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PRICE AND INCOME ELASTICITIES OF AGGREGATE IMPORT DEMAND IN ESTONIA

Bachelor's thesis

Programme Applied Economics, specialisation Economic Analysis

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ABSTRACT

The aim of this bachelor's thesis is to estimate the short and long run models for aggregate import demand in Estonia to understand how changes in the price of domestic goods and services relative to foreign goods and services affect the demand for imports. The first part of the thesis gives a theoretical overview of imports in macroeconomic theory and how imports affect the trade balance. Also, previous empirical studies are analysed. The second part of the thesis is dedicated to the empirical analysis using the Autoregressive Distributed Lag model and Bounds cointegration test to estimate the models. The results of the empirical analysis indicate that import demand is price elastic in the short run, while the elasticity of income was found to be statistically insignificant. However, contrary to the short run model, import demand is found to be income elastic, while the elasticity of the price of domestic goods and services relative to the foreign goods and services was insignificant in the long run model. Since for both short and long run models one of the two parameters was found to be insignificant, aggregate import demand models could not be estimated. The elasticities found still provide useful information for reference in future researches on Estonian import demand.

Keywords: imports, aggregate import demand, price elasticity, income elasticity, autoregressive distributed lag, bounds test

INTRODUCTION

Out of the 28 countries in the European Union, Estonia is among the countries with the highest share of imports as a percentage of the gross domestic product. Net trade of both goods and services is positive, but only marginally, placing Estonia in the bottom half among other European Union member countries. (OECD, table trade in...) Net trade in goods has been negative for every year since 1999 and even though net trade in services has been positive, the difference between exports and imports of services has been slightly decreasing in the past few years (*Ibid.*), making it entirely possible that overall net trade turns negative at some point in the future. Understanding how import demand reacts to changes in the relative price of domestic and foreign goods and services and income is one of the key aspects to establishing trade policies in a way to keep this from happening.

The aim of this thesis is to estimate both short and long run aggregate import demand models for Estonia, for which two research questions have been set:

1. How does the demand for imports of goods and services react to changes in the relative price of foreign goods and services in terms of Estonian goods and services?
2. How does the demand for imports of goods and services react to changes in Estonian income?

To answer the research questions, quarterly data on imports of goods and services, import price index, harmonised consumer price index and real gross domestic product is used. The data on real gross domestic product is obtained from the database of Eurostat and from the database of Statistics Estonia for all other data. The data spans the time between the fourth quarter of 1998 and the fourth quarter of 2017. The econometric software used for the analysis is the 9th version of EViews.

The aggregate import demand function is used, where the dependent variable is import demand and the regressors are relative price and income. The time series of imports of goods and services is divided by the import price index to obtain real imports and the import price index is divided by the harmonized consumer price index to estimate the relative price variable. Income is proxied by real gross domestic product. Similarly to some previous studies on aggregate import demand, the autoregressive distributed lag and bounds testing approach to estimate cointegration is used.

The paper is divided into four chapters. The first chapter gives an overview of imports from a theoretical point of view. Furthermore, the impact of imports on the trade balance is discussed and the chapter ends with describing the findings of previous empirical studies on import demand. Chapter 2 gives an overview of Estonia's foreign trade throughout the years under observation in the thesis. The trade balances of goods and services are analysed separately and Estonia’s most important trading partners are presented. Chapter 3 describes the methodology used in the empirical analysis and also presents the data that is used in the analysis. Chapter 4 is dedicated to the empirical analysis using the Autoregressive Distributed Lag bounds test approach. The findings are presented and diagnostic tests are also conducted on the models. Furthermore, a recommendation will be given based on the results.

The author would like to express their sincere gratitude to the supervisor and co-supervisor for their assistance and support during writing the thesis and also to Liisbet Polakene for her moral support..

1. IMPORTS IN MACROECONOMIC THEORY

This chapter aims to give an overview of imports in general, its determinants and role in macroeconomics. Moreover, the last sub-section summarises previous empirical studies on import demand and their findings.

1.1. Why countries trade

The two most well-known theories on international trade date back hundreds of years. In 1776, Adam Smith proposed the theory of absolute advantage, suggesting that countries should specialise in producing the goods and services in which they have an absolute advantage over other countries. According to the theory, the countries should then export the goods produced and import others. (McCulloch, Smith 1838) However, David Ricardo argued that even if a country has an absolute advantage in everything compared to others, international trade is still possible. In his view, a difference in comparative costs is the necessary condition for international trade. In case of a comparative advantage, a country may be more inefficient in producing a good compared to another country, but it can produce the good more efficiently than it could produce others. (Gandolfo 2014, 11–12) A more contemporary view on international trade is that of Eli Heckscher and Bertil Ohlin, who expanded the Ricardian theory in 1919 and 1933 respectively, suggesting that the proportions of factor endowments and therefore the relative marginal costs of production are different, making countries produce and export the goods for which the factors of production are more abundant (*Ibid.*, 63).

Based on the level of international trade, an economy can be either closed or open, the main macroeconomic difference being that in the case of an open economy, a country's spending does not have to equal its output of goods and services, because such countries can either spend more or less than they produce and therefore act as borrowers or lenders to foreign countries. Closed economies, on the other hand, do not import from or export to foreign countries, meaning they are self-sufficient and get by with domestically produced goods only. (Mankiw 2013, 132) Even though closed economy models are often used by economists for certain countries (where exports and imports are small compared to output) to simplify the analysis, in reality, completely closed economies do not exist (Barro 2010, 18).

1.2. Imports as a component of output

As opposed to closed economies, where domestic spending on domestic goods and services equals their output, output in open economies also takes foreign goods and services into account. The basic model for a country's output is as follows (Mankiw 2013, 133):

$$\boldsymbol{Y} = (C - C^f) + (I - I^f) + (G - G^f) + X \quad (1)$$

where

Y – output,

C – total spending on goods and services,

C^f domestic spending on foreign goods and services,

I – total investment in goods and services,

I^f – domestic investment in foreign goods and services,

G – total government purchases,

G^f – government purchases of foreign goods and services,

X – exports.

Rearranging Equation (1) results in the following (Mankiw 2013, 133):

$$\boldsymbol{Y} = C + I + G + X - (C^f + I^f + G^f). \quad (2)$$

The domestic spending on foreign goods and services part in Equation (2) above – i.e. $C^f + I^f + G^f$ – equals expenditure on imports. This means that the expression for national income accounts is the following (Mankiw 2013, 133):

$$\boldsymbol{Y} = C + I + G + X - IM \tag{3}$$

where

IM – expenditure on imports.

Net exports can be found by subtracting imports from exports or also by subtracting domestic spending from domestic output. The latter shows that, as mentioned earlier, a country's domestic spending does not need to equal its output of goods and services: if output outweighs domestic spending, the remaining difference is exported, i.e. net exports are positive. On the other hand, in case domestic spending is larger than output, the difference is imported, meaning net exports are negative. (Mankiw 2013, 135) Therefore, if exports equalled zero in the first year year and assuming a constant export level, increasing imports in the following year would theoretically affect a country's output negatively.

1.3. The impact of trade openness on economic growth

Growth in exports can positively affect the economy in a number of ways. First, if the foreign demand for a country's domestic goods rises, it positively affects the employment and income of the same sector (Awokuse 2008, 162). Furthermore, a country with an export-oriented policy such that the incentives for sales in domestic and foreign markets are similar, can benefit from a more efficient resource allocation, greater capacity utilization and the boosting of technological improvements due to the high competition in foreign markets (Balassa 1978, 181).

Based on Equation (3), growth in imports decreases aggregate output. This, however, is only true if the imported goods replace domestic goods and hence does not mean that rising imports could not have a positive impact on a country's economy. For example, the export sector of small open developing countries often uses resources that are provided by imports (Awokuse 2008, 162). Moreover, access to foreign knowledge and technology through imports – since new technologies often require the importing of intermediate goods such as computers – can help productivity grow and contribute to economic growth in the long run (*Ibid.)* The effect of imports on economic growth may therefore be even bigger than exports

(*Ibid.*); however, since it is indirect, it is much more difficult or may even be impossible to accurately quantify it compared to the effect of exports.

There are several studies which support the idea that increasing international trade has a positive effect on economic growth. For example, Sachs and Warner (1995) researched a set of countries using data ranging from 1970 to 1989. They found that the real GDP per capita growth is much faster for open economy countries than closed economy countries – even in the case of developed countries, the growth rates are 2.29% and 0.74% respectively. Growth for developing countries is found to be noticeably higher than for developed countries – 4.49% and 0.69% for open and closed economy countries respectively –, suggesting that within open economy countries, trade openness contributes significantly to income convergence (Sachs & Warner 1995, 36). Frankel and Romer (1999) conclude that trade – both international and within-country – does indeed raise income by increasing output by the levels of capital given and also through the accumulation of human and physical capital (Frankel, Romer 1999, 394).

However, Rodriguez and Rodrik (2001) believe that the relationship between trade openness and economic growth is not that simple and feel that many previous researches on the topic have methodological problems. They highlight the common exclusion of simple trade-weighted tariff averages and non-tariff coverage ratios from the analyses, which are often claimed to give misleading information about a country's trade policy without providing reasoning for such biases or explaining why a different indicator would be better, which is in part caused by the effect previous studies have on newer ones (Rodriguez, Rodrik 2001, 316). Dollar and Kraay (2004) agree with the critique by Rodriguez and Rodrik (2001) and have taken it into account in their research. Based on their analysis of about 100 countries, they still conclude that countries with relatively more open trade policies seem to experience faster economic growth.

1.4. Factors affecting demand for imports

In an open economy, the total domestic demand for goods includes demand for domestic goods and foreign goods, where imports are part of the latter. The first determinant of import demand is domestic income – i.e. a country's output (since for both closed and open economies, income and output are equal). An increase in domestic income results in an overall higher demand for all goods and services, which means that import demand also rises. (Blanchard 2006, 397) To estimate how the quantity of imports demanded reacts to changes in income, i.e. the income elasticity of import demand, the formula is the following:

$$\boldsymbol{E_Y} = \frac{\Delta IM_D}{\Delta Y} \times \frac{Y}{IM_D} \tag{4}$$

where

E_Y – income elasticity,

IM_D – quantity of imports demanded,

ΔIM_D – percentage change in quantity of imports demanded,

ΔY – percentage change in income.

The second import determinant is the real exchange rate, also called the terms of trade, which describes the relative price of the goods of two countries – the rate at which one country's goods can be exchanged for another country's goods – as opposed to the nominal exchange rate which describes the relative price of currencies. The real exchange rate is dependent on the prices of the goods in local currencies and the rate at which the currencies of the two countries are exchanged, that is, the nominal exchange rate. (Mankiw 2013, 148) The formula for the real exchange rate is (*Ibid.*, 149):

$$\boldsymbol{\epsilon} = e \times \frac{P}{P^*} \tag{5}$$

where

ϵ – real exchange rate,

e – nominal exchange rate,

P – price level in the home country,

P^* – price level in the foreign country.

