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The Integration of Swedish and Global Grain markets

- A price transmission analysis of Wheat

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- A price transmission analysis

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Abstract

Increased trade and eased policy restrictions have brought markets closer together. Prices at different locations are much likely to affect each other to a certain extent. Since the adaption of Common Agricultural Policy in 1995 the Swedish wheat market has been exposed to the world market and Swedish farmers are facing new challenges. A broader knowledge about market integration and price transmission will facilitate Swedish farmers, banks and politicians in making rational decisions. Therefore the aim of this research is to explain how global wheat prices are transmitted on Swedish wheat prices. In reaching the final result thus explaining the cointegration between separate time series, a Vector Error Correction Model is applied. Monthly time series data from Swedish Board of Agriculture and global price data from the World Bank is used. Initially the price series have been tested for non-stationarity and showed significant results, thus trended time series, followed by a cointegration test. The outcome denoted a long-run relationship between price on the Swedish and global wheat market. Afterwards the vector error-correction model proved that Swedish wheat prices are responding to market disequilibrium in the short-run but not vice versa for the world market. Consequently prices of Swedish wheat are reflecting the volatility on the global wheat market both in the long- and short-runt. However the markets are not perfectly integrated due to various trade barriers such as tariff and quotas. To research can be extended to get more sophisticated representations with threshold- and asymmetric cointegration models.

Sammanfattning

Ökad byteshandel och färre handelshinder har fört världsmarknader närmare varandra. Priser för homogena varor i olika delar av världen kan sannolikt påverka varandra till en viss utsträckning. Sedan medlemskapet i Europeiska Unionen år 1995 och införandet av den gemensamma jordbrukspolitiken har den svenska marknaden blivit mer exponerad för världsmarknaden. Det har lett till nya utmaningar för svenska bönder på grund av ovisshet om framtida vetepriser. En bredare kunskap om korrelationen mellan marknader och pristransmission kan underlätta rationellt beslutsfattande för svenska bönder, banker och politiker. Därmed är syftet för detta examensarbete att förklara om globala vetepriser påverkar svenska vetepriser på lång och kort sikt.

Månadsdata från Jordbruksverket och Världsbanken har använts i undersökningen och omfattar perioden från januari 2000 till december 2013. För att nå det slutgiltiga resultatet, således förklara kointegrationssammanbandet mellan tidsserierna, har en vector error-correction model (VECM) implementerats. Inledningsvis testades prisserierna för icke-stationaritet och påvisade signifikanta resultat således att båda tidsserierna följer en trend. Därefter gjordes ett kointegrationstest där outputen tydde på ett långsiktigt samband mellan priser på den svenska och globala vetemarknaden. VECM ingick i det sista steget i estimering för att förklara möjliga kortsiktiga samband. Det konstaterades att svenska vetepriser reagerar på kortsiktig obalans på marknaden men inte vise versa för den globala marknaden.

Sammanfattningsvis reflekterar svenska vetepriser volatiliteten på den globala marknaden både på lång och kort sikt. Däremot är marknaderna inte fullständigt sammanlänkade på grund av olika handelshinder som tull och kvoter. För att uppnå mer sofistikerade resultat av kointegrations-sambandet kan threshold- och asymmetric kointegrationsmodeller implementeras.

Abbreviations

CAP	Common Agricultural Policy
EU	European Union
VECM	Vector Error Correction Model
VAR	Vector Autoregressive
WTO	World Trade Organization
LOP	Law of One Price
OLS	Ordinary Least Squares
BLUE	Best Linear Unbiased Estimator
AR	Autoregressive
ADF	Augmented Dickey-Fuller
ADL	Autoregressive Distributed Lag
OECD	Organization for Economic Co-operation and Development

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1 Introduction

The introductory chapter presents a background of the Swedish wheat market, question formulation and aim, limitations with the research, target group and finally the disposition of the thesis.

