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The Impact of Brexit on the Swedish Economy

- A Study on the Swedish Forest Products Export Sector

Carl Lundberg

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Carl Lundberg

Supervisor: Yves Surry, Swedish University of Agricultural Sciences, Department of Economics

Examiner: Rob Hart, Swedish University of Agricultural Sciences, Department of Economics

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Abstract

On the 29th of March 2019, the U.K. is scheduled to leave the European Union. This withdrawal is estimated to affect both the U.K. and economies interacting with the U.K. This thesis aims to examine whether Brexit, through its effect on the British Pound, has an impact on the Swedish export of sawn softwood. The impact of exchange rates has been tested on as well aggregate export levels as disaggregate export levels in several other studies but with mixed results. At the same time, it has not been done on the Swedish market at this disaggregated level of forestry products before and is, therefore, an interesting subject to investigate further. The data used is multivariate monthly time series data, ranging from July 2005 to September 2017. A cointegrating relationship is established by the Johansen test leading to an estimation of a Vector Error-Correction Model. Finally, the Granger Causality test tests the existence of short-run causality amongst the variables. The results show that the exchange rate of the GBP/SEK affects the Swedish export of sawn softwood in the long term, but not in the short term. A continued stable and efficient pricing strategy could help to promote the Swedish exports of sawn softwood and retain their market power in the U.K.

Keywords: Brexit, Exchange Rate, Export, Forest industry, Time Series analysis, Vector Error-Correction Model.

Sammanfattning

Den 29 mars 2019 är det planerat att Storbritannien skall lämna EU. Detta utträde är bedömt att påverka både Storbritannien samt de länder som interagerar med Storbritannien. Syftet med denna uppsats är att analysera huruvida Brexit, genom dess effekt på valutakursen av det brittiska pundet, har en påverkan på den svenska exporten av barrträ. Analyser av växelkurseffekter har gjorts på både aggregerad och disaggregerad nivå i andra studier men med blandade resultat. Samtidigt har det inte gjorts på denna disaggregerade nivå på den svenska marknaden förut, vilket gör det till ett intressant ämne att analysera. Datan som har använts är månatlig multivariabel tidsserie-data från juli 2005 till september 2017. Analyserna görs i form av ett Johansen-test av cointegration samt av en Vector Error-Correction Model. Fortsatt utvärderas eventuell kausalitet mellan variablerna på kort sikt med ett Granger Causality-test. Resultaten visar att det finns en påverkan av växelkursförändringar i GBP/SEK på den svenska exporten av barrträ på lång sikt, men inte på kort sikt. En fortsatt effektiv och stabil prissättning kan hjälpa med att främja den svenska exporten av barrträ samt att behålla det marknadsinflytande som Sverige har i Storbritannien.

Nyckelord: Brexit, Växelkurs, Export, Skogsindustri, Tidsserieanalys, Vector Error-Correction Model.

Abbreviations

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
Brexit	Britain’s withdrawal from the European Union
EU	European Union
GBP	British Pound Sterling
GDP	Gross Domestic Product
SEK	Swedish Krona
VECM	Vector Error Correction Model
U.K.	United Kingdom

Table of Contents

List of tables

List of figures

Chapter 1 - Introduction

In this thesis, I will examine the effect of exchange rate changes on Sweden's export of sawn softwood to the U.K., which is a significant market for Swedish sawn softwood[1].

As economies the last century has become increasingly intertwined, we face a higher level of risk regarding macroeconomic factors today than what we have ever done before. The financial crisis in 2007 – 2008, also called the *global* financial crisis, is a clear sign of how vulnerable our economies are to a crisis that occurs in foreign markets. These increased uncertainties and risks that the increased globalisation of the world enables leaves no unaffected, it influences all kinds of markets, from greater economies to smaller economies.

On the 23 of June 2016, the U.K. voted in favour to end its membership in the European Union. This led to responses in the financial markets marked by considerable uncertainty: British FTSE 100 fell by 5.7 %, Swedish OMXS30 fell by 8.4 %, German DAX index fell by 9.6 %, and the American DJ USA fell by 5.1 %.[2,3] This bearish reaction raises awareness of larger concerns that may contribute to a reduced growth of the U.K. economy. Johnston & Buongiorno (2017) mean that these concerns are, amongst others, U.K.s ability to negotiate on favourable trade agreements with the EU and the rest of the world, as well as reduced household incomes. Another significant concern that Johnston & Buongiorno (2017); PwC (2016); KPMG (2016) highlights is that these uncertainties may encourage sales of U.K. assets and discourage investments among U.K. firms, putting downward pressure on the pound. This worry is also shared by Kommerskollegium (2017) which lists it as one of their most important concerns in the repercussions of the Brexit referendum. Overall, Kommerskollegium shows that the depreciation of the pound is one of the most evident effects of Brexit so far. One week after the poll the British Pound had depreciated by 7.3 % against the euro and by 9.3 % against the dollar, and one week further the drop had increased to 10.4 % and 12.6 % respectively (Bank of England, 2018). At the same time, the Pound depreciated against the Swedish Krona by 6.3 % and a week later the drop had increased to 8.8 % (NASDAQ OMX Stockholm AB). KPMG

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[1] Softwood is wood from conifers such as pine and spruce, which also is called coniferous wood.

[2] Stock market data is available on https://www.avanza.se/start

[3] Data on the British FTSE 100 is available on https://uk.finance.yahoo.com/quote/%5EFTSE/

(2016) and PwC (2016) lists it as likely that this development of the exchange rate will be a short to medium term effect of Brexit and that it is something that could have further impacts on Britain's continued trade.

For Sweden, concerns of a depreciating Pound are largely justified due to their elaborated trade relationship with the U.K. In 2015, the U.K. was Sweden's fourth and third largest export market for goods and services, respectively, and they were also the fifth and second most important supplying country for goods and services to Sweden (Kommerskollegium, 2016). The rate of Swedish export of goods to the U.K. was in 2015 the same as that going to the BRICS-countries[4], just to get the perspective of how important U.K. is for the Swedish export market of goods (Kommerskollegium, 2016).

The Swedish sectors that are exposed to the British economy are many, but those more exposed to an exchange depreciation is the export-oriented sectors of goods (Kommerskollegium, 2017). One of the largest export sectors in Sweden which exports goods to the U.K. is the forest products sector, which accounted for 22 % of total Swedish exports in 2015 (Kommerskollegium, 2016). Kommerskollegium presses the importance of the Swedish domestic forest products industry and its contribution to the Swedish economy and shows that Brexit may have adverse effects on the Swedish welfare through the forest sector in conjunction with other large and exposed export sectors.

To get an overall picture of the fundamentals exposing the Swedish forest sector to Brexit and exchange rate effects, this next section provides with a description of Sweden's and Britain's forest industry; this part also serves as an introduction to the forest industry and its peculiarities.

1.1. The Swedish forest industry

The forest industry is an industry where the market is continental rather than global (Skogssällskapet, 2005). It implies that even though Canada is the world leading exporter, they mainly export to their neighbouring countries, making Sweden the largest exporter to the European market. Approximately 70 % of Sweden's surface is covered by forest, and 80 % of

[4] Brazil, Russia, India, China and South Africa.

the forest land is in active use. Furthermore, the sector produced 17.8 million cubic metres of sawn timber in 2016 and had an export value of SEK 125 billion the same year. The sector is an employer for approximately 70 000 individuals and has an additional 30 000 one-man businesses operating within it (Swedish Forest Industries Federation, 2017a). Due to its size, the forest industry plays a more significant role in the Swedish economy compared to what it does to other EU-countries.

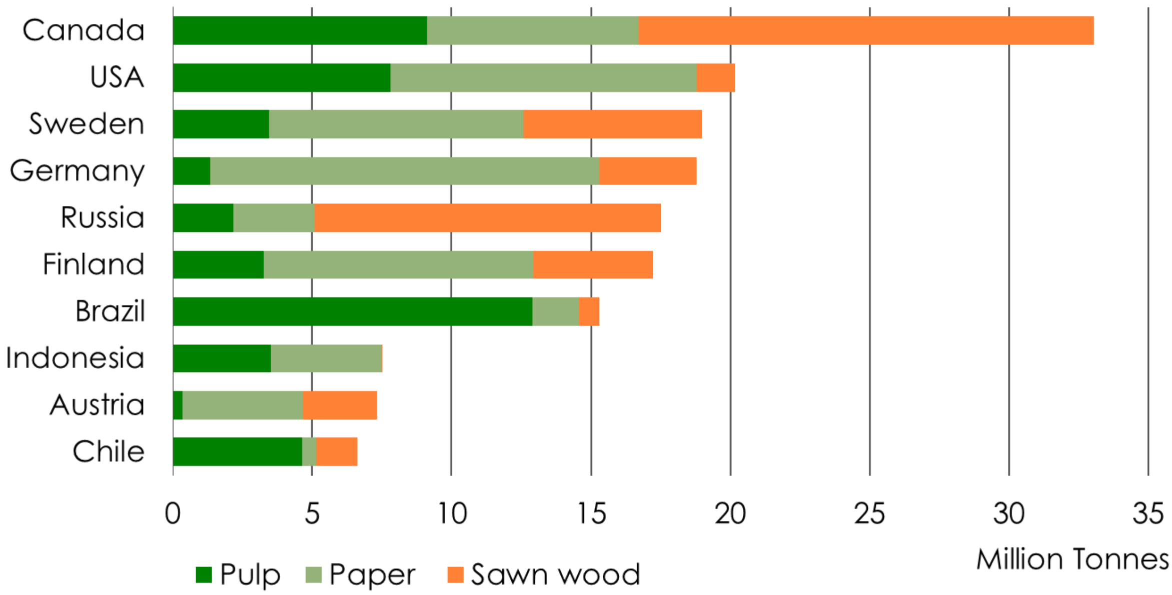

Figure 1 - The world leading exporters in 2016 – Pulp, Paper and Sawn wood.
Source: (Swedish Forest Industries Federation, 2017b).

As Figure 1 shows, in 2016, Sweden, Germany and Finland accounted for a majority of the exports originating from Europe. The major forestry products in Sweden are sawn softwood and pulp (for wood and for paper) which are the commodities with the highest production quantities, but also has the highest export quantities (FAO, 2018). Around 80 % of the total Swedish production of forest products is exported, and for sawn softwood, the same number corresponded to more than 70 % in 2016. For other important goods such as paper and pulp, the corresponding figures were 90 % and 30 % respectively (Swedish Forest Industry Federation, 2017b). Needless to say, the Swedish forest industry is highly oriented towards exports.

1.2. The British forest industry

With around 13 % of forest cover in 2015, the U.K. is one of the least densely forested countries in Europe and the second largest net importer of forest products in the world, with a forest industry that relies heavily on imports (Forestry Commission, 2017). In 2016, U.K. had a net trade deficit of $1.8 billion in sawnwood, and 88 % of the apparent consumption of wood[5] in the U.K. consisted of imports in 2016 (FAO, 2018). The apparent consumption consists largely of sawnwood, where almost all is coniferous (only 4 % is non-coniferous) and where over 60 % of the coniferous sawnwood is imported (Forestry Commission, 2017). Sweden has since 1993 consistently been the principal country of origin for U.K. sawn softwood products and a majority of Swedish export of sawn softwood is directed towards the U.K. (Forestry Commission, 2017; OEC, 2018). This trade relationship is important for Sweden and its forest product industry since a large part of its exports relies on it.