A higher real exchange rate means that foreign goods and services are relatively cheaper than domestic goods and vice versa in case of a lower real exchange rate. Therefore, an increase in the real exchange rate affects imports positively. Taking all of the aforementioned into consideration, the determinants of imports can be written as a simple function (Blanchard 2006, 397):

$$\boldsymbol{IM} = IM(Y, \epsilon) \tag{6}$$

where an increase in either component brings about an increase in the demand for imports as well.

Because foreign goods are different from domestic goods, imports cannot be subtracted from net exports in their nominal value, as is the case in Equation (4). The value of imports must be expressed in terms of domestic goods, meaning the equation for net exports is the following (Blanchard 2006, 405):

$$\boldsymbol{NX} = X(Y^{*}, \epsilon) \; - \frac{1}{\epsilon} \times IM(Y, \epsilon) \tag{7}$$

where

NX – net exports,

Y^{*} – foreign income,

$\frac{1}{\epsilon}$ – relative price of foreign goods in terms of domestic goods.

Since the effect of the real exchange rate on exports is negative, depreciation of the real exchange rate increases exports by making domestic goods relatively less expensive abroad. On the other hand, imports decrease since foreign goods are relatively more expensive, causing the domestic demand for domestic goods to increase. However, the relative price of foreign goods in terms of domestic goods increases, meaning that in terms of domestic goods, imports cost more. To improve the trade balance after a depreciation, the increase and decrease in exports and imports, respectively, must be enough to compensate for the higher cost of imports. Growth in net exports under these conditions is known as the Marshall-Lerner condition. (Blanchard 2006, 405–406)

The substitution between any two goods depends on the differentiation between them. First and foremost, consumers may select one good over another based on their physical differences with greater differences lowering the elasticity of substitution. However, in addition to physical preferences, there are other important aspects to preferring a good over others, such as the convenience of purchase, the time of receiving the product and the perceived quality of the good. (Blonigen, Wilson 1999, 3) In some cases, the latter aspects may have a bigger impact on the consumer's choices, especially in the case of choosing between domestically produced and imported goods. Since imported goods may also pose higher risks, the consumer may opt for domestic goods. In some cases, there may also exist a home bias of some domestic goods (*Ibid.*, 3–4) – a good example for such products would be wine in any of the larger wine-producing countries, where consumers often prefer the local produce over imported wine (Friberg *et al.* 2011, 37). But a home bias may also exist among domestic and foreign goods which are otherwise equal. In such cases, the aspects aside from physical features mentioned in the previous paragraph are even more prevalent, giving the domestic industry an advantage over foreign industries, which can result in a systematic home bias. (Blonigen, Wilson 1999, 5)

1.5. Literature review on import demand

The issue with the import demand model described in the previous sub-section is that it is purely theoretical and even though it is used in the context of this thesis as well, previous research has found that the components of gross domestic product (GDP) separately may describe the demand for imports better. For example, Giovanetti (1989) studied the effect of disaggregated expenditure components on aggregate imports in Italy from 1970–1986. In their model, they included private and public consumption, fixed investment, exports and, in addition, stockbuilding and the relative price of foreign and domestic goods are included as well. Though the relationship between imports and total expenditure is found to be unstable since the composition of expenditure changes over the trade cycle, they concluded that all the included variables have an impact on import demand. Abbott and Seddighi (1996) also researched the impact of final expenditure components and the relative price term on aggregate imports in the UK over the period 1972–1990, finding that there exists a long-run relationship between them. In particular, consumption expenditure is found to be the major determinant of import demand, while the effect of changes in the relative price on import demand is rather small.

Hooper *et al.* (2000) researched the short and long run price and income elasticities for both imports and exports of the G-7 countries, using the Johansen cointegration method and the error-correction model. The time series used are different, starting from the mid-1950s to early 1960s for Canada, Japan, the United Kingdom and the United States and the years around 1970s for Germany, France and Italy – all leading up to the 1990s. For France, Germany and Italy, the income elasticities of import demand are similar: 1.6, 1.5 and 1.4 respectively. The price elasticities of import demand are the same for France and Italy (–0.4), but the price elasticity for Germany is only –0.06. They note that this may come from the fact that they have included oil and services in their measure of trade volume, as in Hooper and Marquez's (1995 referenced in Hooper *et al.* 2000, 8) research, the average of Germany's import price elasticities excluding services is –0.5. Hooper and Marquez have also found that in the case of the U.S., the average price elasticity of imports excluding oil imports is –1.23, while for total imports it is –0.5, suggesting that including oil lowers the estimate of the price elasticity (Hooper *et al.* 2000, 8). In the short run, income elasticities are lower for Germany and Italy at 1.0, but higher for France at 1.7. However, Germany is the only country for which the estimated short run price elasticity of import demand is statistically significant (–0.2), indicating that changes in relative prices may have a smaller role in import demand in the short run.

Narayan and Narayan (2003) used the Autoregressive Distributed Lag (ARDL) model to estimate the long run price and income elasticities for the import demands of South Africa and Mauritius using data for the period 1960 to 1996 and 1963 to 1995, respectively. The price elasticity of import demand is negative as expected, –0.42 for Mauritius and –0.61 for South Africa and income elasticity is positive – 0.87 and 1.19, respectively. The error correction terms for both countries are quite low, –0.34 for Mauritius and –0.12 for South Africa, indicating that a short-term shock in the import demand model would take about 3 and 8 years, respectively, to recover to their long-run equilibrium levels (Narayan, Narayan 2003, 20).

Kee *et al.* (2004) have estimated the price elasticities of import demand at the tariff line level and have done so for more than 4000 goods in 117 countries for the period 1988–2001, finding that the average import demand elasticity across the sample is –1.67, however, the median value is –1.08. What is more, they have found import demand to be more elastic in large and rich countries, but less elastic for less developed countries (Kee *et al.* 2004, 21). The average estimated elasticity for Estonia, for example, is –1.09 – nearly identical to the median value across the whole sample, but lower than the price elasticities of Lithuania and Latvia at –1.2 and –1.16, respectively.

Rashid and Razzaq (2010) use the Dynamic Ordinal Least Squares (DOLS) method in addtion to the ARDL bounds testing approach to examine the income and price elasticities of Pakistan using annual data for the period 1975–2008, finding that the elasticities found with the DOLS method (1.018 and –1.197) are lower than the estimates found using ARDL. Another variable they have added in their import demand model is the availability of foreign exchange, the estimated elasticity of which using the ARDL method is 0.472, suggesting that an increase in the availability of foreign exchange increases import demand.

Aiello, Bonanno and Via (2015) researched the price and income elasticities of both imports and exports of China and 6 countries in the Organisation for Economic Co-operation and Development (OECD) using data from 1990 to 2013. The most important difference compared to other similar studies is that in addition to expecting income elasticity to be positive, they have also expected the price elasticity to be positive. Since using the Pooled Mean Group and Mean Group estimators on panel data for estimating the elasticities of imports yielded inconclusive results, they have also analysed each country individually using the Vector Error Correction Model, finding that the income elasticities for China, Japan and USA are 1.07, 1.25 and 2.05, respectively, while price elasticities are 2.05, 0.65 and 0.2, respectively.

In conclusion, import demand is found to be income elastic in all countries except Mauritius, where it is income inelastic. The empirical studies also show that the income elasticity of import demand can be expected to be higher in more developed countries and lower in less developed countries. Price elasticities, however, are found to be quite different and are statistically insignificant in some countries, hence a generalisation based on the literature reviewed would be arbitrary.

2. OVERVIEW OF FOREIGN TRADE IN ESTONIA

Chapter 2 aims to give an overview of foreign trade in Estonia throughout the years that are under observation in this thesis. The trade balances of goods and services are examined, furthermore, more important consignment and destination countries are presented.

2.1. Trade balances of goods and services

The value of total imports of goods and services in Estonia as a percentage of GDP is rather high, constantly exceeding 60% in most years and reaching over 80% in 2012. After 2012, however, there has been a clear downward trend. Figure 1 shows Estonia's imports and exports of goods as a share of GDP from 1999 to 2017. Through all the years, exports have been lower compared to imports, therefore net trade is negative and Estonia acts as a borrower on the world market. The gap between imports and exports of goods was significantly greater before the financial crash, but following the financial crash, the difference has decreased.

Figure 1. Estonian trade of goods as a share of gross domestic product from 1999 to 2017.
Source: Statistics Estonia (table NAA0061), compiled by the author

Figure 2 shows that the trade balance of services has been positive during all years between 1999–2017, meaning that on the services market, Estonia acts as a lender. The movement of both imports and exports of services has been very similar, both increasing at quite a steady rate, whereas in the trade for goods as a share of gross domestic product, both exports and imports increased at a very fast rate for a few years after the financial crash, but then started decreasing. What is also noteworthy is the smaller impact of the financial crash on the trade of services, especially on imports – while the imports of goods were greatly affected by the financial crash, the impact on the imports of services was much smaller.

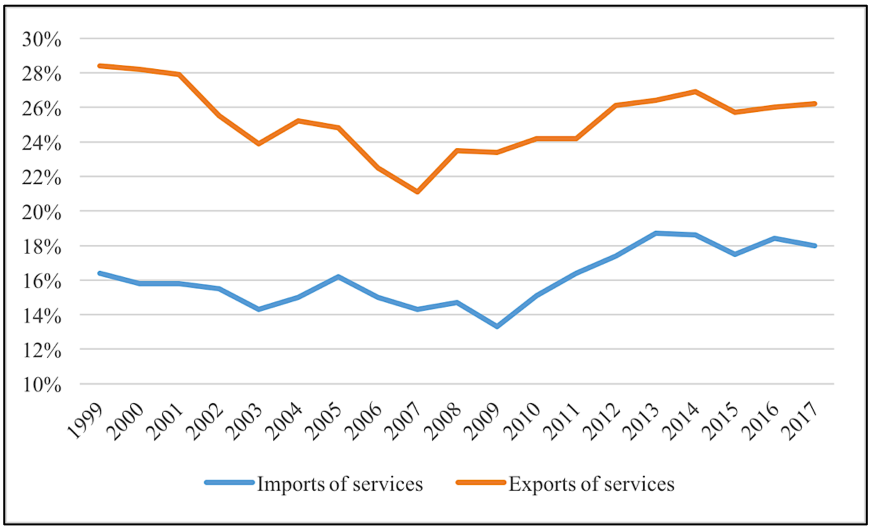

Figure 2. Estonian trade of services as a share of gross domestic product 1999–2017.
Source: Statistics Estonia (table NAA0061), compiled by the author

2.2. Consignment and destination countries

As can be seen from Figure 3, for all the selected years, Finland has been the most important consignment country. Before the accession to the EU in 2004, the percentage of imported goods from Finland made up over 30% of the total amount of imports. Since 2004 the share of imports from Finland has decreased, but still constitutes the largest part of total imported goods. Aside from Finland, Russia, Germany, Sweden and Latvia are among the most important consignment countries (Statistics Estonia, tables FTY199; FTY200; FTY201; FTY202; FTY203; FT09).