1.1. Background

Sweden adopted the common agricultural policy (CAP), after becoming a member of the European Union (EU) in 1995. Prior to the membership, grain prices were guaranteed to secure the production, and since the late 1980s the price-setting regime has undergone many reforms (Johansson et al. 2014). Since the membership the Swedish Government has strived to realise sustainable and competitive agricultural production to achieve lower budget costs and higher economic profit. Thus wheat production is driven by consumers demand and should be economic and ecologically sustainable of that the EU ought to facilitate food security and promote free trade. A reform within the CAP was resolved by the European Commission in 2003 to guide agriculture towards an increased market orientation and letting members be more influential of domestic agriculture policy. The overall objective of the reform was to increase the competitiveness among European farmers. Moreover the fundamental principle for realizing the reform was to reduce the impact of the single farm payment (i.e. decoupled payment) on production (United Nations). Accordingly the European agriculture would be more reciprocated to new challenges, like protection of biodiversity and climate change (European Union 2009). In 2005 the production aid was replaced with farm support, which resulted to Swedish grain prices being more determined by the world market prices (Johansson et al. 2014).

Determinates of world market prices are difficult to anticipate and are affected by occurrences outside Sweden's and the European Unions borders. A higher uncertainty has developed on the market due to implied volatility since 1990. Implied volatility is reflecting market expectations of future prices while volatility refers to the extent of variability of a price or a quantity (Gilbert & Morgan 2010). Moreover the awareness of volatility on the global market has increased due to integration of markets (Lee & Park 2013). The extent and speed of which the global grain prices are transmitted to Swedish depends on the degree of integration. If different markets have a high degree of integration they become more efficient, thus a smoother transmission of prices. A small degree of integration indicates that prices are not transmitted perfectly and therefore create distortions of production, distribution and misallocation of resources (Sanjuán & Gil 2001). Factors that influence domestic price changes are export taxes, import duties, non-tariff barriers, domestic subsidies that mirror the international market of several reasons (Johansson et al. 2014).

From January 2006 to early 2008 the world price of wheat and other foods more than doubled. Food prices began to fall since mid-2008 but most have remain above 2006 levels. Underlying factors behind 2008 price spike have been discussed by a number of authors (Headey 2011). Several explanations are available and some with a greater prominence (Gilbert & Morgan 2010). Accordingly, the US dollar depreciation, poor harvest in especially in Australia, rapid economic growth in China in particular, low inventory levels, underinvestment in agriculture for decades, biofuels production – diversion of food crops. Because of the considerable effect and wide coverage of national grain prices, the international transmission of prices may have changed its magnitude and speed (Lee & Park 2013). Today economics ask if food prices have become more variable and if sudden spikes will occur more frequent (Gilbert & Morgan 2010). Figure 1 is showing the evolution of international weekly prices of Hard Red Winter and Soft Red Winter wheat types since January 2006 until December 2014 (Agricultural Market Information System 2014).