1.3. Problem

As the British pound depreciates foreign commodities becomes more expensive for British importers. Since wood products, in general, have negative price elasticity, this might affect the import demand of forest products in the U.K., which could lead to significant impacts on the British forest products industry as it relies heavily on imports (Michinaka, Tachibana & Turner, 2011). Multiple factors affect the development of an exchange rate, but as Johnston & Buongiorno (2017); KPMG (2016) and PwC (2016) explains, further uncertainties created by speculations and/or announcements regarding Brexit will most likely have effects on the future development of the British Pound. This indicates towards that even if it is certain that the U.K. will exit the EU, Brexit might still generate effects on the development of the British Pound. Michinaka, Tachibana & Turner (2011); Buongiorno (2015) also show that wood products, in general, are normal goods, which in combination with Johnston's & Buongiorno's (2017) projections of declining household incomes might have additional effects on the British import demand of forest products. These combined effects on the British economy could be very drastic, and thereby possible to affect international markets and especially those operating in the sectors which export forest products to the U.K.

[5] Excluding recovered paper.

As of now, Kommerskollegium (2016) reports that the Swedish export of goods going to the U.K. has matted off since 2015 and that the first quarter of 2016 exhibited a reduction of growth by 17 % compared to the same quarter in 2015. As the forest export sector is one of the largest Swedish sectors exporting to the U.K. and at the same time one of the largest exports sectors in Sweden, decreases in export could have additional consequences for the Swedish economy. Increased unemployment rates due to a forest sector on the low is a worst-case scenario, but still a possible outcome, which could generate further undesirable economic effects through multiplier effects. The size of total economic effects will depend on how hard the Swedish forest sector is affected by these effects, and also due to how well the corporations operating within the sector is able to handle them.

Another actuality that the Swedish market could face is an increased competitiveness from nearby exporting countries. Hietala, Hänninen & Toppinen (2013) finds that the Finnish export demand of sawnwood to the U.K. has to a great extent been affected by currency movements in the British market. In periods of depreciation Finnish export demand has been stimulated, while in periods of appreciation it has been reduced. For Swedish forest products to be favourable to Finnish forest products, prices will play an important role, and since Sweden and Finland apply different currencies can fluctuations in the local exchange rate be crucial for the Swedish forest sector. The economic impact of Swedish forest products being substituted by other origin-forest products by the U.K. might be even more drastic compared to a decrease in demand due to an appreciation (depreciation) of the Krona (Pound) alone. It could lead to larger reductions of Swedish forest exports due Sweden losing market power in the U.K. Thereby is it highly interesting to examine how the Swedish forest export sector is affected by fluctuations in the exchange rate of Sweden and its primary trade partner of forest products, the U.K.

Given the information above it is essential to try to identify factors that could have implications for the Swedish forest industry and further significant effects on Sweden's prosperity and wealth.

1.4. Aim and method

Knowing that the U.K. will withdraw from the EU, the question stands: what will be the consequences for the Swedish economy? One way to answer that question is to analyse how different sectors operating with exports to the U.K. are affected by macroeconomic effects. A majority of the research in this field has been done on the viewpoint of how Brexit affects the British economy, while less is known of how this will affect trading partners exporting into the U.K. Therefore, the aim of this thesis is to try to determine, all other things being equal, the consequences for the Swedish export sector of sawn softwood of the U.K.'s departure from the EU, focusing on the effects that Brexit has had and likely will continue having on the development of the Pound. In order to try and reach this aim my research question is the following:

How is the Swedish export of sawn softwood to the U.K. affected by exchange rate changes of the Pound against the SEK?

To try and answer this question, an export supply function for the Swedish sector of sawn softwood is estimated, where explanatory variables that are presumed to have an effect on Swedish export sawn softwood are included. The variables included are time series data on the price of Swedish sawn softwood met by British importers, the nominal exchange rates for the GBP/SEK, and real GDP in the U.K. The stationarity of each time series is evaluated using the Augmented Dickey-Fuller (ADF) test, followed by the Johansen test of cointegration to see whether there is any cointegration amongst the variables. To examine the cointegrating relationship, a Vector Error-Correction Model (VECM) is estimated. Finally, to examine whether the exchange rate of the Pound against the SEK has any short-run effects on the Swedish export of sawn softwood, a Granger causality test is implemented. The data for all the variables is in monthly basis except for real GDP, which is in quarterly basis. The quarterly data will be used to create monthly estimates using cubic spline interpolation, and in that way, all the data has the same time unit which enables time series estimations to be done. The period reaches from July 2005 to September 2017 which equals 147 observations.

1.5. Scope and delimitations

The scope of this thesis will focus on identifying what effect the development of the Pound during Brexit's uncertain era will have on the Swedish forest export sector. This study is also ought to only focus on the Swedish exports of sawn softwood since Michinaka, Tachibana & Turner (2011) finds that the price elasticities for different forest products differ, both between products and in short vs the long-run. This means that the effect of exchange rate fluctuations cannot generally be assumed over a category of products. I will study the impact on coniferous sawnwood as it is one of the most important forest products in the Swedish economy and holds a significant share of total Swedish exports of forest products. At the same time, it is also one of the most imported forest products in the U.K. and thereby a product that has the potential to be affected by exchange rate effects.

Knowledge regarding how the Swedish forest export sector is affected by exchange rate changes constitutes a theoretical gap. Hänninen (1998a) does a similar analysis but focuses on the long-run exchange rate pass-through for the Finnish market. On the same note, Hietala, Hänninen & Toppinen (2013) focuses on the effects of exchange rate changes associated with the establishment of the European Monetary Union (EMU) on international forest industry trade on European markets. There are similarities between this study and the research by Hänninen (1998a) primarily regarding theoretical framework used. The theoretical framework used for the analysis in this study is delimited to Hänninen's (1998b) conclusions of a rejection of the Law of One Price for sawnwood imports in the U.K. market as well the findings of imperfect competition.

1.6. Outline

Chapter 1 introduces the reader to the research problem and research question. It also includes the aim, method, scope and delimitations of the thesis. *Chapter 2* consists of the theoretical framework and a literature review used for the analysis. *Chapter 3* holds a presentation of the data and method used for the study. *Chapter 4* presents the results of the ADF test, the Johansen test of Cointegration, the VECM, and the Granger Causality test. *Chapter 5* includes analysis and discussion of the results obtained by the VECM and above-mentioned tests, and finally, *Chapter 6* presents a completive discussion of the thesis.

Chapter 2 - Theoretical framework and literature review

The matter of measuring exchange rate effects on international trade has been a well-studied subject. Ever since Sweden changed to a regime of floating currency, it has also been an important topic concerning Swedish prominence in international trade relations. In this chapter, a review of how exchange rate should be included in models accounting for exchange rate effects is done. It also contains a partial equilibrium perspective to how changes in exchange rates affect trade flows and production rates in the importing and exporting country. Previous studies on the topics of Brexit and the effects of exchange rate on the trade of forest products are presented, where important implications by a rejection of the Law of One Price on U.K. sawnwood imports and signs of imperfect competition are found. It is followed by a section of concluding remarks of this chapter, where a summary of the most important implications of the theoretical work as well as previous studies are presented.

2.1. The treatment of exchange rate in agricultural trade models

The treatment of exchange rate in trade models can be delicate. If not treated correctly, estimates of exchange rate effects can vary by a lot and undermine outcomes of analyses. In a still relevant paper published in the American Journal of Agricultural Economics, Chambers & Just (1979) criticises the treatment of exchange rate in agricultural trade models and presents solutions to flaws being discovered in earlier research on the subject. They explain that a simple solution often used is to assume that import demand (excess demand) is a function of own price alone. Such an assumption presupposes that exchange rate movements and own-price movements in the exporting country has the same effect on excess demand. This enforces constraints on the effects of exchange rate fluctuations which are unduly restrictive. The authors argue that responses to exchange rates isn’t analogous to responses to own price without further empirical support. By using a more general model of excess demand and supply, the authors find that the responses to exchange rate fluctuations on quantity exported is more sensitive than the overly restricted models suggest. They conclude by showing that more generality is attained by including a separate exchange rate variable in the regression equation rather than adjusting the own price by the exchange rate.

2.2. Impacts of exchange rate fluctuations: a partial equilibrium perspective

Considering the impacts of changes in exchange rates, a partial equilibrium perspective manages to capture the adjustments and its underlying mechanisms that occur on a market affected by a change in exchange rate. It is defined in a market characterized by perfect competition and where the Law of One Price holds. In general, a depreciation of an exchange rate that an importer faces will, ceteris paribus, cause the costs of imports to increase because the value of the domestic currency in terms of the exporter's currency decreases. Ultimately this will lead to a decrease in imports. But the mechanisms that generate this result is not as clear-cut. A depreciation does not change the underlying supply and demand for the importing country, and as a result, the import demand in *domestic currency* for the importer also remains unchanged. Instead, the importer's willingness to pay in terms of foreign currency decreases (Koo & Kennedy, 2005). This has significant implications regarding how the import demand measured in *foreign currencies* changes. Since the domestic currency loses value against the foreign, the import demand curve measured in *foreign currency* will change and rotate. This is a rotation and not a shift because of the depreciation being a percentage change, and this change will occur all along the import demand curve. As a result, the foreign currency-import demand curve will pivot along the price of zero and rotate in a counter-clockwise direction due to the depreciation of the domestic currency.

Assuming that the two trading countries are price makers, this rotation of the foreign-denominated import demand will lead to a decrease in world price, which corresponds to a decline in exports. The domestic prices in the exporting country will adjust to the lower world price, leading to a reduction of domestic production but an increase in consumption in the exporting country (ibid.). This decreased production and increased consumption account for the decrease in exports in the exporting country. While the decline in the world price decreases the domestic price in the exporting country, it has the opposite effect in the importing country, since the importing country's currency depreciates against the exporter's currency (ibid.). This will lead to increased domestic production and a decreased domestic consumption in the importing country. This increased production and decreased consumption account for the decrease of imports in the importing country.

In essence, the expectations of a depreciation for an importer is as followed: higher domestic price, increased production, decrease in demand and decreased imports. For an exporter, an appreciation will lower the domestic price, decrease domestic production and increase domestic consumption as well as decrease exports.

2.3. Previous studies

2.3.1. Brexit

Kommerskollegium (2018) recently released a full rapport conducted on the behalf of the Swedish government where they have investigated the effects of Brexit on Swedish interests for future negotiations. They show that products which originate from the forest sector, and especially from coniferous wood, is of great importance for Swedish priorities. The U.K. is one of Sweden's most important markets for forest products, as goods or as inputs going into goods which are exported. This further implies that even if firms in the forest sector is not directly exposed to Brexit, they are exposed indirectly by companies higher up in the processing chain that produces commodities with forest products as inputs which they export to the U.K.