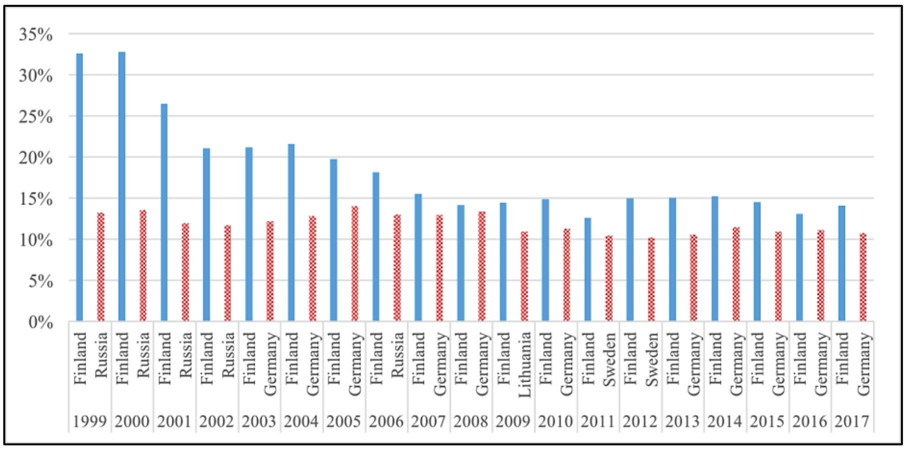

Figure 3. Consignment countries with the highest shares of total imported goods in Estonia 1999–2017
Source: Statistics Estonia (tables FTY199; FTY200; FTY201; FTY202; FTY203; FT09), author's calculations

Figure 4 shows that, as with imports, Finland is also clearly one of the most important destination countries. Again, the share of exports to Finland is higher before joining the EU, however, even after joining the EU, exports to Finland still make up the highest share of overall exported goods. Sweden is another important trading partner and the two have been the top two destination countries during the last 18 years. Other destination countries are much like the countries from which Estonia imports goods: Russia, Germany and the other two Baltic states among others (Statistics Estonia, tables FTY199; FTY200; FTY201; FTY202; FTY203; FT09).

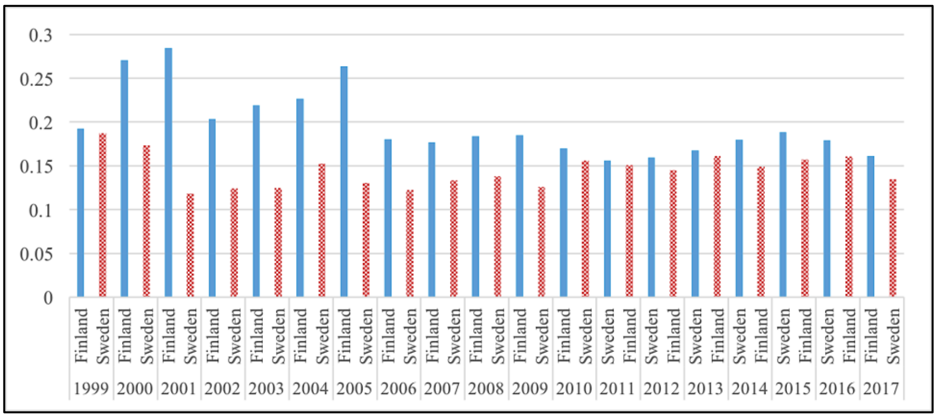

Figure 4. Destination countries with the highest shares of total Estonian exports 1999–2017
Source: Statistics Estonia (tables FTY199; FTY200; FTY201; FTY202; FTY203; FT09), author's calculations

3. DATA AND METHODOLOGY

This chapter aims to give an overview of the data used in the empirical analysis. Moreover, the methodology of the research will be described.

The variables used for determining the income and price elasticities of aggregate import demand in Estonia are real imports, relative price and income. The variables are obtained as follows: real imports is obtained by deflating Estonian nominal imports (Statistics Estonia, table NAA0061) by the Estonian import price index (Statistics Estonia, table XO08) values, relative price from dividing import price index values by the harmonised consumer price index values (Statistics Estonia, table XO023) and income is proxied by the Estonian real GDP (Eurostat, table namq_10_gdp). However, before estimating the variables previously mentioned, some adjustments are needed – first, the base year for the time series of both total imports and real GDP is 2010, however, the base years for the import and harmonised consumer price indices are 1997 and 2005, respectively, both of which are re-based to year 2010. Furthermore, the nominal import time series is seasonally unadjusted, therefore, to remove seasonality, the moving average method is used. The data used, spanning the time from the fourth quarter of 1998 to the fourth quarter of 2017, are obtained from the database of Statistics Estonia with the exception of the seasonally adjusted real GDP, which is obtained from the statistical database of Eurostat.

Table 1 below presents the descriptive statistics for real imports, relative price and income. The difference between the minimal and maximum value of real imports is quite large, which is due to imports as a share of GDP rising since the start of the dataset. On average, the relative price of foreign goods has been higher than domestic goods. The negative skewness values for both imports and income signal that the left-hand tail values are longer, but in the case of income, the skewness indicates the data are moderately skewed while for imports the data are fairly symmetrical, as is the case with the relative price variable. However, looking at the values for kurtosis, the values are significantly different from 0 and are negative – hence, none of the variables are normally distributed but rather the distribution is platykurtic.

Table 1. Descriptive statistics for real imports, relative price and income.

Statistic	Real imports	Relative price	Income
Mean	2660.886	107.072	3753.295
Median	2809.620	107.588	3892.600
Standard deviation	708.880	9.773	680.548
Maximum value	3743.794	125.921	4819.600
Minimum value	1333.411	91.466	2386.400
Skewness	–0.360	0.326	–0.556
Kurtosis	–1.163	–0.813	–0.861

Source: Eurostat (table namq_10_gdp) and data in Appendix 1, author's calculations

3.1. Aggregate import demand function

Similarly to previous studies, the aggregate import demand function is used, the basic form of which is the following (Frimpong, Oteng-Abayie, 3):

$$\boldsymbol{IM_t} = \alpha_0 + \alpha_1 \times \frac{P_{imt}}{P_{dt}} + \alpha_2 \times Y_t \tag{8}$$

where

IM_t – demanded imports,

α_1 – coefficient of relative price,

P_{imt} – price of imports,

P_{dt} – domestic prices,

α_2 – coefficient of income,

Y_t – income,

For import prices, the import price index is used, which is also used to find the value of real imports by deflating the values of nominal imports by the import price index. Since an index for domestic prices does not exist, the consumer price index, similarly to Narayan and Narayan (2003), is used to proxy the domestic prices. However, it is important to note that in the context of this thesis, the harmonised consumer price index (HICP) is used, which is an indicator of inflation for the European Central Bank. The reason behind using HICP instead of CPI is the possibility of new studies on import demand in other EU member countries, making the findings better comparable. For income, real GDP is used.

A possible method for estimating elasticities is transforming the function to the log-linear model. (Gujarati, Porter 2010, 134) More specifically, Goldstein and Khan (1985, 1065) note that the log-linear instead of the linear specification may be preferred for estimating import demand, hence the log-linear form of the aggregate import demand function has been used in this thesis as well. Therefore, the final equation is as follows:

$$\boldsymbol{lnIM_t} = \alpha_0 + \alpha_1 \times (ln\frac{P_{imt}}{P_{dt}}) + \alpha_2 \times (lnY_t) \ + u_t \tag{9}$$

where

u_t – error term.

As as result of transforming the equation to the log-linear form, the coefficients now represent the price and income elasticities of import demand, respectively. A positive relationship between import demand and income is expected, the relationship between import demand and the relative price, however, is presumably negative.

3.2. Autoregressive distributed lag bounds test approach to cointegration

Following previous studies researching the price and income elasticity of import demand, such as Narayan and Narayan (2003) and Rashad and Razzaq (2010), the Autoregressive Distributed Lag (ARDL) bounds test approach to cointegration by Pesaran *et al.* (Pesaran, Shin 1998; Pesaran *et al.* 2001) is used for the empirical analysis. The model being autoregressive means that the current value of a dependent variable is, in part, described by previous values of the dependent variable itself. The distributed lag component refers to the lags of the regressors, which impacts the current value of the dependent variable. The general model specification for an ARDL(p, q_1, q_2,..., q_k) is the following (Pesaran, Pesaran 1997, 397–399 referenced in Narayan, Narayan 2003, 6–7):

$$\boldsymbol{\Omega(L,p)y_t} = \alpha_0 + \sum_{i=1}^{k} \beta_i(L,q_i)x_{it} + \delta' w_t + \mu_t \tag{10}$$

where

$\Omega(L,p) = 1 - \Omega_1\delta_1 L^1 - \Omega_2\delta_2 L^2 - \ldots - \Omega_p L^p$,

$\beta_i(L,q_i) = \beta_{i0} + \beta_{i1}L + \beta_{i2}L^2 + \ldots + \beta_{iqi}L^{qi}, i = 1,2,\ldots,k.$

In Equation (10), y_t is the dependent variable, α_0 is a constant, L is a lag operator with $Ly_t = y_{t-1}$ and x_{it} is the i independent variable where $i = 1,2,\ldots,k$ (Narayan, Narayan 2003, 7).

The main argument in favour of using this method among multiple other cointegration methods – e.g. Engle-Granger cointegration – is the fact that it is possible to estimate the relationship even when variables are not integrated of the same order, which means they can be either integrated of zero order (I(0)), the first order (I(1)) or also be a combination of the two (Pesaran, Shin 1998). However, it is necessary that the variables used in the analysis are not integrated of the second order (I(2)), as in such case the conclusions reached on a possible long run relationship would be meaningless due to the fact that the calculated F-statistic in the bounds test is based on the assumption that the variables are I(0) or I(1) (Pesaran *et al.* 2001). In addition to the aforementioned advantage over other cointegration analysis methods, it is possible to derive the Error Correction Model (ECM) from the ARDL model for estimating the elasticities in the short run without losing any information about the long run. The 9th version of EViews is used, where the ARDL and bounds test method is already a built-in function.

The first step is making sure the variables used in the analysis are not integrated of the second order, for which unit root tests are conducted. In this thesis, the Augmented Dickey-Fuller (ADF) unit root test is chosen. The ADF test's null hypothesis is that there is a unit root and vice versa for the alternative hypothesis.