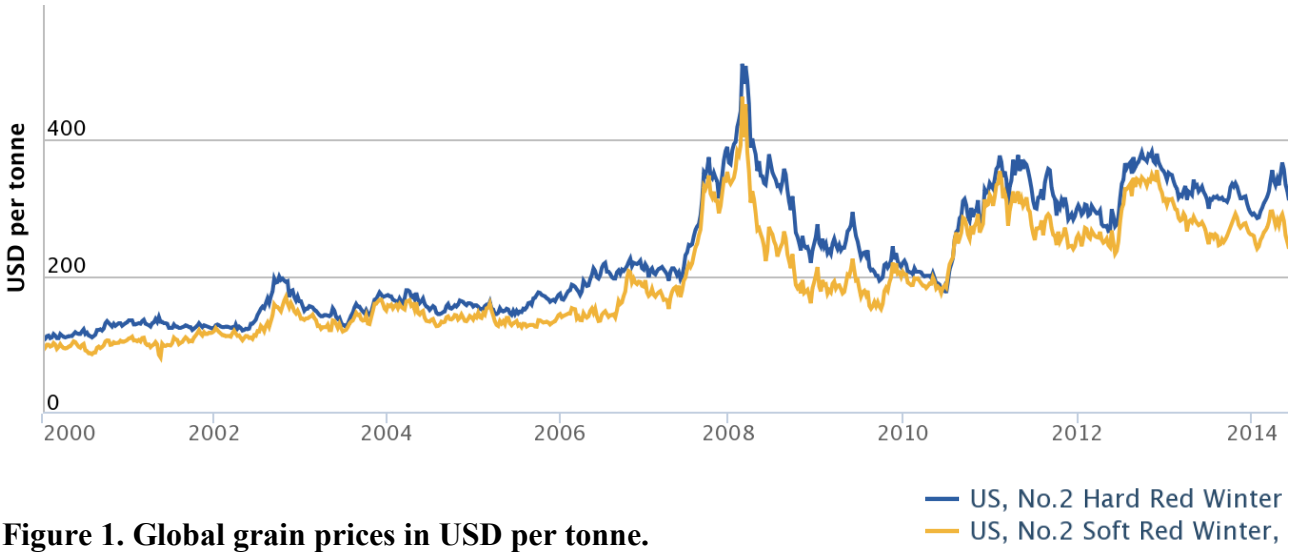

Figure 1. Global grain prices in USD per tonne.

In July 2007 the Swedish agricultural authority reported a high increase of grain prices because of drought in major parts of United States and south of Europe. Rain and cold weather had troubled north Europe that arose a concern for the quality and coming for crop yield. On Chicago Board of Trade the wheat price had almost reached the same level as in 2008. The price movement indicated on a short-term disturbance and Swedish wheat price were still high much due to reduced yield in Russia, Ukraine and Kazakhstan (Jordbruksverket 2012). The Swedish trade magazine *Butikstrender* (2014) wrote in March 2014 about increased wheat prices because of the agitation in Ukraine. The country is called "granary of Europe" and much of the sold wheat was still on the hold to be transported from Ukraine.

In a study by Dawe the pass-through of prices depends on commodity type when studying about transmission of international grain prices to seven large Asian countries during the years 2003-2007. International wheat prices have for instance a stronger transmission to domestic prices in Asia than rice. Incomplete price transmission was due to the real appreciation of their currencies compared to US dollar neutralized global price increase when grains were imported to Asia (Dawe 2008). Generally the extent of price transmission of global agricultural commodities to domestic food prices is greater for grains than for fruit and vegetables (Lee & Park 2013).

Commodity prices that follow established trends, reflect the market fundamentals and exhibit a distinctive seasonal pattern are not seen as problematic. Difficulties arise when price variations are large and cannot be anticipated, as a result, increased risks and uncertainty for producers, traders, consumers and governments, which can induce sub-optimal decisions. Less developed countries with poor consumers are most immediately affected by price changes because of inappropriate policy response for example. Henceforth farmers with limited resources are especially vulnerable when there is a price fall (High Level Panel of Experts 2011).

Like many other researches about price transmission Dawe's article was published as a result of the rising food prices. Agricultural economics have especially been considered for price transmission analysis because of the attention to gaps in economic theory and also policy purposes due to market failure (Meyer & Cramon-Taubadel 2004). Studies about the wheat market including "Price asymmetry in the international wheat market" by Cramon-Taubadel and Loy (1996) and "Threshold effects in price transmission: the case of Brazilian wheat, maize, and soya prices" by Balcombe, Bailey and Brooks (2007) have been examine the degree of price transmission of wheat but the Swedish market lack of comparative analysis with the world market especially regarding grains.

Different econometric methodologies have been used to evaluate a spatial price linkage with additional testing for consistent outcomes. The preferred econometric framework is today based on more recent developments for analysing price transmission and properties of price data (Hassouneh et al. 2012). In the literature many analysis are inadequate as not being comprehensive concerning deviation from competitive models. Only recently writers have taken to account the dynamic in a price transmission process, using properties of cointegrated time series and following a "non-structural" approach. This implies that price series can behave differently in the short runt but converge to a similar long run relationship, if so is the case a vector error-correction model

(VECM) can be used to verify these characteristics. Accordingly VECM is used in this research with additional property testing (Conforti 2004).