In a recent study by Johnston & Buongiorno (2017), the two authors use a dynamic spatial price equilibrium model to estimate the effects of Brexit on the forest products industry in the U.K. and the rest of the world. They use two storylines (optimistic and pessimistic future scenario) to simulate the model concerning the effect of Brexit on GDP-growth rates. The global market of sawnwood production was estimated to reduce by 100 000-220 000 m^3 in the two scenarios by 2030, which most likely is due to the decline in sawnwood consumption in the U.K. which was 1.0 % lower in 2030 in the optimistic scenario and 2.1 % lower in 2030 in the pessimistic scenario. This decline represents 84 – 87 % of the estimated total European decline. In conjunction with reduced domestic demand, the U.K. net trade deficit decreased by 4.8 % under the optimistic storyline and 9.9 % under the pessimistic storyline by 2030, mainly reflecting decreased imports but also reflecting increased domestic production.

2.3.2. The effect of exchange rate on the trade of forest products

A lot of research has been conducted in the area of exchange rate effects on the trade of forest products. Since forest products typically are met by very low or non-existing tariffs and that changes in tariffs on forest products have a very modest effect on demand, tariffs or changes in tariffs will show no or a minimal distortion of any measured effect of exchange rates (Sedjo & Simpson, 1999). This makes the forest products industry a suitable sector to examine.

Sun & Zhang (2003) examines the effect of exchange rate volatility on the export of U.S. forest products by conducting a multivariate time series analysis. They use a vector autoregressive model, where the Johansen cointegration analysis and Vector Error-Correction Model are employed. In the long run, they find that the exchange rate volatility has significant negative effects on the impact on the export of the four forest commodities of interest (wood chips, softwood logs, dissolving wood pulp, and bleached sulphate wood pulp). In the short run, they find mixed results for the different commodities. These inconsistent short-run effects show that there is a response on the market in volatile environments, but that the kind of reaction depends on the individual commodity. This response to volatile environments is somewhat consistent to Orcutt's (1950) hypothesis (though stated in an environment characterised by fixed exchange rates) that economic agents react more quickly to exchange rate fluctuations than to market price changes. He indicates that when exchange rates are inflexible, consumers perceive a devaluation or revaluation as being more permanent than short-term price changes, and in this case, exchange rate movements usually involve much more substantial percentage change than market price fluctuations taking place in a similarly short time interval. Despite testing an environment characterised by a flexible floating exchange rate, these responses during volatile periods as found by Sun & Zhang (2003) indicates a more substantial uncertainty during short-term changes in the exchange rate compared to price changes, as Orcutt (1950) describes.

Hietala, Hänninen & Toppinen (2013) aim to investigate the effects of the exchange rate changes associated with the establishment of the European Monetary Union (EMU) on international forest industry trade on European markets. They do so by analysing the effects of currency movements on Finland's and Sweden's competitiveness in the global sawnwood market. They apply Johansen’s multivariate cointegration method for the formulation of the separate partial equilibrium model systems used to analyse bilateral trade flows from Finland and Sweden to the U.K. To examine at what rate the Finnish exporters is affected by currency movements in the U.K. market, the authors use the concept of exchange rate *pass-through* (PT). From Koo & Kennedy (2005), a definition of the concept PT is described: “*Generally, we assume that a, i.e., 1 % depreciation of a currency leads to a 1 % increase in import prices, which leads to a corresponding decrease of imports. This relationship normally holds in the* *long run. However, over shorter periods of time adjustments might be done to maintain market shares or achieve other objectives. The responsiveness of import price to a currency depreciation is referred to as the degree of pass-through. If a 1 % depreciation leads to a 1 % increase in import prices, then the degree of pass-through is one (or complete). If a 1 % depreciation results in less than a 1 % increase in import prices, then the degree of pass-through is incomplete*". Hietala's, Hänninen's and Toppinen's (2013) findings indicate the existence of price discrimination and market power rather than competitive markets, and that Finland to a great extent has been affected by currency movements between euros and the British Pound. For Sweden, the pricing strategy has been somewhat different compared to Finland's, despite the two currencies having developed rather parallel against the British Pound since the beginning of their analysis. Sweden's pricing strategy has led them to be able to generate a more stable sawnwood price for the customers in the U.K., ultimately leading to a more stable export demand faced by Swedish forest sector. This indicates towards the Swedish exchange rate pass-through as being incomplete.

Hänninen (1998a) does a similar analysis but with the aim of studying the long-run exchange rate pass-through (PT) for the Finnish price of sawnwood in the U.K. market by estimating a demand and price equation system. She used multivariate time series data and assessed the model with the Johansen cointegration method. The result indicates of a large PT, which means that exchange rate changes are reflected almost proportionally in Finnish export prices. This result is also supported by Hietala, Hänninen & Toppinen (2013). Thus, the Finnish price of sawnwood has decreased as a result of the depreciating Finnish markka (FIM) which has improved Finland's competitiveness and market share in the U.K. Appreciation of the FIM had the opposite effect. Though, the largest implication of her findings is that the large PT also implies imperfect competition and rejection of the Law of One Price for U.K. sawnwood imports, which is supported by her further work (Hänninen, 1998b).

Finally, Hänninen (1998b) does a test of the Law of One Price (LOP) for imports of sawn softwood to the U.K. from Finland, Sweden, Canada and Russia, using the concept of cointegration. She used the multivariate cointegration method of Johansen on quarterly data covering the period 1978 – 1992. Her results do not support the LOP for U.K. sawnwood imports, but instead indicates the existence of differences over the long run between different suppliers' sawnwood prices. These results differ from the traditional assumption that commodity prices are perfectly arbitraged, with instantaneous exchange rate pass-through. This rejection of the LOP on the market for U.K. sawnwood imports implies that prices of sawnwood from different countries are not equal in the U.K. market, and thus no existence of perfect substitution amongst sawnwood from the supplier countries.

2.4. Concluding remarks

This section holds a summary of the main findings in the literature review. It includes an explanation of why the concepts embedded in the theoretical framework applies to the analysis of exchange rate fluctuations on the Swedish export of sawn softwood. It also includes the findings that points to the other direction, that the Swedish export of sawn softwood might be less affected by exchange rate fluctuations.

The theoretical impacts of exchange rate fluctuations as described by Koo & Kennedy (2005) are supported by the findings of Johnston & Buongiorno (2017). According to their rapport, the British economy will exhibit a declining demand on coniferous sawnwood consumption in the aftermath of Brexit. A reduced national income mainly drives this decline in conjunction with a depreciating currency. They describe the total effect on all partners trading with the U.K. to be: a decrease in the importing country's domestic demand, a reduction in the exporting countries exports, and an increase in the importer's domestic production. These reported effects are in conjunction with what Koo & Kennedy (2005) describes will happen due to a depreciation of an importer's currency.

On the one hand, the outcome might be that the Swedish export sector of sawn softwood will face this concept of impacts of exchange rate fluctuations and that Brexit, in reality, may imply a decrease of Swedish sawn softwood exports to the U.K. On the other hand, Hänninen (1998b) finds support for the existence of imperfect competition and a rejection of the law of one price for U.K. sawnwood imports from Sweden. This implies that the traditional view of exchange rate changes on exports as described by Koo & Kennedy (2005) cannot be applied in this thesis. Together with the rapport from Hietala, Hänninen & Toppinen (2013), which shows that the Swedish exports of sawnwood has a lower rate of pass-through than its competing countries, there are indications to that the effects of a short-run exchange rate depreciation might have a lesser impact on the Swedish export of sawn softwood.

Chapter 3 - Methodology and data

This chapter includes an explanation of the methodological framework used in this thesis. It examines the model plus the variables included in the model and explains the main concept of time series analysis. It is followed by a graphical display of the main variables and an explanation of the different steps of time series analysis used in this study. The chapter concludes by assessing the validity of the time series method and introduces the reader to the data set and its validity.

3.1. Research design

Due to the nature of the thesis research question and the availability of data, this study will be conducted using a quantitative method based on econometrical analyses. This enables the use of the large data sets which can be used to analyse any causal relationships between the variables which will be included in the model.

3.1.1. Model

The model that will be used in the empirical analysis is based on the following export equation;

$$X_t = \alpha + \beta_1 NER_t + \beta_2 P_t + \beta_3 GDP_t + \varepsilon_t, \qquad (3.1)$$

where α is the intercept, *X* is the export quantity of sawn softwood from Sweden to the U.K. and *NER* is the nominal exchange rate between the Swedish Krona and the British Pound (GBP/SEK). *P* is the Swedish price of sawn softwood faced by British importers, *GDP* is the real GDP for the U.K., and ε is the stochastic error term. All βs are coefficients and *t* indexes time. All variables are converted to their natural logarithms, which allows for the coefficients in Equation (3.1) to be interpreted as elasticities which furthermore simplifies the interpretations of the long-run and short-run relationships (Stock & Watson, 2010).

The nominal exchange rate of the Swedish Krona against the British Pound is used to evaluate to what extent fluctuations in the exchange rate influence the Swedish forest exports to the U.K. A rise in the variable *NER* represents a depreciation of the Swedish Krona against the Pound. The variable *P* captures how the exports of forest products from Sweden to the U.K. is affected by changes in its price, and a rise in the variable represents a price increase of the Swedish sawn softwood. The variable *GDP* represents the well-being of the British economy, and an increase in the variable can be seen as a promoting factor for the Swedish forest export sector.

The coefficient β_1 is expected to be positive. If the GBP/SEK exchange rate increases, the British Pound experiences appreciation and imports become relatively cheaper compared to domestically produced goods. Initially, this will make economic agents' change their behaviour and increase their consumption of imported products, consequently increasing their imports from Sweden. The same interpretation of the coefficient is made for a depreciation of the exchange rate. The coefficient β_2 is expected to be negative as exports should decrease when the price of the exported good increase, due to its negative price elasticity. These interpretations of the coefficients β_1 and β_2 hold given that the market is characterised by perfect competition and that the Law of One Price holds. Furthermore, the coefficient β_3 is expected to be positive. Increases in the British national income positively affects consumption of Swedish forest products by increasing the British demand for forest products, as they are normal goods.

3.2. Time series

As the variables in Equation (3.1) possibly affects each other with a time lag, time series analysis can be successfully used. The exchange rate is likely to have lagged effects on the export of Swedish sawn softwood in the sense that adjustments due to exchange rate changes might take time, and its result might take several periods to observe (Stock & Watson, 2010). Time series data and analysis is commonly used when examining exchange rate effects on the forest products sector (see, i.e., Hietala, Hänninen, & Toppinen (2013); Hänninen (1998a); Sun & Zhang (2003); Zhang, Lin & Prestemon (2017)).

A dependent variable that is expected to depend on its own or other variable's lagged values can be successfully estimated with time series analysis. A time series analysis requires time series data, which is data on a variable over time. The advantage of using time series analysis over regular regression analysis is, amongst others, that time series analysis captures the effect that the lagged values of a variable might have on itself or other variables included in the regression. When estimating two or more variables, the process is called multiple or multivariable time series, in which there is an expectancy that the dependent variable is affected by other variables than the dependent variable itself, with a time lag.