Before continuing with estimating the cointegrating model, testing for possible structural breaks is also required. Since it is necessary to test for possible structural breaks in the whole sample, the Quandt-Andrews breakpoint test is used. The test is similar to the Quandt likelihood ratio test, however, since the values of multiple F-statistics are compared, nonstandard distribution rather than F-distribution must be used, which is what differentiates the Quandt-Andrews breakpoint test from the Quandt likelihood ratio test.

Having made sure that there are no variables integrated of the second order, it is possible to estimate the long run relationship using the ARDL bounds approach. This itself is divided into three steps, the first of which is choosing the most suitable order of lags for the ARDL model. The Akaike Information Criterion is used in the context of this thesis (AIC), where the model with the smallest AIC value is the best. This means that an ARDL(1, 1) model, for example, also includes the first order lags of the variables.

Choosing the lag orders for the variables is followed by conducting the bounds test, which makes it possible to test for a long run relationship between variables. The null hypothesis of the bounds test states that a long run cointegration between the variables is not present. For this, the Wald F-statistic is estimated, which is then compared to the lower and upper critical bounds found by Pesaran *et al.* (2001, 300). If the F-statistic falls below the lower critical bound, a long run cointegration is not found. In case it is above the upper critical value, it is concluded that a long run relationship is present. However, should it fall between the lower and upper critical bounds, it is not possible to reach a definite conclusion. (Rashad, Razzaq 2010, 10)

Provided that a long run relationship exists, the cointegrating long run model is estimated using ECM. In addition to the long run relationship, ECM also allows the researcher to derive the short run relationship coefficients and the error correction term, which reflects the speed of adjustment to the long run equilibrium after a short-term shock. (Duasa 2007, 93)

Finally, tests for heteroskedasticity (White's test), autocorrelation (Breusch-Godfrey), the normality of residuals (Jarque-Bera) and goodness of the fit (Ramsey's RESET) are also conducted. Cumulative SUM (CUSUM) and cumulative SUM of squares (CUSUMQ) charts are used to check the stability of the model's parameters.

4. EMPIRICAL ANALYSIS AND RESULTS

The aim of this chapter is to present the results of the empirical analysis – i.e., tests for structural breaks, unit roots, the bounds test and the short and long run models of import demand. Having found the ARDL model, diagnostic tests are also conducted. Finally, policy recommendations for Estonia are given in the last sub-section based on the results.

4.1. Unit root tests

The first step before estimating the ARDL model is testing for unit roots in the variables. Though not actually a requirement since the ARDL bounds test method can be used with variables that are either I(0), I(1) or a combination of the two, it is still important to make sure they are not I(2). The ADF test is used to test for unit roots, using AIC to select the optimal lag lengths. The results are given below in Table 2, where the variables are as follows: LN_IM is the natural logarithm of real imports, LN_RP is the natural logarithm of the relative price variable and LN_Y is the natural logarithm of income.

Table 2. ADF tests results

	Level			First difference		
	LN_IM	LN_RP	LN_Y	LN_IM	LN_RP	LN_Y
Trend and intercept	0.299	0.612	0.307	0.102	0.000	0.102
Intercept	0.208	0.702	0.492	0.035	0.000	0.025
Without trend or intercept	0.910	0.059	0.950	0.005	0.000	0.005

Source: Author's calculations in EViews 9

Even though the ADF test statistic is significant for imports already in the equation with an intercept, the intercept itself is statistically insignificant, requiring further testing, as is the case with the relative price variable. As seen from the test results, all variables – real imports, relative price and income – are integrated of the first order.

4.2. Tests for structural breaks

To test for the possible existence of structural breaks in the import demand model to be used later, the Quandt-Andrews breakpoint test is used. The test finds values for the Chow test F-statistics for different breakpoints. The breakpoint with the highest F-statistic value is chosen, the corresponding p-value of which is used to accept or reject the null hypothesis of no structural breaks.

A simple Ordinary Least Squares model is used to check for structural breaks, using logarithm values of real import as the dependent variable and relative price and real GDP as regressors. The results of the Quandt-Andrews test are presented below in Table 3.

Table 3. Quandt-Andrews breakpoint test results

Test statistic	Value	P-value
Maximum Wald F-statistic (2005Q1)	113.988	0.000

Source: Appendix 2, compiled by the author

The highest value of the F-statistic is at the first quarter of 2005, which is statistically significant at 1%, meaning the structural break needs to be accounted for in the ARDL model as well. A possible reason for the break might be Estonia's accession into the European Union in May 2004, making international trading with other member countries substantially easier.

4.3. ARDL bounds test for cointegration

Since the assumption of no variables integrated of the second order is met, the ARDL bounds test method can be used to test for cointegration. Optimal lag lengths need to be found, for which the Akaike Information Criterion is used again, as with the ADF test. The model with the smallest AIC value (see Appendix 3) is ARDL(1, 1, 3) – 1 lag of the import and relative price variables and 3 lags of the GDP variable are included in the model (see Appendix 4). It is important to remind that as a structural break in the first quarter of 2005 is found earlier, a dummy variable is included in the ARDL model as a fixed regressor, with the value of 0 from 1999Q3 until 2004Q4 and 1 from 2005Q1 onwards.

Having found the ARDL model with the most suitable lags, the bounds test can be conducted. The F-statistic obtained from the test is then compared to the critical value bounds proposed by Pesaran *et al.* (2001, 300). Should the F-statistic fall below the lower bound, the null hypothesis of no long-run relationships is accepted, vice versa in case the F-statistic is greater than the upper critical bound. However, if the F-statistic falls between the lower and upper bounds, the result is inconclusive – the null hypothesis cannot be accepted, nor can it be rejected. The output of the test is presented below in Table 4.

Table 4. Bounds test result and the critical bounds

		10%		5%		1%	
Test statistic	Value	Lower	Upper	Lower	Upper	Lower	Upper
F-statistic	6.881	2.630	3.350	3.100	3.870	4.130	5.000

Source: Appendix 5, compiled by the author

Since the value of the F-statistic is greater than the upper bound even at the 1% level, the null hypothesis of no long run relationships is rejected. However, it is important to note one aspect of the bounds test equation: the dummy variable included in the model earlier is statistically very insignificant (see Appendix 5). Even though the Quandt-Andrews test for structural breaks conducted earlier found a structural break, including it in the ARDL model possibly gives less reliable results, therefore, it is excluded from the equation. This affects the bounds test F-statistic marginally (6.785 after the exclusion of the structural break dummy), meaning the null hypothesis of no cointegration is still rejected. The adjusted R-squared, however, is higher, confirming the superiority of the equation without the dummy (see Appendices 5 and 6).

4.3.1. Short and long run models

Provided the result of the bounds test is positive, i.e. the variables are cointegrated, the short and long run models can be estimated. For the estimation of the short term coefficients, the error correction model is used. First differences of the variables in the ECM are the short term coefficients, while the error correction term shows the speed of adjustment from a shock in the short run to the long run equilibrium. The results are presented below in Table 5.

Table 5. Short run model coefficients

Variable	Coefficient	Standard error	t-statistic	P-value
D(LN_RP)	–1.284	0.309	–4.163	0.000
D(LN_Y)	0.374	0.309	1.155	0.252
ECM(–1)	–0.439	0.082	–5.327	0.000

Source: Appendix 7, compiled by the author

The coefficient of the relative price variable is highly significant. In the short run, 1% change in the relative price of imports causes import demand to move in the opposite direction by 1.284%. The absolute value of the coefficient is greater than 1, therefore it can be said that in the short run, imports are price elastic. The error correction term (ECM(-1) in Table 5 above) is also highly significant and with the expected negative sign. The value of the term is -0.439 (or 43.9%), meaning that a deviation in the short run from the long run equilibrium adjusts in about two months. As for income, the coefficient is very small and also insignificant, which means no conclusion on the effects of income to real imports in the short run can be made.

The coefficients are statistically significant for both income and relative price variables in the long run, at 1% and 10% respectively. In the long run, import demand is not price elastic as is the case in the short run, but is price inelastic instead. The coefficient is -0.865, meaning a 1% change in the relative price affects import demand in the opposite direction, but the impact on the demand for imports is smaller than 1%. Income, which is statistically insignificant in the short run, is now statistically very significant. The elasticity of income to import demand is 1.228, meaning import demand is income elastic in the long run. The long run coefficients are presented below in Table 6.

Table 6. Long run model coefficients

Variable	Coefficient	Standard error	t-statistic	P-value
LN_RP	–0.865	0.469	–1.846	0.069
LN_Y	1.228	0.192	6.393	0.000
C	1.754	3.674	0.477	0.635

Source: Appendix 7, compiled by the author

4.4. Diagnostic tests

To check the validity of the estimated model, six different tests are used: Breusch-Godfrey serial correlation test, White's heteroskedasticity test, Jarque-Bera test for the normality of residuals, Ramsey's RESET test for model specification and CUSUM and CUSUMQ tests to check the stability of the model. The results of the first four diagnostic tests are given in Table 7, the plots for CUSUM and CUSUMQ tests are presented in Appendices 12 and 13, respectively.

Table 7. Diagnostic tests results

Test	Value of F-statistic / JB test statistic	P-value
Breusch-Godfrey	1.367	0.256
White	8.750	0.000
Jarque-Bera	16.757	0.000
Ramsey's RESET	2.168	0.146

Source: Appendices 8–11, compiled by the author

Serial correlation of the residuals is rejected as the F-statistic for the Breusch-Godfrey test is statistically insignificant. In addition, Ramsey's RESET test gave confirmation regarding the validity of the functional form of the model. Both CUSUM and CUSUMQ tests show that the parameters of the model are relatively stable during the sample period. As seen from the table above, the White's test for heteroscedasticity and Jarque-Bera test for normality of the residuals have unfortunately failed. However, since the model estimated is not used for forecasting, the failure of the Jarque-Bera test is not considered as that big of an issue as to dismiss the estimated model completely. Moreover, previous research on the normality of residuals suggests that a sample size under 100 is often large enough to not require normal distribution (Lumley *et al.* 2002, 166). Secondly, heteroscedasticity does not have an impact on the coefficients of the parameters, but on the effectiveness of the parameters themselves, possibly resulting in considering a parameter as statistically significant even if it is actually insignificant. Therefore, to account for the presence of heteroskedasticity, the ARDL model is estimated again, using White heteroskedasticity-consistent standard errors and covariance. As a result, the relative price variable which was statistically significant at 10% before, is now statistically insignificant. The long run coefficients with adjusted standard errors and t-statistics are presented below in Table 8.