1.2. Question formulation and aim

Prevailing integrated markets are creating new challenges for countries, much due to the increased volatility and regulatory reforms. When Sweden adapted the common agricultural policy Swedish the wheat market experiences drastic changes and the farmers had to take the world market into account. The examined period of fourteen years begins in 2000 when the global stock of grain declined followed by a volatile grain market parallel with reforms of CAP. By analysing price data of the Swedish and global wheat markets the aim is to answer to what extent global wheat prices are transmitted to Swedish wheat prices. The research comprises quantitative price data to establish a casual link between the two markets. With econometric methods it is possible to examine the existence of a long-run relationship followed by a short-run relationship. By knowing the degree of integration it will facilitate Swedish farmers, banks and policy makers in making rational decisions concerning production, consumption, financial- and policy instruments. Thus integrated markets are expected to employ information from each other when forming own price expectations.

1.3. Limitations

The research is evaluating necessary statistically conditions that can be crucial for the final linkage of the two markets. Initially the estimation procedure is examining the presence of unit-roots in each time series and then test for cointegration to explain the long-run relationship. As expected it has to be clear whether the time series are non-stationary and need to be differentiated to become stationary. Moreover a low powered unit-root test can lead to false conclusion and lead to a spurious regression with incorrect results. If a long-run relationship exists the time series can be further tested for a possible short-run relationship. Alternatively if it is no long-run relationships the data can be estimated using a vector autoregressive (VAR) model that strictly tests for short-run relationship. Consequently the vector error correction model would not be the appropriate model if the time series were not cointegrated.

Other factors that are influencing integrated markets are not taking into account in the econometric modelling. For instance can oil price, transaction cost and policy regulations have an impact on market conditions for wheat and are therefore carefully considered in the analysis.

1.4.Target group

The reading of this thesis is suggested to people with some knowledge about statistics, econometrics and basic economic theories. As well as people with the interest about market integration and price transmission within the agricultural-, food-, bank- and policy sector. A deeper understanding of the degree of transmission of wheat prices from global to domestic market will help farmers to adapt to influencing factors that could affect wheat prices. It is also fundamental knowledge for Swedish banks when specifying agreement to secure revenue from harvest and purchase expenditures. Moreover such agreements are linked to CAP and thereof the policy sector. The Swedish government could, with a greater understanding of wheat price transmission, design more consistent bilateral, regional or multilateral agreements with the European Union to promote food security and preserve the national environmental for instance.

1.5. Disposition

The structure of the papers is as follows. Section 2.1 gives a brief background about Swedish grain pricing, the common agricultural policy followed by a few previous studies about price transmission. Section 3 outlines, based on economic theory the concept of market integration, the law of one price, trade barriers, market efficiency and analysis of time series. The econometric framework is introduced in section 4 and describes the fundamental steps in reaching the results and the empirical procedure. Section 5 explains the estimated results, whether global and Swedish wheat prices are integrated and a sensitivity analysis. At last, section 6, evaluates the result followed by an analysis, reflections of the method and a conclusion of the research.

2 Literature review

This chapter presents a brief history of Swedish grain prices and the role of CAP in Sweden after becoming a member of the European Union. Finally an overview of previous studies of price transmission concerning wheat is given.

2.1. Swedish grain prices

Swedish farmers were before more protected against price fluctuation on the world market on the basis of the prevailed agriculture regime, and therefore it was unnecessary to know about price changes on the world market (Tarighi 2005). Regulations of the Swedish grain market broaden when entering the European Union. Today the grain market has become a part of the equity market where speculations are important, when for instance the market experience a shortage hence augmented price fluctuations. Hans Ström, business manager at Södra Åby local society declared the complex market and how the farmers must keep track on the stock exchange to adapt to various influencing factors (Douglasdotter 2013). Consequently the EU membership has brought on new risks within the Swedish agriculture because of the harmonization of the common agricultural policy (Johansson et al. 2014).

There are a few alternative approaches when it comes to sales. Fundamentally it is about selling securities or the physical product. Farmers that are selling the actual product can choose to sell directly to daily prices or be assisted by a local society or other organizations like *Lantmännen* thus agree on a fixed price in advance. Furthermore wheat can be stored at the farm and later be sold when the price is right (Douglasdotter 2013).