3.2.1. Graphical interpretation

A good way to start any analysis of time series data is by plotting the data and visualising it. It simplifies the process of detecting stationarity and seasonality in the data and also gives an overview of the dataset. The primary dependent and explanatory variable are depicted in Figure 2 and Figure 3 below.

The following Figure 2 shows the exports of sawn softwood from Sweden to the U.K. on a monthly basis during the period July 2005 to September 2017. The primary trend is slightly negative during the period, and the exports have been fluctuating around this trend.

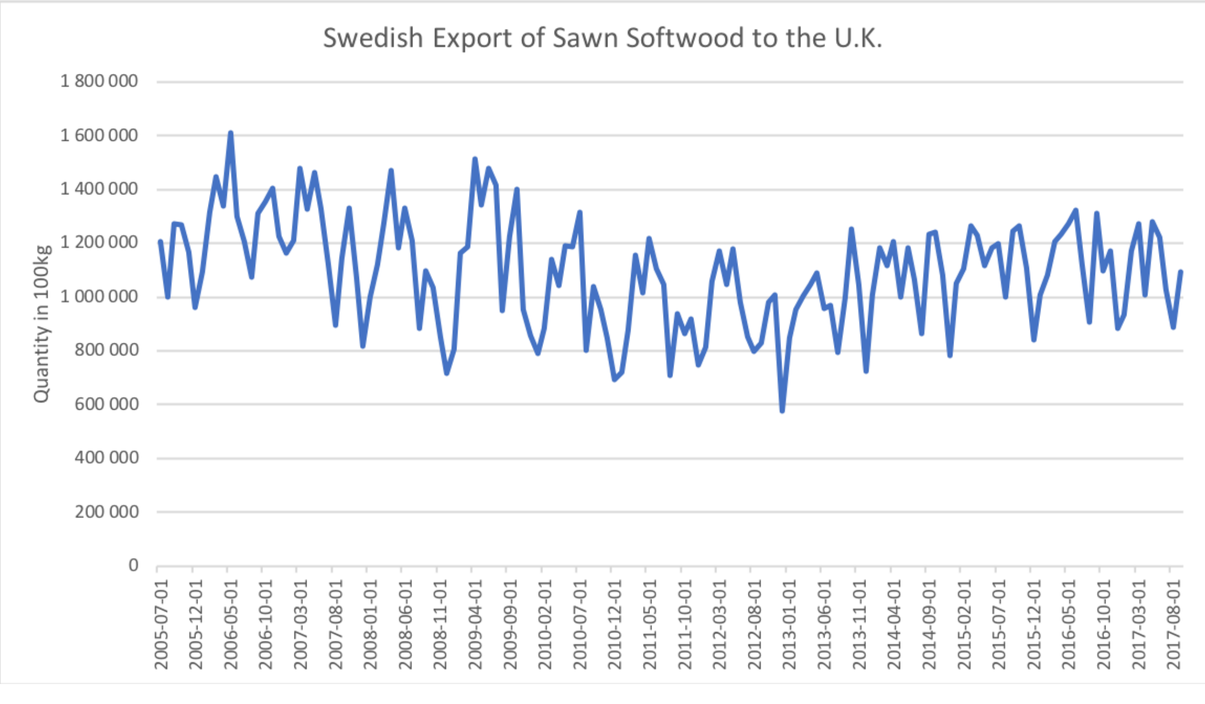

Figure 2 - Swedish Export of Sawn Softwood to the U.K., from July 2005 to September 2017. Source: (Eurostat, 2018).

It is evident when examining the above figure that the data on exports possesses seasonality. Since the acquired data is not seasonally adjusted, this is not surprising. The seasonality issue exists since there are some months each year were exports are consequently lower compared to others, and these are mainly January, August and December.[6] This holds for all years except for the period 2006-01 through 2007-07. This period showed on average a higher level of exports compared to other years, and during this period the decrease associated with certain months was not as strong as the previous and following years. Furthermore, the global financial crisis in 2007 – 2008 is important to mention as it might have had impacts on sectors trading across borders. Though it does not seem to have had any substantial effect on the Swedish sawn softwood sector and its exports to the U.K. as there is no change in export trends after the crisis compared to before the crisis.

In Figure 3 below is the monthly average exchange rate of the GBP against the SEK during the period July 2005 to September 2017 depicted. Ever since the beginning of the analysed period through 2012, the exchange rate has shown a depreciating trend, and from 2013 through 2017 it has initially demonstrated an increasing and later a decreasing trend. The actual exchange rate and has fluctuated around these trends.

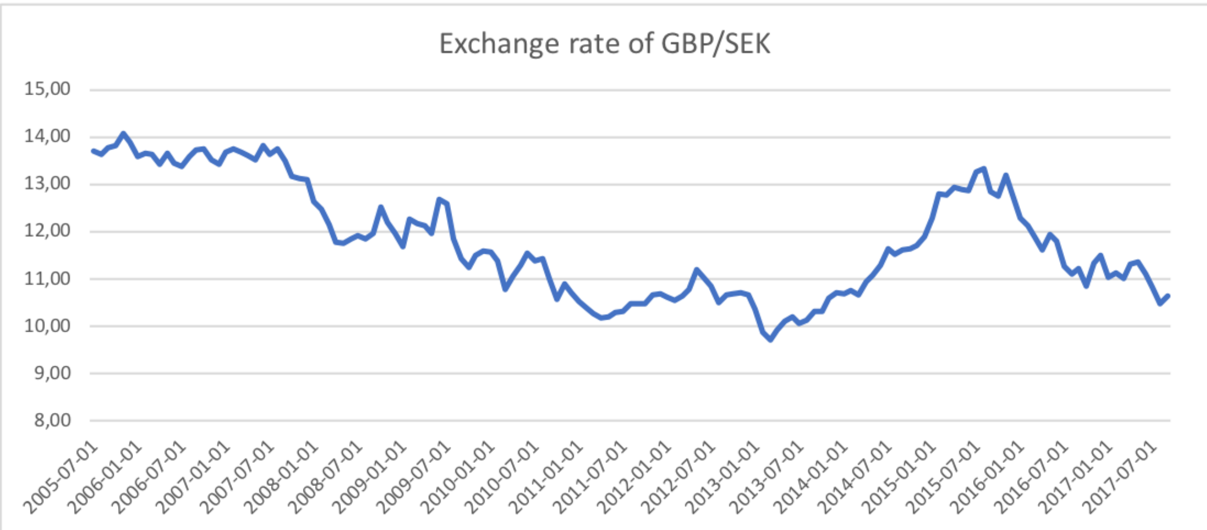

Figure 3 - The exchange rate of the British Pound against the Swedish Krona, from July 2005 to September 2017. Source: (NASDAQ OMX Stockholm AB

These trends are stochastic since they do not follow any pattern, they follow a random walk and varies over time. Series with a stochastic trend is not stationary or strictly stationary, but a

[6] To account for seasonal effects, I have included dummy variables for each month in the regression analysis. More on this will be presented in part 3.4 below.

stochastic trend in a series can be removed by first differencing, and then become stationary (Stock & Watson, 2010). More on the importance of stationarity in time series data will be presented in section 3.2.2 below.

According to the partial equilibrium model on exchange rates discussed in Chapter 2, the two variables depicted above should have a direct relationship. As the British pound appreciates against the Swedish Krona, the Swedish exports to the U.K. should increase, and as the exchange rate depreciates the exports should decrease. By inspecting figure 2 and figure 3, this relationship can be reasonably motivated. As the exchange rate has shown a depreciating trend during the period 2005 through 2012, so has the exports. In the appreciating period of 2013 through 2015 as well as the depreciating period of 2016 until now, the exports have shown a similar trend. There has been a slight increase in the trend of exports during the period 2013 through 2015, and from 2016 and onwards the exports have shown a somewhat stable trend.

3.2.2. Stationarity and unit root

There are important differences between stationary and non-stationary time series. In stationary time series, shocks will be temporary, and over time their effects will be eliminated as the series revert to their long-run mean values. Stationary time series reverts around a constant mean and has a constant variance independent of time, denoted as $N(0, \sigma^2)$. Non-stationary time series will contain permanent components and therefore will the mean and/or the variance of a non-stationary time series depend on time (Asteriou & Hall, 2016). Results obtained by using non-stationary time series may be spurious in the sense that they may indicate relationships between variables which doesn't exist, and in these cases, the norm is to get very high values of R^2 (Asteriou & Hall, 2016). The existence of unit roots in time series data is common and causes the need of transforming the time series into data that can become stationary. Time series data of GDP is, as we know from economic theory, non-stationary. It exhibits constant growth and has thereby a non-constant mean and will be non-stationary no matter how many times it is differenced. This gives rise to one of the many reasons for taking the logarithm of data before exposing it to any formal econometric analysis, as the log of an average growth rate follows a linear trend and is integrated (Asteriou & Hall, 2016).

To identify non-stationarity in time series, a simple graphing of the variables could suffice, but a test of the presence of unit roots is the most robust method to use (Stock & Watson, 2010).

The Augmented Dickey-Fuller (ADF) test is a test for the presence of unit roots and works well in medium-sized to large time series samples (Stock & Watson, 2010). It is also the test for unit root that will be implemented in the analysis of this thesis. The critique against the ADF test mainly revolves around the fact that it has weak power when the unit root parameter ϕ in the autoregressive process is close to one, as a near unit root process will have the same shape of autocorrelation function as a real unit root process (Asteriou & Hall, 2016). This can lead to stationary processes being established as non-stationary when ϕ is close to one.

The ADF has the following two hypotheses:

H_0: *$\phi=1$, The data contains unit root – is non-stationary*

H_1: *$|\phi|<1$, The data contains no unit root – is stationary*

If the ADF fails to reject the null hypothesis, we cannot conclude that the data is stationary, ergo the data is non-stationary. If the ADF does reject the null hypothesis, we accept the alternative hypothesis that the data is stationary.

If the ADF disclose that a time series is non-stationary, it needs to be transformed to become a stationary process before conducting any further analyses. The kind of transformation depends on the sort of non-stationary process that is present. A variable with a stochastic trend can become a stationary process by differencing it, and a variable with a deterministic trend becomes a stationary process by subtracting the trend or *"detrending"* the data. If a data series contain both a stochastic as well as a deterministic trend, both differencing and detrending should be applied (Enders, 2015). The procedure of making a non-stationary time series stationary by differencing is presented in Appendix 1.

After generating time series data that is first difference-stationary, a Johansen test can be conducted to examine the level of cointegration of the time series.

3.2.3. Cointegration

After establishing that the variables of interest are first difference-stationary, a Johansen test of cointegration can be conducted. It is a test that determines the number of cointegrating vectors in a time series data set.

Suppose that the two variables Y_t and X_t are integrated of order one. If for some coefficient θ, $Y_t - \theta X_t$ are integrated of order zero, then the two variables are said to be cointegrated; that is, the spread of the variables will be stationary, and Y_t and X_t have the same, or common, stochastic trend (Stock & Watson, 2010). When there are more than two variables, the Johansen test makes it possible to examine all the cointegration vectors. In general, if there are *n* variables which all have unit roots, there are at most *n-1* cointegrating vectors (Asteriou & Hall, 2016).