Table 8. Re-estimated long run model coefficients with White heteroskedasticity-consistent standard errors and covariance

Variable	Coefficient	Standard error	t-statistic	P-value
LN_RP	–0.865	0.555	–1.559	0.124
LN_Y	1.228	0.299	4.098	0.000
C	1.754	4.981	0.352	0.726

Source: Appendix 14, compiled by the author

4.5. Analysis of the results

Import demand in Estonia is price elastic in the short run, with the coefficient of the relative price variable being –1.284. At first, the long run coefficient of the relative price variable is estimated to be –0.865, which would have meant that import demand in Estonia is price inelastic. However, after discovering the issue of heteroskedasticity in the estimated model, the model was re-estimated using White heteroskedasticity-consistent standard errors and variations. This showed that the relative price variable is unreliable in the long run since the increase in the standard error caused it to be statistically insignificant. On the other hand, income, which is not statistically significant in the short run, clearly has an impact on import demand in the long run, with its coefficient of 1.228 suggesting import demand is income elastic. Due to the income elasticity of import demand in the long run, the Estonian government should focus on encouraging the industries in which there is relatively less demand for imports, which would help increase the trade balance and also domestic output.

After the sample adjustment due to the lag orders of the ARDL model, only 74 observations were included in the analysis, which is the main shortcoming of the analysis. The elasticities should therefore be re-estimated in a few years when more observations can be included in the analysis. Moreover, price and income elasticities could also be estimated for different sectors. However, the time series of import price indices by economic activites are available from 2010, meaning that at the time of writing this thesis, using disaggregated data would make the data sample even smaller. Also, even though the import price indices are estimated monthly, it would be difficult to find a good proxy for monthly income, therefore increasing the risk of incorrect estimates. Having said that, at some point it may provide much more detailed information about the impact of changes in income and price on import demand.

SUMMARY

Researching import demand is important as estimating a model presenting the income and price elasticities helps policy makers formulate more efficient trade policies, which in turn have an effect on the country's trade balance. The aim of this bachelor's thesis was to estimate an aggregate import demand model for Estonia, where imports as a share of gross domestic product have historically been rather high and in the case of imported goods, exceeded exports in all the years under observation in this thesis, making Estonia a net borrower on the international goods market. To the best of the author's knowledge, the price elasticity of Estonia's import demand has been estimated only in the research of Kee *et al.* (2004), however, no known research has been conducted on the income elasticity of import demand in Estonia.

The structure of the thesis was as follows. Chapter 1 gave an overview of the theory of imports: its role in macroeconomic theory and the determinants of imports. Furthermore, the difference between and the possibilities of economic growth in open and closed economies are discussed and finally, findings of previous studies on import demand elasticities are presented. Chapter 2 gave an overview of Estonia's trade balance during the sample period. Chapter 3 explained the methodology of the analysis and presented the data used in the research. The empirical analysis is conducted in Chapter 4, using the Autoregressive Distributed Lag bounds test approach to cointegration from the fourth quarter of 1998 to the fourth quarter of 2017.

Two research questions were set for this thesis: firstly, how import demand reacts to changes in the relative price of foreign goods and services in terms of Estonian goods and services; secondly, how import demand reacts to changes in Estonian income. To find the answers for the research questions, unit root tests needed to be conducted to check for the order of integration of the variables used, as including a variable integrated of the second order would have disproved the model immediately. Since no such variables were found, an

autoregressive distributed lag model with optimal lag lengths was estimated, for which the Akaike Information Criterion was used. This was followed by conducting the bounds test for a long run relationship between the variables. The result of the bounds test was positive, a prerequisite for estimating the short and long run coefficients, confirming a long run relationship at 1% significance. Therefore, the short and long run coefficients could be estimated. Import demand was found to be price elastic in the short run, with the elasticity being –1.284, however, the impact of income on import demand in the short run was statistically insignificant. In the long run, income elasticity of import demand is 1.228, meaning import demand is income elastic in the long run. However, no conclusions can be made on the price elasticity or inelasticity as there was a problem with heteroskedasticity and after estimating the model again with heteroskedasticity accounted for, the relative price parameter turned out to be statistically insignificant. The purpose of this thesis was unfortunately not fulfilled since aggregate import demand models could not be estimated for neither short nor long run. Having said that, the findings of this thesis, namely the price elasticity and income elasticity in the short and long run models, respectively, provide useful information for future reference.

The main problem with the analysis is the small size of the data sample. With only 74 observations, it is unsurprising that the models could not be estimated, especially in the long run as the sample spans just 18 years. It is also highly likely that the economic recession of 2007–2008 has a notable impact on the parameters estimated. For these reasons, further research on import demand is required in the future when more observations can be included in the analysis, making the results more accurate and reliable and therefore enabling to draw more valid conclusions. What is more, the import price and income elasticities could be researched using disaggregated data as well, to obtain a better understanding of the effects of changes in prices and income to the import demand in different sectors.

KOKKUVÕTE

IMPORDINÕUDLUSE HINNA- JA SISSETULEKUELASTSUS EESTIS

Markus Alttoa

Euroopa Liidu riikide seas on Eestis kaupade ja teenuste import osakaaluna sisemajanduse kogutoodangust üks suurimaid, samal ajal on väliskaubanduse bilanss finantskriisi järgsete aastate jooksul olnud küll positiivne, kuid küllalt väikesel määral. Vaadeldes kaupade ja teenuste bilansse eraldi nähtub, et viimaste aastate positiivne kaubandusbilanss tuleneb teenuste bilansi ülejäägist, samas kui kaupade import on terve vaatluse all oleva perioodi jooksul eksporti ületanud. Selleks, et hoida väliskaubandusbilanssi negatiivseks pöördumast ning võimalusel kaubandusbilansi ülejääki kasvatada, on muu hulgas oluline teada, kuidas imporditud ning kodumaiste kaupade ja teenuste suhteline hind ning sissetulek Eestis impordinõudlust mõjutavad. Sellest tulenevalt seati ka käesoleva bakalaureusetöö eesmärgiks impordinõudluse lühi- ning pikaajaliste mudelite koostamine Eestis, hinnates, kuidas muutused suhtelises hinnas ning sissetulekus mõjutavad nõudlust impordi suhtes.

Bakalaureusetöö struktuur oli järgnev: esimeses peatükis anti ülevaade impordi teoreetilisest käsitlusest makroökonoomikas, impordinõudlust mõjutatavatest teguritest ning selle rolli riigi väliskaubandusbilansis. Lisaks anti ka ülevaade varasematest impordinõudlust käsitlenud uuringutest. Teises peatükis uuriti eraldi Eesti kaupade ning teenuste kaubandusbilansse vaatluse all olevate aastate jooksul. Kolmandas peatükis kirjeldati uurimismetoodikat ning tutvustati analüüsis kasutatavaid andmeid. Neljandas peatükis kirjeldati analüüsitulemusi ning tehti nende põhjal järeldusi.

Autor kasutas analüüsis Eesti impordi reaalväärtusi, mis saadi nominaalse impordi ja impordi hinnaindeksi jagatise tulemusena. Suhtelise hinna leidmiseks jagati omavahel läbi impordi hinnaindeks ning tarbijahindade harmoneeritud indeks, mida kasutati kodumaiste

hindade kirjeldamiseks. Sissetuleku jaoks kasutati sisemajanduse kogutoodangu reaalväärtusi. Analüüsiks kasutati autoregressiivse jaotatud viitaegadega mudeli ning piiride testi kombinatsiooni, mille abil on võimalik modellerida nii lühi- kui ka pikaajalisi mudeleid. Uurimise all oli periood 1999. aasta teisest kvartalist 2017. aasta neljanda kvartalini. Sisemajanduse kogutoodangu reaalväärtused saadi Eurostati andmebaasist, kõik ülejäänud andmed Statistikaameti andmebaasist.

Analüüsi tulemusena leiti, et lühiajaliselt on impordinõudlus hinnaelastne ning vastav elastsuskoefitsient oli –1.284, samas sissetuleku parameeter oli lühiajalises mudelis statistiliselt ebaoluline. Pikaajalises mudelis oli olukord aga vastupidine – suhtelise hinna parameeter oli statistiliselt ebaoluline, kuid sissetuleku elastsuskoefitsient oli 1.228 ehk pikaajaliselt on impordinõudlus sissetulekuelastne. Kuna mõlema mudeli puhul oli üks kahest parameetrist statistiliselt ebaoluline, polnud võimalik impordinõudluse mudeleid modelleerida. Sellegipoolest on võimalik leitud elastsusi kasutada tulevastes töödes võrdlusinformatsioonina.

Käesoleva analüüsi suurimaks probleemiks on küllalt lühike uurimisperiood. Selle tõttu on tulevikus vajalik teostada täiendavaid analüüse Eesti impordinõudluse osas, kui vaatluse alla on võimalik võtta pikem periood ning mille tulemusena saaks teha paikapidavamaid järeldusi. Peale selle oleks teatud hetkel, kui andmeid on piisavalt, võimalik uurida impordinõudluse hinna- ja sissetulekuelastsuseid ka tegevusalade lõikes, mis annaks veelgi detailsemat informatsiooni impordinõudluse hinna- ning sissetulekuelastsuse kohta.

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APPENDICES

Appendix 1. Quarterly data for ARDL estimation 1998–2017

Quarter	Seasonally adjusted nominal imports	Import price index	Harmonised consumer price index	Real imports	Relative price
1998Q4	1296.329	77.964	62.239	1662.724	125.266
1999Q1	1200.336	77.859	63.155	1541.680	123.282
1999Q2	1206.649	78.019	63.712	1546.600	122.457
1999Q3	1237.925	78.154	63.730	1583.963	122.632
1999Q4	1387.841	78.314	64.163	1772.145	122.054
2000Q1	1092.675	81.946	65.077	1333.411	125.921
2000Q2	1157.273	82.493	65.600	1402.871	125.752
2000Q3	1236.225	83.320	66.516	1483.715	125.262
2000Q4	1274.425	83.851	67.593	1519.867	124.054
2001Q1	1245.055	84.664	68.822	1470.579	123.020
2001Q2	1365.291	84.617	69.895	1613.497	121.062
2001Q3	1365.262	84.635	70.379	1613.112	120.257
2001Q4	1375.984	84.735	70.583	1623.862	120.050
2002Q1	1473.451	84.138	71.833	1751.232	117.129
2002Q2	1568.014	84.509	72.818	1855.440	116.055
2002Q3	1504.052	84.714	72.406	1775.442	116.999
2002Q4	1523.418	84.630	72.666	1800.090	116.465
2003Q1	1671.213	83.409	73.495	2003.637	113.489
2003Q2	1713.278	83.351	73.375	2055.495	113.597
2003Q3	1718.109	83.146	73.322	2066.380	113.398
2003Q4	1814.058	82.583	73.548	2196.657	112.284
2004Q1	1679.278	82.296	73.963	2040.539	111.266
2004Q2	2125.738	82.656	75.712	2571.778	109.173
2004Q3	2038.021	83.104	76.182	2452.383	109.086
2004Q4	2162.985	83.638	76.786	2586.129	108.924
2005Q1	2088.187	85.664	77.305	2437.640	110.813
2005Q2	2246.910	86.091	78.414	2609.936	109.791
2005Q3	2419.149	86.267	79.490	2804.260	108.525
2005Q4	2600.988	86.425	79.884	3009.538	108.188
2006Q1	2668.597	88.856	80.714	3003.268	110.088
2006Q2	2795.600	89.388	81.903	3127.488	109.139
2006Q3	2852.884	89.696	82.998	3180.618	108.070
2006Q4	2991.397	90.209	83.484	3316.071	108.056

