Descriptive statistics of developing countries for variables used in model 2.

Variable	Obs	Mean	Std. Dev.	Min	Max
log EV	114	21.541	2.221	13.33	24.649
log GDP L1	113	28.39	1.024	26.734	30.302
log EPC	114	4.595	.145	4.155	4.908
log ERate	114	2.157	.924	-.001	3.789
log IE	114	-10.018	1.043	-12.218	-8.528
log ERisk L1	113	.014	.128	-.419	.53
log EX IMP	114	-21.162	8.348	-33.853	.005

Table 8: Correlation analysis for developed countries.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) log_GDP	1.000					
(2) log_EPC	0.346	1.000				
(3) log_ERate	0.337	-0.021	1.000			
(4) log_IE	-0.192	0.043	0.323	1.000		
(5) log_ERisk	0.071	0.215	0.015	-0.013	1.000	
(6) log_EX_IMP	-0.344	0.015	-0.992	-0.240	-0.015	1.000

Table 9: Correlation analysis for developing countries.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) log_GDP	1.000					
(2) log_EPC	0.309	1.000				
(3) log_ERate	0.097	0.041	1.000			
(4) log_IE	-0.453	-0.008	0.465	1.000		
(5) log_ERisk	0.033	0.089	-0.018	-0.145	1.000	
(6) log_EX_IMP	-0.287	-0.057	-0.961	-0.211	-0.031	1.000

Unit-root Tests

Levin-Lin-Chu unit-root test for log_GDP

	Statistic	p-value
Unadjusted t	-5.9761	
Adjusted t*	-4.9586	0.0000

Levin-Lin-Chu unit-root test for log_EPC

	Statistic	p-value
Unadjusted t	-1.2595	
Adjusted t*	0.3569	0.6394

Levin-Lin-Chu unit-root test for log_ERate

	Statistic	p-value
Unadjusted t	-11.3589	
Adjusted t*	-6.2800	0.0000

Levin-Lin-Chu unit-root test for log_IE

	Statistic	p-value
Unadjusted t	-9.1487	
Adjusted t*	-4.5701	0.0000

Levin-Lin-Chu unit-root test for log_ERisk

	Statistic	p-value
Unadjusted t	-16.0974	
Adjusted t*	-8.9975	0.0000

Levin-Lin-Chu unit-root test for log_EX_IMP

	Statistic	p-value
Unadjusted t	-11.6488	
Adjusted t*	-6.7492	
0.0000		