Before doing a Johansen test of cointegration, the appropriate lag length of the model must be decided. The most common procedure, as explained by Asteriou & Hall (2016) is to estimate a VAR model including all the variables in levels. This model should be estimated for a large number of lags and then re-estimated for one lag less until zero lags are reached. Since the data is monthly, the lag length will span from twelve to zero lags. For each lag, the Akaike Information Criteria (AIC) should be inspected as well as the diagnostics concerning autocorrelation in the residuals. The VAR with the lag that minimises the AIC and also passes the diagnostics test is the one with the optimal lag length. The last step is to conduct the actual cointegration test with the lag length chosen from the VAR that minimises AIC, minus one since the cointegration model is run in first differences.

For the Johansen method, the trace test and maximum eigenvalue test are implemented to establish the number of cointegrating vectors. The distribution of the trace statistic is presented in Appendix 3. If the trace statistic exceeds the critical level which is obtained by running the test the null hypothesis is rejected, and the alternative hypothesis is accepted. If the trace statistics below the critical level the null hypothesis cannot be rejected.

3.2.4. Vector Error-Correction Model

After testing the variables order of integration and the presence of a cointegrating vector, the model in Equation (3.1) can successfully be adapted to a Vector Error-Correction Model (VECM). The structure of a VECM is useful when you have cointegrated variables that are first difference stationary which you want to analyse causal relationship amongst (Stock & Watson, 2010). A VECM extends a univariate Error-Correction Model (ECM) to a vector of time series variables. In the case of two time-series variables Y_t and X_t and one lagged difference, the bivariate VECM consists of the two equations

$$\Delta Y_t = \beta_{y0} + \beta_{yy1}\Delta Y_{t-1} + \gamma_{yx1}\Delta X_{t-1} + \lambda(Y_{t-1} - a_0 - a_1 X_{t-1}) + u_{yt}, \tag{3.2}$$

$$\Delta X_t = \beta_{x0} + \beta_{xy1}\Delta Y_{t-1} + \gamma_{xx1}\Delta X_{t-1} + \lambda(Y_{t-1} - a_0 - a_1 X_{t-1}) + u_{xt}, \tag{3.3}$$

where the β's and the γ's are unknown coefficients and u_{yt} and u_{xt} are error terms. Appendix 2 contains the general approach of the error-correction mechanism and cointegration.

With the structure of a VECM, I can establish how the Swedish export of sawn softwood is affected by its own as well as the independent variables lagged values in the short-run as well as in the long-run. Hence, the VECM I will estimate is

$$\begin{aligned} \Delta X_t &= a_{10} + \alpha_{11}EC_{t-1} + \beta_{11i}\Delta X_{t-i} + \beta_{12i}\Delta NER_{t-i} + \beta_{13i}\Delta P_{t-i} + \delta_t GDP_{t-i} + \gamma_t D_m + u_{Xt} \\ \Delta P_t &= a_{20} + \alpha_{21}EC_{t-1} + \beta_{21i}\Delta X_{t-i} + \beta_{22i}\Delta NER_{t-i} + \beta_{23i}\Delta P_{t-i} + \delta_t GDP_{t-i} + \gamma_t D_m + u_{Pt} \\ \Delta NER_t &= a_{30} + \alpha_{31}EC_{t-1} + \beta_{31i}\Delta X_{t-i} + \beta_{32i}\Delta NER_{t-i} + \beta_{33i}\Delta P_{t-i} + \delta_t GDP_{t-i} + \gamma_t D_m + u_{NER,t} \end{aligned} \tag{3.4}$$

where a_0 is each vector's corresponding intercept, α_1 is each vector's coefficient of the error correction-term, which is denoted as EC_{t-1} and is the residual from the cointegrating regression. i denotes each period, where $i = 1,\ldots p$, where p is the total number of lags. The variable *GDP* is included as a control variable together with D_m which controls for seasonal effects. D_m represents each dummy variable, where m = *January,…November*. The dummy variable for December is omitted to avoid the dummy variable-trap. In the presentation of the results of the VECM only the first vector in Equation (3.4), that of ΔX_t, will be interpreted, since it is the vector showing the relationships which are of interest.

The VECM has been widely used in models of forest products (see, i.e., Sun & Zhang, 2003, Hänninen, 1998a, Hietala, Hänninen & Toppinen, 2013).

3.2.5. Causality

After estimating the vector error-correction model, a Granger Causality test can be established. The Granger Causality method is conducted to detect short-run causality amongst the variables. A variable W_t is said to "Granger-cause" another variable Z_t if, given the lags of Z_t, the lags of W_t are jointly statistically significant in the Z_t equation. The null and alternative hypothesis of the Granger Causality method is

H_0: The lagged coefficients of W_t are jointly zero

H_1: The lagged coefficients of W_t are not jointly zero

By conducting a Granger Causality test, I can examine whether lagged effects of the independent variables Granger-cause the Swedish export of sawn softwood.

3.3. Validity

When conducting research, it is important to have an appropriate sample size to be able to capture the actual conditions of the real world. When dealing with different kind of regression analysis, including time series analysis, small samples can lead to insignificant results or spurious regressions which undermines any analysis to be made. The size of a small sample depends on what is being measured or analysed, and with the use of lags in a time series analysis the number of observations quickly diminish. A general rule of thumb is that samples below 30 units of observations is defined as small. In order not to face these problems the collected dataset consists of 147 observations, which is considered a long time series (Stock & Watson, 2010).

When estimating a large number of coefficients, the amount of estimation error increases in the analysis, which can result in a deterioration of the accuracy of the analysis (Stock & Watson, 2010). Depending on the number of lags and variables, Equation (3.4) will have different amounts of coefficients to be estimated. The number of coefficients increase rapidly if further lags are included, and even more rapidly by increasing the number of variables. The implication is that it is essential to keep the number of variables small in a time series analysis, and most important that they are plausibly related to each other so that they will be useful for estimating causal relationships between one another (Stock & Watson, 2010). For example, we know from a combination of empirical evidence (such as that discussed in Chapter 2) and economic theory that exports are affected by exchange rates, price and national income, suggesting that these variables are appropriate to use when estimating causal effects on exports in a time series analysis.

3.3.1. Validity of the model

Due to its autoregressive structure, time series data cannot be estimated using OLS (Ordinary Least Square) without violating some of its assumptions. Furthermore, regressions of non-stationary data time series data can lead to spurious values of R^2 and z statistics, causing erroneously conclusions that meaningful relations exist, if not treated correctly (Stock & Watson, 2010). The Vector Error-Correction Model is a convenient model as it measures the correction from disequilibrium of the previous period, which has a very good economic implication. Furthermore, when a cointegrating relationship exists amongst variables, the VECM's are expressed in first differences, which typically eliminates trends from the included variables and thereby resolve the problem of spurious regressions (as shown in Appendix 2). The most important feature of the VECM comes from the fact that the disequilibrium error term is a stationary variable (by definition of cointegration). This creates important implications of the VECM: the fact that a cointegrating relationship exists implies that there is some adjustment process preventing the errors in the long-run relationship from becoming larger and larger (Asteriou & Hall, 2016).

A note on the VECM is that there is a loss of observations when transforming the data into first differences, but also by the number of lags. In order not to miss any important relationships due this loss of observations, the number of observations is important, as discussed above in the first section of part 3.3.

3.4. Data

The data is collected from various sources. Data on the nominal exchange rate of the GBP/SEK is from the Swedish Central Bank (NASDAQ OMX Stockholm AB), and the data on export and prices is gathered from Eurostat (Eurostat, 2018a). The quarterly real GDP data is from the Organisation for Economic Co-operation and Development (OECD, 2018). It is seasonally adjusted, in national currency and chained volumes.

To deal with the issue of seasonal effects in the data of sawn softwood exports, I have included dummy variables representing each month in the regression analysis. This means that I have 12 dummies that represent each month during the 13-year period and that each dummy variable captures any seasonal effect that each month may possess.

Table 1 below displays the summary statistics of the variables in the empirical model, before being log-transformed.

Table 1. Summary statistics of variables in the empirical model (before log-transformed): July 2005 – September 2017.

Variable	Unit	Observed	Mean	St.Dev.	Minimum	Maximum
Exports	100kg	147	1,092,785	198,963.5	574,858	1,612,522
Exchange rate	GBP/SEK	147	11.80	1.20	9.71	14.08
Price	£ per 100kg	147	41.74	4.44	29.78	52.97
Real GDP	Millions £ (2015)	147	445,471.5	21,450.48	417,650.5	490,876

3.4.1. Data validity

When screening the data, it was found that there were small but still noticeable asymmetries between the declared exports from Sweden to the U.K. and the declared imports by the U.K. from Sweden. Eurostat (2018b) explains that this in general occurs "*either from errors in reporting or differences in the concepts and definitions applied by the partner countries"*. They report the most common causes of methodological asymmetries, and which whom applies depends on the kind of good that is traded. Either way, this asymmetry is most likely due to errors in reporting since both countries apply the same description and coding system, the harmonised system. Eurostat informs that time lags are one probable explanation to why these errors in reporting occur: *"the same operation*[7] *can be recorded under a different reference period because of transportation times or processing delays"* (Eurostat, 2018b). By focusing only on the export sector in Sweden, data on declared exports from Sweden is used and thereby this asymmetry of declared imports and exports is avoided.

The quarterly real GDP data has been interpolated to create estimates of monthly values. The used method is a cubic spline interpolation. It is important to remember that these values are estimates and not actual values, but since the real gross domestic product in the U.K. has grown more or less at a constant rate since the beginning of my analysis, the monthly growth of the

[7] By operation; exports from Sweden being reported as imports in the U.K. is meant.

real GDP can be assumed to have shown a similar pattern. The monthly estimates created by the cubic spline interpolation show a same pattern of monthly growth as the quarterly data, meaning that the estimates of monthly real GDP data won’t pose an issue regarding the validity of the analysis. But, due to the fact that it is estimated data, the variable for real GDP is included as a control variable in the model. This means that there will not be any short run or long run interpretations of the real GDP variable in the VECM, but the estimations will not be biased by an exclusion of the variable.

Chapter 4 - Empirical results

This chapter presents the results of the various tests leading up to the implementation of the VECM. Furthermore, the empirical findings of the VECM are shown here, as well as the results from the Granger Causality test.

4.1. Augmented Dickey-Fuller test

The empirical estimation of Equation (3.4) starts with a test for stationarity for each variable in the model. The number of lags in the ADF test is selected according to the Akaike Information Criteria. Table 2 presents the results.

Table 2. Results of the unit root test of individual time series.

	Augmented Dickey-Fuller statistic			
Variable	Levels		1st difference	
Exports	-1.91	(10)	-9.73^{b}	(9)
Exchange rate	-1.99	(8)	-7.53^{b}	(2)
Price	-3.47^{b}	(6)	-5.55^{b}	(3)
Real GDP	0.47	(12)	-2.97^{a}	(11)

Notes: (1) The numbers in parenthesis are lags decided by the Akaike Information Criterion (AIC). (2) The variables in levels are transformed to their logarithmic values.
^{a} $P < 0.05$
^{b} $P < 0.01$

As the test failed to reject the null hypothesis of unit root with all the level data except for the log of prices, I conclude that most of the time series are non-stationary. However, in first differences all of the variables become stationary. With stationary first differences, I can proceed with a cointegration test to test whether there is a cointegrating relationship amongst the variables.