Appendix 1 continued

Quarter	Seasonally adjusted nominal imports	Import price index	Harmonised consumer price index	Real imports	Relative price
2007Q1	3263.229	91.654	84.815	3560.385	108.063
2007Q2	3309.467	92.062	86.690	3594.834	106.197
2007Q3	3155.779	92.606	88.586	3407.730	104.539
2007Q4	3077.164	93.122	91.204	3304.434	102.104
2008Q1	3210.881	96.370	94.433	3331.837	102.050
2008Q2	2982.189	96.754	96.631	3082.242	100.127
2008Q3	3057.494	97.817	98.367	3125.727	99.441
2008Q4	2784.432	99.454	99.123	2799.720	100.334
2009Q1	2252.239	91.670	97.923	2456.909	93.614
2009Q2	1981.552	91.704	96.857	2160.817	94.680
2009Q3	1997.936	91.459	97.445	2184.514	93.857
2009Q4	2117.392	92.456	97.099	2290.150	95.219
2010Q1	2307.550	97.696	97.941	2361.969	99.749
2010Q2	2422.151	99.054	99.646	2445.285	99.406
2010Q3	2551.921	100.949	100.486	2527.938	100.461
2010Q4	2794.482	102.301	101.927	2731.618	100.367
2011Q1	3139.451	110.891	103.070	2831.116	107.588
2011Q2	3152.879	112.217	104.910	2809.620	106.965
2011Q3	3361.999	113.701	105.916	2956.864	107.351
2011Q4	3193.274	114.180	106.423	2796.690	107.290
2012Q1	3416.131	117.346	107.809	2911.154	108.846
2012Q2	3435.915	118.838	109.385	2891.250	108.643
2012Q3	3705.344	119.544	110.290	3099.574	108.390
2012Q4	3531.726	119.170	110.563	2963.603	107.784
2013Q1	3653.000	117.238	111.947	3115.874	104.726
2013Q2	3635.690	117.373	113.433	3097.563	103.473
2013Q3	3626.555	116.873	114.003	3102.999	102.517
2013Q4	3474.564	116.125	112.882	2992.084	102.873
2014Q1	3807.822	114.375	113.218	3329.237	101.022
2014Q2	3650.859	114.086	114.111	3200.102	99.978
2014Q3	3753.160	114.104	114.011	3289.241	100.082
2014Q4	3690.320	114.162	113.087	3232.528	100.951
2015Q1	3804.636	109.033	112.932	3489.435	96.548
2015Q2	3561.177	110.220	114.578	3230.976	96.196
2015Q3	3617.435	111.528	114.003	3243.528	97.829
2015Q4	3654.200	111.951	113.218	3264.092	98.881
2016Q1	3919.706	104.699	113.273	3743.794	92.430
2016Q2	3902.344	104.930	114.720	3718.986	91.466
2016Q3	3756.491	105.870	115.371	3548.217	91.764
2016Q4	3819.200	106.938	115.004	3571.407	92.987
2017Q1	4086.455	111.662	116.773	3659.665	95.623

Appendix 1 continued

Quarter	Seasonally adjusted nominal imports	Import price index	Harmonised consumer price index	Real imports	Relative price
2017Q2	3959.902	111.941	118.622	3537.492	94.368
2017Q3	3921.342	111.599	120.016	3513.784	92.986
2017Q4	3979.443	111.494	119.696	3569.213	93.147

Source: (Statistics Estonia, tables NAA0061; XO08; XO023), author's calculations

Notes:

1. Nominal imports (Statistics Estonia, table NAA0061) are seasonally unadjusted in the database of Statistics Estonia, therefore the moving average method is used for seasonal adjustment.
2. The import price index (Statistics Estonia, table XO08) is presented monthly in the database of Statistics Estonia and is based to December 1997. The data is converted into quarterly data and is re-based to 2010.
3. The harmonised consumer price index (Statistics Estonia, table XO023) is also presented monthly in the database of Statistics Estonia and is based to 2005. Again, the data is converted into quarterly data and is re-based to 2010.
4. Real imports are obtained by deflating the seasonally adjusted nominal imports by the import price index.
5. The relative price time series is obtained by dividing the import price index by the harmonised consumer price index.

Appendix 2. Quandt-Andrews test

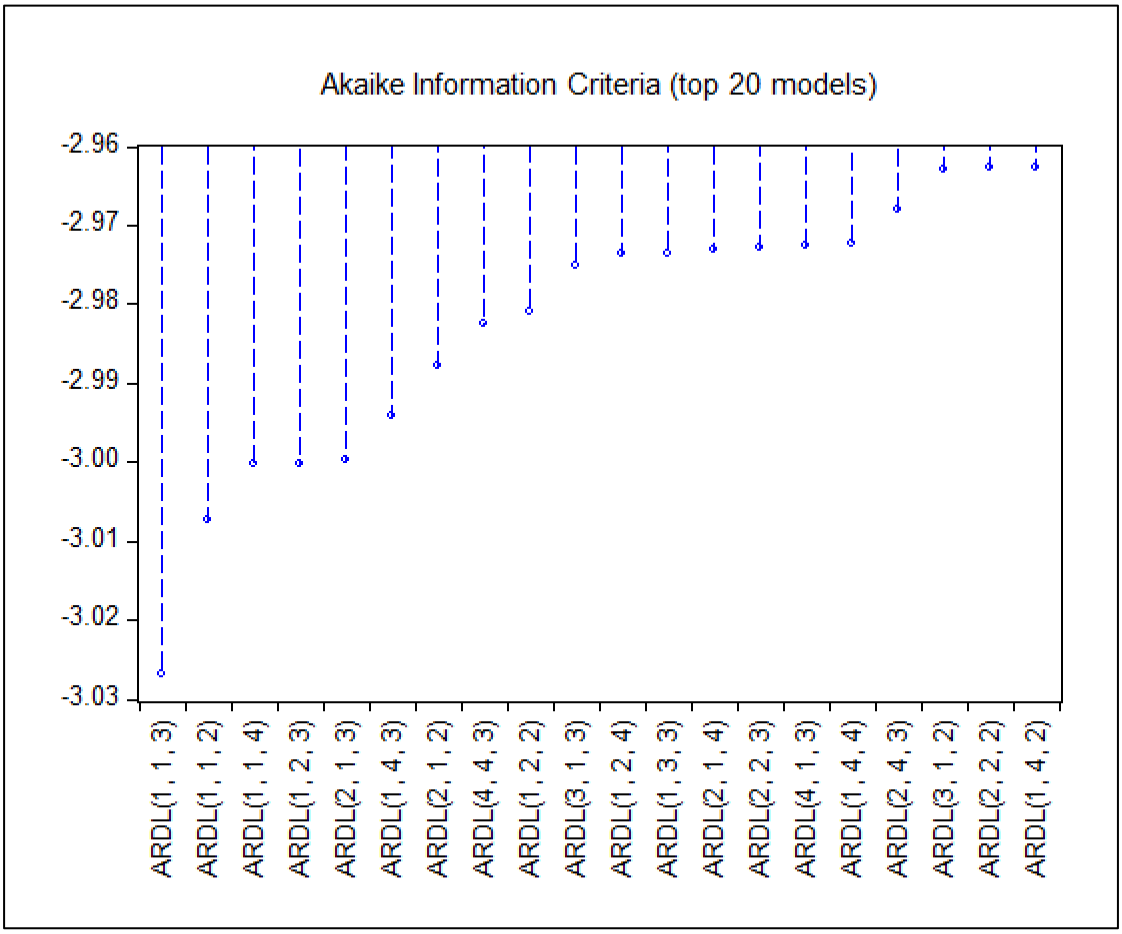
Quandt-Andrews unknown breakpoint test
Null Hypothesis: No breakpoints within 15% trimmed data
Varying regressors: All equation variables
Equation Sample: 1998Q4 2017Q4
Test Sample: 2001Q4 2015Q1
Number of breaks compared: 54

Statistic	Value	Prob.
Maximum LR F-statistic (2005Q1)	37.99610	0.0000
Maximum Wald F-statistic (2005Q1)	113.9883	0.0000
Exp LR F-statistic	15.74739	1.0000
Exp Wald F-statistic	53.15587	1.0000
Ave LR F-statistic	12.00150	0.0000
Ave Wald F-statistic	36.00450	0.0000

Note: probabilities calculated using Hansen's (1997) method

Source: Author's calculations in EViews based on data in Appendix 1 and Eurostat (table namq_10_gdp)

Appendix 3. AIC of evaluated models



Source: Author's calculations in EViews based on data in Appendix 1 and Eurostat (table namq_10_gdp)

Appendix 4. ARDL model with optimal lag lengths

Dependent Variable: LOG(REAL_IMPORT)
Method: ARDL
Date: 05/13/18 Time: 21:21
Sample (adjusted): 1999Q3 2017Q4
Included observations: 74 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LOG(RELATIVE_PRICE) LOG(Y)

Fixed regressors: DUMMY C
Number of models evalulated: 100
Selected Model: ARDL(1, 1, 3)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LOG(REAL_IMPORT(-1))	0.559972	0.099547	5.625206	0.0000
LOG(RELATIVE_PRICE)	-1.375988	0.389695	-3.530934	0.0008
LOG(RELATIVE_PRICE(-1))	0.995268	0.342522	2.905704	0.0050
LOG(Y)	0.341286	0.357912	0.953545	0.3438
LOG(Y(-1))	2.007456	0.489482	4.101189	0.0001
LOG(Y(-2))	-1.278862	0.499157	-2.562046	0.0127
LOG(Y(-3))	-0.590302	0.386575	-1.527003	0.1316
DUMMY	0.028058	0.028573	0.981973	0.3298
C	1.251390	1.611012	0.776772	0.4401

R-squared	0.970761	Mean dependent var	7.865730
Adjusted R-squared	0.967162	S.D. dependent var	0.284661
S.E. of regression	0.051584	Akaike info criterion	-2.977638
Sum squared resid	0.172960	Schwarz criterion	-2.697414
Log likelihood	119.1726	Hannan-Quinn criter.	-2.865853
F-statistic	269.7545	Durbin-Watson stat	2.088418
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

Source: Author's calculations in EViews based on data in Appendix 1 and Eurostat (table namq_10_gdp)