4.2. Johansen test of cointegration

The preceding test for the error-correction model is the Johansen test of cointegration. The optimal lag length for the Johansen test is achieved by running a VAR with the variables in level and obtaining the lag length which minimises the value of the AIC. I found that the AIC is minimised when the lag length in the underlying VAR is six. A robustness test also concludes that there is no autocorrelation in the residuals in the VAR, which is of importance in order to continue the analysis. Table 6 in Appendix 4 displays the results of the Lagrange Multiplier test on the VAR.

The Johansen test is conducted using five lags, since it is run in first differences, and includes a control variable for the effects of real GDP as well as monthly dummy variables controlling for seasonal effects. The null hypothesis is that there are *r* cointegrating vectors at most, while the alternative hypotheses are $r + 1$ and at least $r + 1$ for the λ_{max} and λ_{trace} statistics, respectively. The results from the Johansen Likelihood ratio tests for cointegration are presented in Table 3.

Table 3 Results of the Johansen cointegration rank test.

Maximum Rank	Parameters	LL	Eigenvalue	Trace statistics (λ_{trace})	5 % critical value
$r = 0$	75	808.99	.	52.96	29.68
$r > 1$	80	829.08	0.25	12.78*	15.41
$r > 2$	83	833.91	0.07	3.13	3.76
$r > 3$	84	835.47	0.02		
Maximum Rank	Parameters	LL	Eigenvalue	Max statistics (λ_{max})	5 % critical value
$r = 0$	75	808.99	.	40.18	20.97
$r = 1$	80	829.08	0.25	9.65*	14.07
$r = 2$	83	833.91	0.07	3.13	3.76
$r = 3$	84	835.47	0.02		

Notes: (1) The number of lags in the Johansen test was estimated to be five (six minus one) by the underlying VAR in levels which minimises the AIC. (2) The first five rows display the results of the trace statistics while the last five rows show the results of the maximum-eigenvalue statistics. (3) Both the trace statistics and maximum-eigenvalue statistics cannot reject the null hypothesis of at least one and one cointegrating vector amongst the variables at the 5 % level.

The trace test (λ_{trace}) and maximum-eigenvalue test (λ_{max}) are used to verify for common stochastic trends amongst the time series. Starting with λ_{trace} test result, the null hypothesis of $r = 0$ is rejected against the alternative hypothesis of $r > 1$. The test statistics of 52.96 is well above the 5 % critical value of 29.68. Furthermore, the null hypotheses of $r \leq 1$, and $r \leq 2$ cannot be rejected in favour of the alternative hypotheses $r > 2$, and $r > 3$. These results indicate the presence of at least one cointegrating vector. For the λ_{max} test result, similar conclusions are obtained. The null hypothesis of $r = 0$ is rejected against the alternative hypothesis of $r = 1$. The calculated test statistic of 40.18 is also above the 5 % critical value of 20.97. Also, the null hypotheses of $r = 1$, and $r = 2$ cannot be rejected in favour of the alternative hypotheses $r = 2$, and $r = 3$. These results suggest that there is one cointegrating vector, a long-term equilibrium relationship, amongst Swedish exports of sawn softwood to the U.K., its prices and the exchange rate of the GBP against the SEK.

4.3. Vector Error-Correction Model

Due to the presence of a cointegrating vector, the Vector Error-Correction Model which is presented in Chapter 3, Equation (3.4), can be estimated. Out of the three vectors in Equation (3.4), which constitutes the VECM, the vector equation which is used to model the effects on the Swedish export of sawn softwood is of most interest. It is in the results of that vector that we can interpret the effects of exchange rate changes on the Swedish export of sawn softwood. It is estimated as follows:

$$\Delta X_t = a_{10} + \alpha_{11} EC_{t-1} + \beta_{11}\Delta X_{t-i} + \beta_{12}\Delta NER_{t-i} + \beta_{13}\Delta P_{t-i} + \delta_t GDP_{t-i} + \gamma_t D_m + u_{1t}, \quad (4.1)$$

where EC_{t-1} is the lagged error correction term; the residual from the cointegrating regression, i denotes each period, where $i = 1,\ldots p$. D_m represents each dummy variable, where *m* = *January*,…*November*. The dummy variable representing December is omitted to avoid the dummy variable-trap. GDP_{t-i} controls for the effects of real GDP on each variable, so that Equation (4.1) does not suffer from omitted variable bias. Since the variables (X, NER, P) have a cointegrating vector, EC_{t-1} is an $I(0)$ process and represents the deviation from equilibrium in period t. The variable α_{11} represents the response of the dependent variable in each period to departures from equilibrium. The results from the regression of the VECM are presented in Table 4.

Table 4. Regression result for the Vector Error-Correction Model

	Exports of sawn softwood	
EC_{t-1}	-0.75[b]	(-5.19)
ΔX_{t-1}	-0.06	(-0.45)
ΔX_{t-2}	0.25	(1.95)
ΔX_{t-3}	0.49[b]	(4.15)
ΔX_{t-4}	0.13	(1.36)
ΔNER_{t-1}	-0.36	(-0.90)
ΔNER_{t-2}	-0.39	(-0,93)
ΔNER_{t-3}	-0.37	(-0.89)
ΔNER_{t-4}	0.15	(0.37)
ΔP_{t-1}	-0.03	(-0.12)
ΔP_{t-2}	0.22	(1.01)
ΔP_{t-3}	0.24	(1.16)
ΔP_{t-4}	0.17	(0.85)
January	0.28[b]	(4.31)
February	0.57[b]	(9.11)
March	0.63[b]	(10.42)
April	0.40[b]	(8.31)
May	0.39[b]	(7.54)
June	0.40[b]	(8.25)
July	0.39[b]	(7.94)
August	0.16[b]	(3.39)
September	0.49[b]	(8.95)
October	0.55[b]	(9.43)
November	0.41[b]	(7.48)
GDP	0.27	(1.54)
Constant	0.11	(0.05)
R^2	0.81	
χ^2	485.00	
$LM_{Lag\ 1}$	10.02	
$LM_{Lag\ 2}$	15.51	
Norm χ^2 [2]	4.24	

NOTES: (1) Numbers in parentheses are z-statistics. [a] P < 0.05; [b] P < 0.01. (2) LM (Lagrange Multiplier test) tests the existence of autocorrelation in the residuals. It has a chi-square distribution with nine degrees of freedom: $\chi^2_{(9,\ 5\ \%)} = 16.92$; $\chi^2_{(9,\ 1\ \%)} = 21.67$. The reported values for the LM test are chi-square values for two lags. The full LM test on all five lags is included in Appendix 4. The null hypothesis cannot be rejected for each lag. Normality χ^2 is the Jarque-Bera test for normally distributed disturbances. It has a chi-square distribution with two degrees of freedom: $\chi^2_{(2,\ 5\ \%)} = 11.07$; $\chi^2_{(2,\ 1\ \%)} = 15.09$.

The error-correction term EC_{t-1} is a measurement of the long-run causality amongst the variables. According to the findings in Table 4, it is statistically significant at the 1 % level and has the expected negative sign. This coefficient gives a measure of the average speed at which exports volumes of sawn softwood adjust to a change in equilibrium conditions. The coefficients on the exchange rate (*NER*) and prices (*P*) in the VECM shows the average speed of export adjustments. They are the short-run effects running from each variable to the exports of sawn softwood. Each lag is insignificant and does not have significant short-term effects on exports. The coefficient for *GDP* is positive as expected but insignificant, and furthermore, the monthly dummy variables are all significant. The R^2 is approximately 0.81, which means that the model can explain about 81 % of the variability in the exports of Swedish sawn softwood. The variables $LM_{Lag\ 1}$ and $LM_{Lag\ 2}$ are the probability values of a Lagrange Multiplier test on the VECM. The values for the other lags are included in the full test in Appendix 4. The test fails to reject its null hypothesis of autocorrelation in the residuals for all lags, which is a good sign in terms of the validity of the model. The Normality χ^2 [2] is a Jarque-Bera test for normally distributed disturbances in the VECM. The null hypothesis of normally distributed disturbances cannot be rejected at any level or lag, which also is a good sign in terms of the validity of the model.

Given the findings from the VECM, the included variables do not seem to have any short-run effects on the dependent variable, as they are not statistically significant. Though, it does seem to exist a long-run relationship amongst them, as established by the significant error-correction term EC_{t-1}.

To interpret each variable’s long-run effect on the Swedish export of sawn softwood, their long run-elasticities are calculated. Table 5 present the estimated long-term equilibrium cointegrating relationships. Since the model is in natural logarithms, the estimates shown in Table 5 are the long-run elasticities.

Table 5 – Estimates of the cointegrating relationship.

	X	*NER*	*P*
Export of Sawn softwood	-1	0.96[b]	-0.14
		(10.50)	(-1.57)

NOTES: (1) z-values are in parentheses.
[a] $P < 0.05$
[b] $P < 0.01$

The exchange rate (*NER*) elasticity has the expected positive sign and is significant at the 1 % level. It indicates that a depreciation (appreciation) in the long-run decreases (increases) the exports of sawn softwood from Sweden. The price (*P*) elasticity has the expected negative sign but is insignificant.

4.4. Granger Causality

Table 6 shows the results of the Granger Causality test. The test concludes that there is no short-run causality in the VECM running from the included variables to the Swedish exports of sawn softwood to the U.K.

Table 6 – Granger Causality test of Nominal Exchange Rate and Prices on Exports of sawn softwood.

	Granger Causality test	
	Nominal Exchange Rate	*Prices*
$H_0: \sum\Delta_{t-i}$	$= 0$	$= 0$
χ^2 *[4]*	2.82	2.31
Probability $> \chi^2$	0.59	0.68

Notes: (1) H_0: Coefficients are jointly zero. (2) The test has a chi-square distribution with four degrees of freedom: $\chi^2_{(4, 5\,\%)} = 9.49$; $\chi^2_{(4, 1\,\%)} = 13.28$.

The null hypothesis that the short-run joint coefficients ΔNER_{t-i} are different from zero could not be rejected at the 5 % level. A test for Granger Causality running from prices (*P*) to exports was also conducted but could not either reject the null hypothesis at the 5 % level.

Chapter 5 - Analysis and discussion

This chapter includes analysis and discussion of the empirical findings from the Vector Error-Correction Model and the Granger Causality test with respect to the research question in Chapter 1 and the theoretical framework in Chapter 2. The discussion ought to create an understanding of how the Swedish export of sawn softwood is affected by the exchange rate of the Pound against the SEK.

5.1. Swedish sawn softwood's exposure to exchange rate effects

To determine how the Swedish export of sawn softwood is affected by the exchange rate of the Pound against the SEK, estimations of the VECM presented in Chapter 3 was done. The estimation included other variables to increase the power of the model, and the empirical findings provide interpretation of those variables as well. The results from the VECM on Swedish exports of sawn softwood in Table 4 contains both short-run and long-run effects and an additional table of the cointegrating relationships where estimated and presented in Table 5.

5.1.1. Long-run effects

The absolute value of the error-correction term and its significance indicates that there is a movement of exports towards the elimination of a disequilibrium. This implies that there is a long-run relationship amongst exports of sawn softwood, its prices, and exchange rates. The interpretation of the coefficient EC_{t-1} is that about 75 % of the adjustments towards equilibrium occurs in one month. Furthermore, the total adjustment of export volumes to changes in the previous period's disequilibrium would take approximately a little less than one and a half month (1/0.75 = 1.33).

The rather small and insignificant estimate for *GDP* indicates a relatively weak response of Swedish exports of sawn softwood to changes in the British economic activity. This result conflicts with those found by Johnston & Buongiorno (2017), which found a much more significant effect of national income on the import demand of sawnwood products in the U.K. The significant monthly dummy variables controlling for seasonality further indicates that the Swedish exports of sawn softwood are affected by season. The effect of the dummy variables for January and August is lower compared to other months, which agrees with the graphical interpretation of the time series in Chapter 3. December was also established to have a lower rate of exports, and its effect is captured in the constant, which is positive but insignificant.

Table 5 in Chapter 4 presents the estimated long-term equilibrium elasticities. As the long-run exchange rate elasticity is positive and significant, we can interpret it as a long-run depreciation of the British Pound generates a decrease in the Swedish export of sawn softwood, and the opposite with a long-run exchange rate appreciation. These results are expected, as the purchasing power of the U.K. should decrease as its exchange rates depreciate, ultimately leading to a decrease of sawn softwood imports, and thereby a decrease of Swedish sawn softwood exports. In Table 5, we can see that the price elasticity is negative as expected but insignificant. These results are supported by the findings of Hietala, Hänninen & Toppinen (2013) and Hänninen (1998b): that the rejection of the Law of One Price in combination with Sweden’s effective pricing strategies makes the Swedish export sector insensitive to price changes. Given this information, it is possible that there is a linkage between Sweden’s long-run insensitivity to price changes and its exposure to long-run changes in exchange rate, as a stable import price in combination with a depreciating Pound may cause the British imports to decline.

5.1.2. Short-run effects

The error-correction model in Table 4 presents the significance of each variable's lag, where each lag is interpreted as the short-run effects running to the dependent variable. Furthermore, to see whether the lags of each variable has a combined significance and thereby has a short-run joint impact on the exports of sawn softwood, a Granger Causality test was done. The results of the test are presented in Table 6 in Chapter 4.

The insignificance of the short-run elasticities in the VECM are supported by the indications of imperfect competition and a rejection of the Law of One Price found by Hänninen (1998b). Generally, as found in research in the same field but in different markets, we would see short-run adaptions to exchange rate fluctuations as Sun & Zhang (2003) and Johnston & Buongiorno (2017) does, where the underlying mechanisms creating adjustments to changes are similar to those in the traditional view of impacts of exchange rate changes, as described by Koo & Kennedy (2005). But due to Hänninen’s (1998b) findings, the traditional view of the impact of exchange rate changes cannot be applied to the scenario with U.K. imports of sawnwood from

Sweden. Thereby, by applying the same scenario of an exchange rate change with the same underlying mechanisms on multiple countries, which do not have the same underlying mechanism, misleading results could be generated. The Swedish pricing strategy, which Hietala, Hänninen & Toppinen (2013) has shown to be very effective, strengthens the Swedish position on the export market of sawn softwood. This pricing strategy could thereby work as protection against any short-run changes in the exchange rate and prices, and furthermore as support to why short-run effects of price changes and exchange rate changes are insignificant.

The Granger Causality test concludes that a joint significance of the lags of prices and exchange rate cannot be established, meaning that the short-run effects of price changes and exchange rate changes do not have a statistically significant effect on the exports of sawn softwood. As the results of the VECM in Table 4 showed that all the individual lags of the two variables where insignificant, this is not surprising. These insignificant short-run effects are supported by the same arguments presented by Hietala, Hänninen & Toppinen (2013) above, that the pricing strategy adopted by Sweden has enabled them to generate a more stable sawnwood price and export demand. They further show that this pricing strategy has generated a lower rate of pass-through for the Swedish forest export sector, and thereby making it relatively less sensitive to short-run exchange rate changes. When they compare the forest exports of Finland and Sweden they show that Finland, which adopts a different pricing strategy, has generated a higher rate of pass-through. Their results indicate towards the Swedish forest sector being less exposed towards short-run exchange rate due to its pricing strategy.

Altogether, these results indicate towards the Swedish forest sector being protected against short-run exchange rate depreciation, but that Sweden needs to be cautious when adopting a pricing strategy in the long-run. Hietala's, Hänninen's and Toppinen's (2013) findings of a larger pass-through coefficient for the Finnish forest export sector compared to the Swedish forest export sector indicates that Finland could utilize an extended depreciation of the Pound against the euro and thereby gain market power in the U.K. If the Swedish price setters does not respond to these exchange rate changes of the Pound/EUR, the Swedish forest sector might lose market power in the U.K. which could have consequences for the Swedish economy.

Chapter 6 - Conclusion

This thesis aimed to determine, all other things being equal, the consequences for the Swedish export sector of sawn softwood of the U.K.'s departure from the EU, focusing on the effects that Brexit has had and is estimated to have on the development of the British Pound.

In order to fulfil this aim, the study addressed the following research question:

How is the Swedish export of sawn softwood to the U.K. affected by exchange rate changes of the Pound against the SEK?

This research question was addressed with the use of time series data from July 2005 to September 2017 on the Swedish export of sawn softwood to the U.K., the exchange rate of the GBP/SEK, the price of Swedish sawn softwood met by U.K. importers, as well as the U.K. real GDP. An ADF test evaluated the level of stationarity of the time series, which concluded that a Johansen test of cointegration could be applied. The Johansen test concluded that the time series data could be estimated by a Vector Error-Correction Model (VECM).

The empirical findings from the Johansen test as well as the econometrical estimations of the VECM showed:

A cointegrating relationship amongst the variables *Exports, Exchange Rate* and *Prices*. This long-run connection was significant in the VECM, which showed no further signs of any short-run relationships amongst the variables. The error-correction term, which is a parameter showing the correction of disequilibrium from the previous period (the long-run relationship) was -0.75 and significant, indicating that 75 % of the adjustments towards equilibrium occurs in one month.

The insignificant short-run results on exchange rate changes as well as prices indicate that Swedish exports of sawn softwood are less affected by changes in these variables in the short run. These findings are supported by those made by Hänninen (1998a); Hänninen (1998b) and Hietala, Hänninen & Toppinen (2013), which show that a rejection of the Law of One Price, as well as the indication of imperfect competition, can be made on the U.K. market for imports of sawn softwood from Sweden. Hietala, Hänninen & Toppinen (2013) further show that Sweden has an effective pricing strategy enabling them to generate a stable export price, ultimately generating a steady export demand. This has made Sweden less exposed towards price changes and eventually could have made them less exposed to short-run exchange rate changes.

The results in this thesis are not supported by those found by Johnston & Buongiorno (2017), which shows that Brexit will have a negative impact on the Swedish export of sawnwood by using a dynamic economic equilibrium model. The findings by Hänninen (1998b) explains these conflicting results by the fact that the underlying mechanism, which ultimately affects a country's adjustments to exchange rate changes, differs amongst nations and import markets, and that these differences need to be accounted for when analysing any effects.

It is evident that the Swedish export of sawn softwood has great potential when it comes to keeping its export levels steady during periods of a depreciating Pound. Any additional uncertainties during the period leading up to the execution of Brexit affecting the Pound are likely to have a small effect on the Swedish export of sawn softwood. Also, any future impact on Swedish export of sawn softwood by short-run exchange rate fluctuations is also likely to be small, due to Sweden's low rate of pass-through. Furthermore, due to its importance in the Swedish economy, policymakers should pay important notice to other factors affecting the Swedish export of sawn softwood. To uphold Sweden's prominence in exports of sawn softwood, the price strategies used to maintain its market power in the U.K. needs to be thought through carefully. Sweden's neighbouring country Finland, which earlier research has shown can utilise exchange rate changes in favour to increase their market power in the U.K., is a competitor of Swedish sawnwood exports, and might thereby have effects on the Swedish forest export sector.

This study provides information on how the Swedish export of sawn softwood is affected by both short-run and long-run depreciation of the Pound against the SEK. It is evident that exchange rate relationships, regarding markets with a floating exchange rate, is something that continually changes, and its behaviour could have implications for producers and exporters. Sweden has, as described by Kommerskollegium (2016), a very elaborate trade relationship with the U.K., and it could therefore be of further interest to examine how other economically essential sectors exporting into the U.K. are affected by changes in the exchange rate of the

Pound against the SEK, which can provide with better guidance for Swedish producers and exporters to maintain or increase their competitiveness in the U.K. market.

References

Asteriou, D., and Hall, S., 2016. *Applied Econometrics*. 3rd ed. London: Palgrave Macmillan.

Bank of England, 2018. *Statistics – Exchange Rates*. Bank of England, London. https://www.bankofengland.co.uk/statistics/exchange-rates (Accessed on 1 March, 2018).

Buongiorno, J., 2015. Income and time dependence of forest product demand elasticities and implications for forecasting. *Silva Fennica* 49 (5). https://doi.org/10.14214/sf.1395 (Accessed on 23 February, 2018).

Chambers, R., and Just, R., 1979. A Critique of Exchange Rate Treatment in Agricultural Trade Models. *American Journal of Agricultural Economics* 61 (2). http://www.jstor.org/stable/1239729 (Accessed on 27 March, 2018).

Enders, W., 2015. *Applied Econometric Time Series*. 4th ed. Hoboken, New Jersey: Wiley.

Eurostat, 2018a. *International trade – EU trade since 1988 by HS6 (DS-016893)*. European Commission, Luxembourg. http://ec.europa.eu/eurostat/data/database (Accessed on 9 March, 2018).

Eurostat, 2018b. *Statistics Explained – International trade statistics - background*. European Commission, Luxembourg. http://ec.europa.eu/eurostat/statistics-explained/index.php/International_trade_statistics_-_background (Accessed on 29 March, 2018).

FAO, 2018. *FAOSTAT Forestry production and trade.* Food and Agriculture Organization of the United Nations, Rome. http://www.fao.org/faostat/en/#data (Accessed on 20 February, 2018).

Forestry Commission, 2017. *Forestry Statistics 2017*, Forestry Statistics and Forestry Facts & Figures. Forestry Commission, Bristol. https://www.forestry.gov.uk/forestry/infd-7aqdgc (Accessed on 18 February, 2018).

Hietala, J., Hänninen, R., and Toppinen, A., 2013. Finnish and Swedish Sawnwood Exports to the UK Market in the European Monetary Union Regime. *Forest Science* 59 (4): 379-389. http://dx.doi.org/10.5849/forsci.10-122 (Accessed on 20 February, 2018).