Appendix 5. Bounds test with dummy variable included

ARDL Bounds Test
Date: 05/13/18 Time: 21:22
Sample: 1999Q3 2017Q4
Included observations: 74
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	6.881481	2

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.63	3.35
5%	3.1	3.87
2.5%	3.55	4.38
1%	4.13	5

Test Equation:
Dependent Variable: DLOG(REAL_IMPORT)
Method: Least Squares
Date: 05/13/18 Time: 21:22
Sample: 1999Q3 2017Q4
Included observations: 74

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(RELATIVE_PRICE)	-1.375988	0.389695	-3.530934	0.0008
DLOG(Y)	0.341286	0.357912	0.953545	0.3438
DLOG(Y(-1))	1.869164	0.359191	5.203811	0.0000
DLOG(Y(-2))	0.590302	0.386575	1.527003	0.1316
DUMMY	0.028058	0.028573	0.981973	0.3298
C	1.251390	1.611012	0.776772	0.4401
LOG(RELATIVE_PRICE(-1))	-0.380720	0.179156	-2.125077	0.0374
LOG(Y(-1))	0.479578	0.187555	2.557005	0.0129
LOG(REAL_IMPORT(-1))	-0.440028	0.099547	-4.420314	0.0000

R-squared	0.512457	Mean dependent var	0.011301
Adjusted R-squared	0.452452	S.D. dependent var	0.069712
S.E. of regression	0.051584	Akaike info criterion	-2.977638
Sum squared resid	0.172960	Schwarz criterion	-2.697414
Log likelihood	119.1726	Hannan-Quinn criter.	-2.865853
F-statistic	8.540191	Durbin-Watson stat	2.088418
Prob(F-statistic)	0.000000		

Source: Author's calculations in EViews based on data in Appendix 1 and Eurostat (table namq_10_gdp)

Appendix 6. Bounds test without dummy variable

ARDL Bounds Test
Date: 05/13/18 Time: 21:22
Sample: 1999Q3 2017Q4
Included observations: 74
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	6.784829	2

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.63	3.35
5%	3.1	3.87
2.5%	3.55	4.38
1%	4.13	5

Test Equation:
Dependent Variable: DLOG(REAL_IMPORT)
Method: Least Squares
Date: 05/13/18 Time: 21:22
Sample: 1999Q3 2017Q4
Included observations: 74

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(RELATIVE_PRICE)	-1.284439	0.378276	-3.395504	0.0012
DLOG(Y)	0.373818	0.356279	1.049227	0.2979
DLOG(Y(-1))	1.797068	0.351513	5.112386	0.0000
DLOG(Y(-2))	0.544740	0.383677	1.419788	0.1604
C	0.769721	1.534107	0.501739	0.6175
LOG(RELATIVE_PRICE(-1))	-0.379579	0.179104	-2.119330	0.0378
LOG(Y(-1))	0.538891	0.177514	3.035766	0.0034
LOG(REAL_IMPORT(-1))	-0.438807	0.099512	-4.409587	0.0000

R-squared	0.505224	Mean dependent var	0.011301
Adjusted R-squared	0.452748	S.D. dependent var	0.069712
S.E. of regression	0.051570	Akaike info criterion	-2.989939
Sum squared resid	0.175526	Schwarz criterion	-2.740851
Log likelihood	118.6277	Hannan-Quinn criter.	-2.890574
F-statistic	9.627677	Durbin-Watson stat	2.062414
Prob(F-statistic)	0.000000		

Source: Author's calculations in EViews based on data in Appendix 1 and Eurostat (table namq_10_gdp)

Appendix 7. ARDL cointegrating and long run form

ARDL Cointegrating And Long Run Form
Dependent Variable: LOG(REAL_IMPORT)
Selected Model: ARDL(1, 1, 3)
Date: 05/13/18 Time: 21:23
Sample: 1997Q1 2017Q4
Included observations: 74

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(RELATIVE_PRICE)	-1.284439	0.308511	-4.163351	0.0001
DLOG(Y)	0.373818	0.323782	1.154535	0.2524
DLOG(Y(-1))	1.797068	0.280534	6.405877	0.0000
DLOG(Y(-2))	0.544740	0.343677	1.585034	0.1177
CointEq(-1)	-0.438807	0.082380	-5.326624	0.0000

Cointeq = LOG(REAL_IMPORT) - (-0.8650*LOG(RELATIVE_PRICE) + 1.2281*LOG(Y) + 1.7541)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(RELATIVE_PRICE)	-0.865025	0.468628	-1.845867	0.0694
LOG(Y)	1.228081	0.192094	6.393122	0.0000
C	1.754121	3.674339	0.477398	0.6347

Source: Author's calculations in EViews based on data in Appendix 1 and Eurostat (table namq_10_gdp)

Appendix 8. Breusch-Godfrey serial correlation test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.367073	Prob. F(4,62)	0.2557
Obs*R-squared	5.997685	Prob. Chi-Square(4)	0.1993

Test Equation:
Dependent Variable: RESID
Method: ARDL
Date: 05/13/18 Time: 21:24
Sample: 1999Q3 2017Q4
Included observations: 74
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(REAL_IMPORT(-1))	0.144896	0.168623	0.859288	0.3935
LOG(RELATIVE_PRICE)	0.031368	0.378589	0.082855	0.9342
LOG(RELATIVE_PRICE(-1))	-0.048035	0.329197	-0.145916	0.8845
LOG(Y)	-0.051555	0.354370	-0.145483	0.8848
LOG(Y(-1))	-0.043038	0.499320	-0.086193	0.9316
LOG(Y(-2))	-0.236992	0.558410	-0.424404	0.6727
LOG(Y(-3))	0.103931	0.411469	0.252584	0.8014
C	0.811545	1.583195	0.512600	0.6101
RESID(-1)	-0.201607	0.217673	-0.926195	0.3579
RESID(-2)	-0.121112	0.154568	-0.783548	0.4363
RESID(-3)	-0.117058	0.142672	-0.820471	0.4151
RESID(-4)	0.220852	0.135458	1.630405	0.1081

R-squared	0.081050	Mean dependent var	-3.68E-15
Adjusted R-squared	-0.081990	S.D. dependent var	0.049035
S.E. of regression	0.051006	Akaike info criterion	-2.966354
Sum squared resid	0.161300	Schwarz criterion	-2.592722
Log likelihood	121.7551	Hannan-Quinn criter.	-2.817307
F-statistic	0.497117	Durbin-Watson stat	1.898066
Prob(F-statistic)	0.897964		

Source: Author's calculations in EViews based on data in Appendix 1 and Eurostat (table namq_10_gdp)

Appendix 9. White's heteroskedasticity test

Heteroskedasticity Test: White

F-statistic	8.750366	Prob. F(18,55)	0.0000
Obs*R-squared	54.84765	Prob. Chi-Square(18)	0.0000
Scaled explained SS	94.48566	Prob. Chi-Square(18)	0.0000

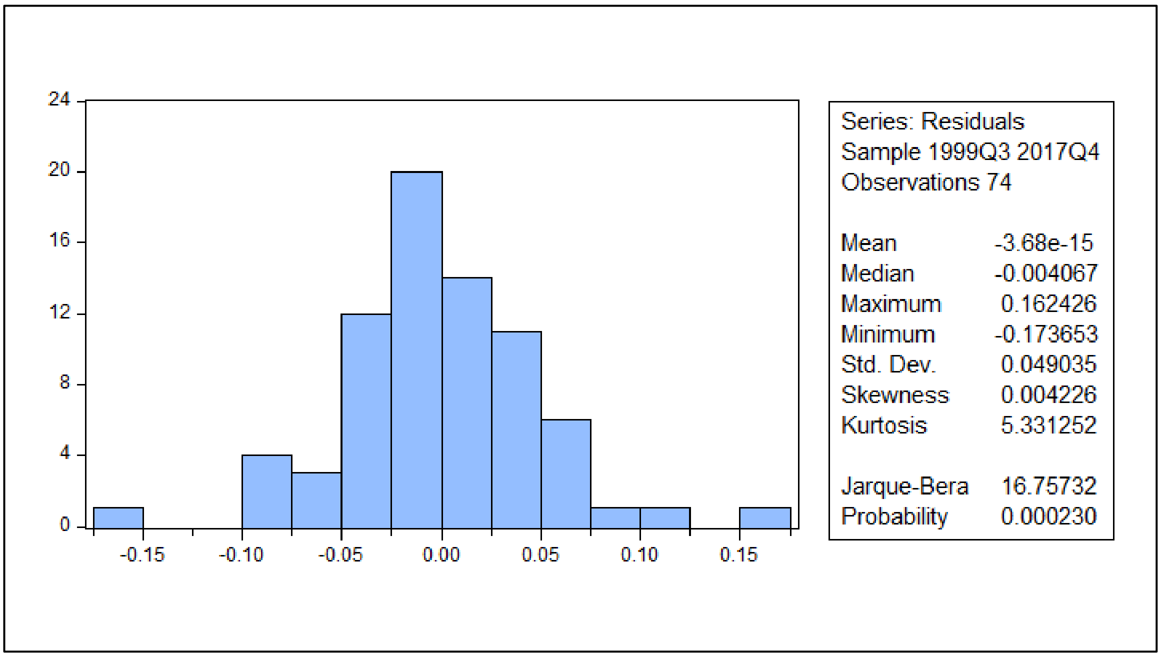
Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/13/18 Time: 21:24
Sample: 1999Q3 2017Q4
Included observations: 74
Collinear test regressors dropped from specification

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-7.322684	9.608393	-0.762113	0.4492
LOG(REAL_IMPORT(-1))^2	0.130472	0.083534	1.561906	0.1240
LOG(REAL_IMPORT(-1))*LOG(RELATIVE_	0.306140	0.167416	1.828615	0.0729
LOG(REAL_IMPORT(-1))*LOG(RELATIVE_	-0.043240	0.098169	-0.440467	0.6613
LOG(REAL_IMPORT(-1))*LOG(Y)	-0.215475	0.153912	-1.399991	0.1671
LOG(REAL_IMPORT(-1))*LOG(Y(-1))	-0.371098	0.171798	-2.160085	0.0351
LOG(REAL_IMPORT(-1))*LOG(Y(-2))	0.221378	0.106240	2.083755	0.0418
LOG(REAL_IMPORT(-1))*LOG(Y(-3))	-0.089247	0.211451	-0.422067	0.6746
LOG(REAL_IMPORT(-1))	0.466594	0.814279	0.573014	0.5690
LOG(RELATIVE_PRICE)^2	0.232587	0.438073	0.530932	0.5976
LOG(RELATIVE_PRICE)*LOG(RELATIVE_	-0.568813	0.827481	-0.687403	0.4947
LOG(RELATIVE_PRICE)*LOG(Y)	-0.240771	0.154040	-1.563040	0.1238
LOG(RELATIVE_PRICE)*LOG(Y(-1))	0.031308	0.172063	0.181958	0.8563
LOG(RELATIVE_PRICE)*LOG(Y(-2))	-0.378422	0.180065	-2.101584	0.0402
LOG(RELATIVE_PRICE)*LOG(Y(-3))	0.069180	0.164233	0.421230	0.6752
LOG(RELATIVE_PRICE)	2.350032	3.036226	0.773998	0.4422
LOG(RELATIVE_PRICE(-1))^2	0.320862	0.444682	0.721554	0.4736
LOG(Y)*LOG(Y(-1))	0.341465	0.168784	2.023085	0.0479
LOG(Y(-3))^2	0.022294	0.101920	0.218738	0.8277