Hänninen, R., 1998a. Exchange Rate Changes and the Finnish Sawnwood Demand and Price in the UK Market. *Silva Fennica* 32 (1): 61-73. https://doi.org/10.14214/sf.700 (Accessed on 20 February, 2018).

Hänninen, R., 1998b. The Law of One Price in United Kingdom Soft Sawnwood Imports – A Cointegration Approach. *Forest Science* 44 (1): 17-23. https://academic.oup.com/forestscience/issue/44/1 (Accessed on 20 April, 2018).

Johnston, C., and Buongiorno, J., 2017. Impact of Brexit on the forest products industry of the United Kingdom and the rest of the world. *Forestry: An International Journal of Forest Research* 90 (1): 47-57. https://doi.org/10.1093/forestry/cpw062 (Accessed on 14 February, 2018).

Kommerskollegium, 2016. Storbritanniens betydelse för Sveriges utrikeshandel – inför britternas folkomröstning om EU-medlemskap. Kommerskollegium (National Board of Trade Sweden), Stockholm. ISBN: 978-91-88201-15-7. (Accessed on 6 February, 2018).

Kommerskollegium, 2017. Sveriges handel med Storbritannien året efter brexitomröstningen. Kommerskollegium (National Board of Trade Sweden), Stockholm. ISBN: 978-91-88201-31-7. (Accessed on 28 February, 2018).

Kommerskollegium, 2018. Efter Brexit – analys av svenska intressen inför kommande förhandlingar. Kommerskollegium (National Board of Trade Sweden), Stockholm. https://www.kommers.se/publikationer/Rapporter/2018/ (Accessed on 28 February, 2018).

Koo, W., and Kennedy, L., 2005. *International Trade and Agriculture*. Malden, Massachusetts: Blackwell Publishing.

KPMG, 2016. Brexit: The Economic Implications. https://assets.kpmg.com/content/dam/kpmg/pdf/2016/05/BrexitReportMay16.pdf (Accessed on 21 February, 2018).

Michinaka, T., Tachibana, S., and Turner, J., 2015. Estimating price and income elasticities of demand for forest products: Cluster analysis used as a tool in grouping. *Forestry Policy and Economics* 13 (6): 435-445. https://doi.org/10.1016/j.forpol.2011.05.011 (Accessed on 23 February, 2018).

NASDAQ OMX Stockholm AB. *Räntor och Valutakurser*. Sveriges Riksbank. https://www.riksbank.se/sv/statistik/sok-rantor--valutakurser/ (Accessed on 14 February, 2018).

OEC, 2018. *Sweden*. The Observatory of Economic Complexity. https://atlas.media.mit.edu/en/profile/country/swe/ (Accessed on 18 February, 2018).

OECD, 2018. *OECD.stat*. Organisation for Economic Co-operation and Development, Paris. http://stats.oecd.org/ (Accessed on 27 March, 2018).

Orcutt, G., 1950. Measurement of Price Elasticities in International Trade. *The Review of Economics and Statistics* 32 (2): 117-132. http://www.jstor.org/stable/1927649 (Accessed on 9 April, 2018).

PwC, 2016. Leaving the EU: Implications for the UK Economy. https://www.pwc.co.uk/economic-services/assets/leaving-the-eu-implications-for-the-uk-economy.pdf (Accessed on 21 February, 2018).

Sedjo, R., and Simpson, D., 1999. *Tariff Liberalization, Wood Trade Flows, and Global Forests*. Discussion Paper, Resources for the Futures, Washington. http://purl.umn.edu/10557 (Accessed on 21 February, 2018).

Skogssällskapet, 2005. *Finland Behöver Skogsindustrin - Behöver Skogsindustrin Finland*. Skogssällskapet pressarkiv. http://www.skogssallskapet.se/skogsvarden/2005_1/sv26.php (Accessed om 28 February, 2018).

Stock, J., Watson, M., 2010. *Introduction to Econometrics*. 3rd ed. Boston, Massachusetts: Addison-Wesley.

Sun, C., and Zhang, D., 2003. The Effect of Exchange Rate Volatility on U.S. Forest Commodities Exports. *Forest Science* 49 (5): 807-814. https://academic.oup.com/forestscience/article/49/5/807/4617249?searchresult=1 (Accessed on 19 February, 2018).

Swedish Forest Industries Federation, 2017a. *Forest Industries – Facts & figures*. Swedish Forest Industries Federation, Stockholm. http://www.forestindustries.se/forest-industry/facts-and-figures/ (Accessed on 26 March, 2018).

Swedish Forest Industries Federation, 2017b. *Forest Industries - Statistics*. Swedish Forest Industries Federation, Stockholm. http://www.forestindustries.se/forest-industry/statistics/ (Accessed on 28 February, 2018).

Zhang, D., Lin, Y., and Prestemon, J., 2017. From Deficit to Surplus: An Econometric Analysis of US Trade Balance in Forest Products. *Forest Science* 63 (2): 209-217. https://doi.org/10.5849/FS-2016-018 (Accessed on 26 April, 2018).

Appendix

Appendix 1: First Differences

A series Y_t is integrated of the order one (denoted by $Y_t \sim I(1)$) and contains one unit root if Y_t is non-stationary but ΔY_t is stationary. The order of integration is basically a test of the number of unit roots. If a stochastic trend still is non-stationary after first differencing it can be differenced further to become stationary. In general, $Y_t \sim I(d)$ if $\Delta^d Y_t$ is stationary (Asteriou & Hall, 2016).

The procedure of making a non-stationary times series with a stochastic process stationary by differencing is done in the following steps. Consider the AR(1) model

$$Y_t = \phi Y_{t-1} + \varepsilon_t, \qquad (A1.1)$$

Where ϕ is equal to one if the series contains a unit root and is non-stationary. First differencing the non-stationary Equation (A1.1) yields

$$Y_t - Y_{t-1} = Y_{t-1} - Y_{t-1} + \varepsilon_t \qquad (A1.2)$$

$$\Delta Y_t = \varepsilon_t, \qquad (A1.3)$$

where ε_t is a white noise term. After first differencing the non-stationary series *A1.1* we obtain the stationary series *A1.3* (Enders, 2015). If the first difference still is non-stationary, the stationarity of the second difference of the time series is tested and so on, until $\Delta^d Y_t \sim I(0)$. This means that Y_t needs to be differenced *d* times to become stationary and contains *d* unit roots.

The above information can be summarised under a general rule, from Asteriou & Hall (2016):

$$\begin{pmatrix} order\ of \\ integration \\ of\ a\ series \end{pmatrix} \equiv \begin{pmatrix} number\ of\ times\ the \\ series\ needs\ to\ be \\ differenced\ in\ order \\ to\ become\ stationary \end{pmatrix} \equiv \begin{pmatrix} number \\ of \\ unit\ roots \end{pmatrix}$$

Appendix 2: Cointegration and the error-correction mechanism

As discussed in Chapter 3, including non-stationary variables in a regression may return results that are spurious. That is, if the two variables Y_t and X_t are both *I*(1) and we regress

$$Y_t = a_1 + aX_t + u_t \qquad (A2.1)$$

we will not generally get satisfactory estimates of $\hat{a}_1$ and $\hat{a}_2$. By differencing as described in Appendix 1, we end up with ΔY_t and ΔX_t being *I*(0), and the regression model will be:

$$\Delta Y_t = a_1 + a_2 \Delta X_t + \Delta u_t. \qquad (A2.2)$$

In this case, the regression model may give us correct estimates of the $\hat{a}_1$ and $\hat{a}_2$ parameters. This also solves the spurious equation problem in Equation (A2.1). However, the results that we receive from Equation (A2.2) is only the short run relationship between the two variables. This constitutes a big problem, but by implementing the concept of cointegration and the error-correction model, this issue can be resolved (Asteriou & Hall, 2016).

If we have variables that are *I*(1) and there is a linear combination of them that is *I*(0), they are said to be cointegrated. If this is the case, the regression of Equation (A2.1) is no longer spurious, and it provides us with the long run connection of Y_t and X_t:

$$\hat{u}_t = Y_t - \hat{\beta}_1 - \hat{\beta}_2 X_t \qquad (A2.3)$$

By definition $\hat{u}_t$ is *I*(0), thus we can express the relationship between Y_t and X_t with an error-correction model specification such as:

$$\Delta Y_t = a_0 + b_1 \Delta X_t + \lambda \hat{u}_{t-1} + e_t = a_0 + b_1 \Delta X_t + \lambda\left(Y_{t-1} - \hat{\beta}_1 - \hat{\beta}_2 X_{t-1}\right) + e_t \qquad (A2.4)$$

Equation (A2.4) now has the advantage of including both long-run and short-run information. b_1 is the impact multiplier (the short-run effect) that measures the immediate impact of a change in X_t on Y_t. The $\hat{u}_{t-1}$ term is the magnitude by which Y was above or below its long-run equilibrium value in the previous period (the long-run effect). The coefficient λ (which is expected to be negative) is the error-correction term and represents the amount of correction of the disequilibrium in the previous period (Asteriou & Hall, 2016).

Appendix 3: Distribution of trace statistics

The distribution of the trace statistic is as follows:

$$-T\sum_{i=r+1}^{n}\ln\left(1-\hat{\lambda}_{r+1}\right), \qquad (A3.1)$$

where T is the number of observations, n is the number of time series variables, r is the number of cointegrating vectors, and the λ_i are the estimated eigenvalues (Asteriou & Hall, 2016).

Appendix 4: Robustness tests

Lagrange Multiplier test on VAR

Table 7 presents the results of the Lagrange Multiplier test on the VAR with the number of lags that minimises the AIC, which is used as an indicator for the number of lags used in the Johansen test of cointegration.

Table 7. Results of the LM test on the VAR.

Lag	χ^2 [9]	Prob > χ^2
1	12.17	0.20
2	14.40	0.11
3	6.36	0.70
4	10.55	0.31
5	11.51	0.24
6	7.46	0.59

Notes: (1) H_0: No autocorrelation at lag order. (2) The LM test has a chi-square distribution with nine degrees of freedom. $\chi^2_{(9, 5\%)} = 16.92$; $\chi^2_{(9, 1\%)} = 21.67$.

Since no lags cannot reject the null hypothesis of no autocorrelation in the residuals at the five percent level, the VAR in levels and six lags is appropriate for establishing the lag length of the Johansen cointegration test.

Lagrange Multiplier test on VECM

Table 8 presents the results of the Lagrange Multiplier test on the Vector Error Correction-Model. The VECM is conducted using five lags, and Table 8 shows the results at each lag.

Table 8 – Results of the LM test on the VECM

Lag	χ^2 [9]	Prob > χ^2
1	10.02	0.35
2	15.51	0.08
3	8.49	0.49
4	8.57	0.48
5	12.62	0.18

Notes: (1) H_0: No autocorrelation at lag order. (2) The LM test has a chi-square distribution with nine degrees of freedom. $\chi^2_{(9, 5\%)} = 16.92$; $\chi^2_{(9, 1\%)} = 21.67$.

The null hypothesis of no autocorrelation in the residuals cannot be rejected for each lag at the five percent level.