R-squared	0.741184	Mean dependent var	0.002372
Adjusted R-squared	0.656481	S.D. dependent var	0.004970
S.E. of regression	0.002913	Akaike info criterion	-8.622457
Sum squared resid	0.000467	Schwarz criterion	-8.030872
Log likelihood	338.0309	Hannan-Quinn criter.	-8.386466
F-statistic	8.750366	Durbin-Watson stat	1.836389
Prob(F-statistic)	0.000000		

Source: Author's calculations in EViews based on data in Appendix 1 and Eurostat (table namq_10_gdp)

Appendix 10. Jarque-Bera test



Source: Author's calculations in EViews based on data in Appendix 1 and Eurostat (table namq_10_gdp)

Appendix 11. Ramsey's RESET test

Ramsey RESET Test
Equation: UNTITLED
Specification: LOG(REAL_IMPORT) LOG(REAL_IMPORT(-1)) LOG(RELATIVE_PRICE) LOG(RELATIVE_PRICE(-1)) LOG(Y) LOG(Y(-1)) LOG(Y(-2)) LOG(Y(-3)) C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.472356	65	0.1458
F-statistic	2.167833	(1, 65)	0.1458

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.005665	1	0.005665
Restricted SSR	0.175526	66	0.002659
Unrestricted SSR	0.169861	65	0.002613

Unrestricted Test Equation:
Dependent Variable: LOG(REAL_IMPORT)
Method: ARDL
Date: 05/13/18 Time: 21:25
Sample: 1999Q3 2017Q4
Included observations: 74
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic):
Fixed regressors: C

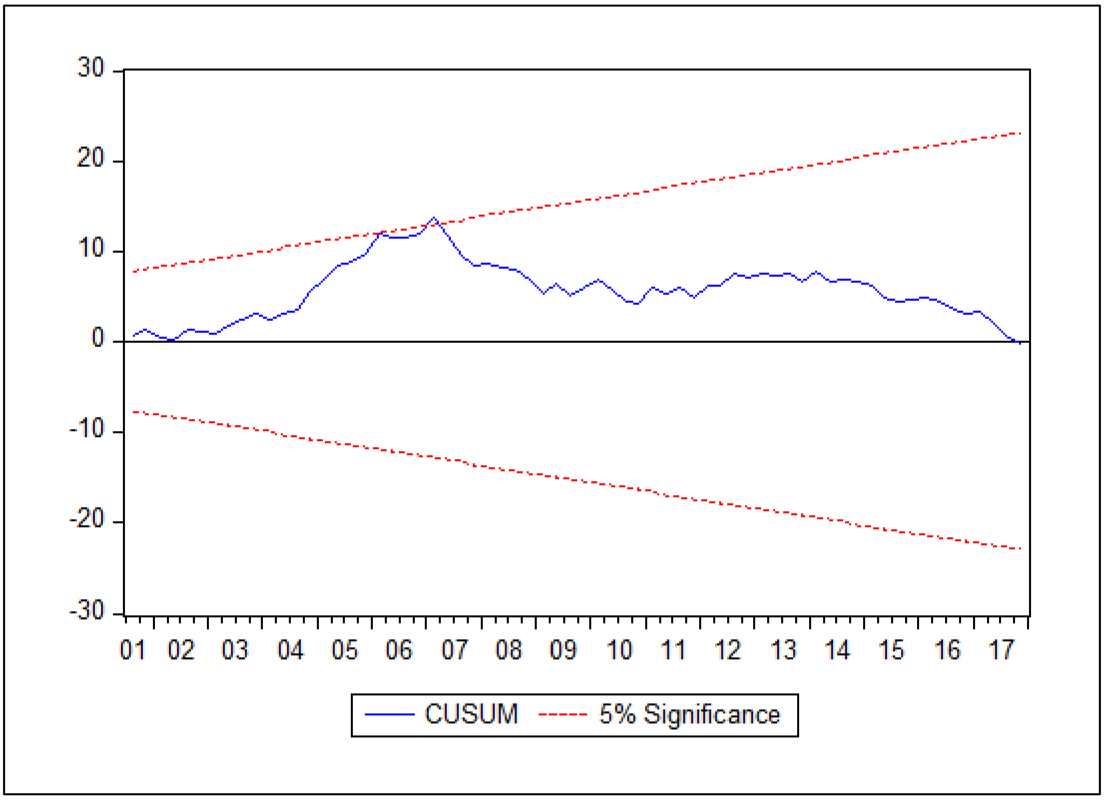
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LOG(REAL_IMPORT(-1))	1.760630	0.820588	2.145570	0.0356
LOG(RELATIVE_PRICE)	-4.114207	1.958169	-2.101048	0.0395
LOG(RELATIVE_PRICE(-1))	2.903103	1.396000	2.079587	0.0415
LOG(Y)	1.124752	0.620363	1.813054	0.0744
LOG(Y(-1))	6.140398	2.878599	2.133120	0.0367
LOG(Y(-2))	-3.928260	1.883373	-2.085757	0.0409
LOG(Y(-3))	-1.743604	0.898693	-1.940155	0.0567
C	-5.213636	4.339010	-1.201572	0.2339
FITTED^2	-0.133798	0.090874	-1.472356	0.1458

R-squared	0.971285	Mean dependent var	7.865730
Adjusted R-squared	0.967750	S.D. dependent var	0.284661
S.E. of regression	0.051120	Akaike info criterion	-2.995719
Sum squared resid	0.169861	Schwarz criterion	-2.715495
Log likelihood	119.8416	Hannan-Quinn criter.	-2.883934
F-statistic	274.8246	Durbin-Watson stat	2.175750
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

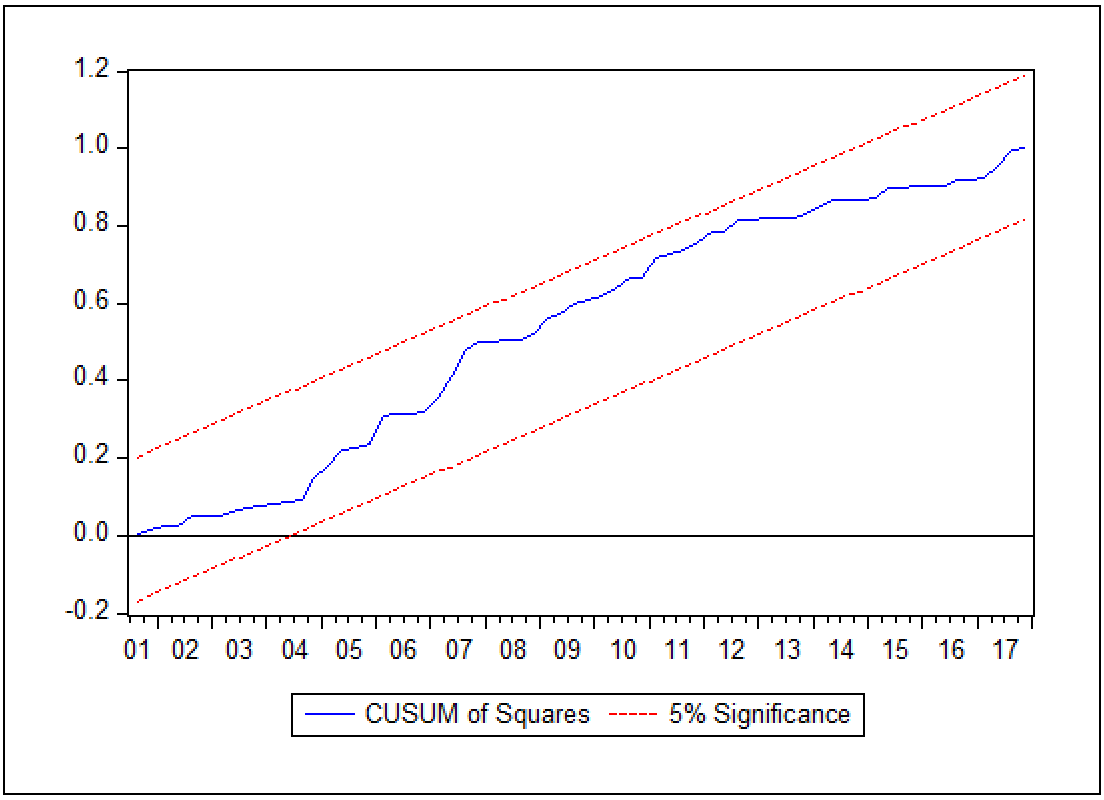
Source: Author's calculations in EViews based on data in Appendix 1 and Eurostat (table namq_10_gdp)

Appendix 12. CUSUM test



Source: Author's calculations in EViews based on data in Appendix 1 and Eurostat (table namq_10_gdp)

Appendix 13. CUSUMQ test



Source: Author's calculations in EViews based on data in Appendix 1 and Eurostat (table namq_10_gdp)

Appendix 14. ARDL cointegrating and long run form using White heteroskedasticity-consistent standard errors and covariance

ARDL Cointegrating And Long Run Form
Dependent Variable: LOG(REAL_IMPORT)
Selected Model: ARDL(1, 1, 3)
Date: 05/13/18 Time: 21:26
Sample: 1997Q1 2017Q4
Included observations: 74

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(RELATIVE_PRICE)	-1.284439	0.308511	-4.163351	0.0001
DLOG(Y)	0.373818	0.323782	1.154535	0.2524
DLOG(Y(-1))	1.797068	0.280534	6.405877	0.0000
DLOG(Y(-2))	0.544740	0.343677	1.585034	0.1177
CointEq(-1)	-0.438807	0.082380	-5.326624	0.0000

Cointeq = LOG(REAL_IMPORT) - (-0.8650*LOG(RELATIVE_PRICE) + 1.2281*LOG(Y) + 1.7541)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(RELATIVE_PRICE)	-0.865025	0.554995	-1.558618	0.1239
LOG(Y)	1.228081	0.299692	4.097811	0.0001
C	1.754121	4.981496	0.352127	0.7259

Source: Author's calculations in EViews based on data in Appendix 1 and Eurostat (table namq_10_gdp)