The individual Swedish farmer has no influence on prices as the prices are established on the global market. Consequently banks offer specific agreement to help secure revenue from harvest and purchase expenditures. Enhanced knowledge about price changes will help banks to accomplish improved risk assessment and thereof help Swedish farmers to make rational decisions regarding grain commerce, hence reduce the risks (Handelsbanken 2014).

There are several factors that contribute to fluctuations of Swedish wheat prices and obviously weather. A high oil price adds to the demand of wheat due to the production of biofuel. It is more lucrative to produce biofuel when the oil price is high although the ethanol industry will suffer because of high wheat prices. Another factor that increases the demand of wheat in the long run is our lifestyle. Today developing countries are consuming more dairy food and meat thus an increase breeding of animals that eat wheat (Jordbruksverket 2012).

Swedish wheat consumption measures up to a defined amount of the total food expenses, when in developing countries the share is far larger. Henceforth, high global wheat prices have a moderate impact on Swedish food prices though it can result in serious consequences in poorer countries. On the other hand, wheat as feed is having a big impact on the animal production. Henceforth the meat price will increase if wheat prices remain high (Jordbruksverket 2012).

2.2. Common Agricultural Policy in Sweden

Since the considerable CAP reform in 2003 the policy impact on Swedish production has declined. Production has become less sensitive to trade and agricultural policy changes because of the decoupled support payment. Accordingly with previously adopted policy changes, the land use for cereal farming has declined while the price for land has risen and the number of farm enterprises increased (United Nations).

To preserve the national environmental quality and sustainable develop rural areas, which is also the overall goal for Swedish agricultural policy, a program called Rural Development Programme was implemented during the period 2007-2013. EU and the Swedish government equally financed the program (Jordbruksverket 2009).

Accordingly with a weight of international opinion CAP has an adverse impact on world trade with agricultural products. Sweden supported the mandate for the Doha Round of trade negotiations of World Trade Organization (WTO) to achieve reduction of trade distortions, increased market access and elimination of export subsidies. Similarly support the need and interests of developing countries to reduce poverty. Traditionally Sweden has defended open trade although the protection of humans, animals and plant health could restrict trade.

Since joining the European Union the Swedish Government has seek to eliminate tariffs on ethanol because countries with the best conditions to produce biofuels should be able to so and export. Consequently if trade were restricted or more costly by trade barriers, it would not be economically profitable to produce biofuels and prevent reduction of greenhouse gas emissions. In addition the demand for organic food has increased as well as the trade. Sales of Swedish organically produced cereals have been growing strongly on the international market for organic food (United Nations). In 2014 yet another agricultural farm policy has come into force in Europe and induced further challenges for the Swedish government (Regeringskansliet 2014).

2.3. Previous research

Prior to the food crisis Mohanty, Peterson and Kruse (1995) described the allocation of wheat export to a limited number of countries specialized in wheat and with diverse policy regimes. Then prices were approximately determined between the interaction countries. After investigated the trade linkage they found that the majority of exporting countries respond asymmetrically to price changes in North America although the degree of response differs among the countries. Canada and Australia show greater response to rising prices than to falling, while the opposite coincide to the European Union and Argentina.

After Agricultural and Applied Economics Association annual conference an article on how CAPs' reforms have effected international wheat price transmission was published. The estimation on price transmission was made on producers' wheat prices in Germany accordingly with 1992 CAP reform and Uruguay Round Agreement on Agriculture. Due to policy regimes before 1992 the domestic market was rather closed to the rest of the world. The MacSharry reform was the first major structural adjustment in European agricultural policy although the European agriculture was still isolated. During the Uruguay round it was established that trade barriers should be reduced over time. For example was the tariff for wheat ought to be reduced by 36 percent over a sig year period. Finale estimates of the research proved German prices to vary considerably less world prices. Even though agricultural reforms the variability of domestic price remained half than for the world. Thus the international price transmission elasticity on German wheat prices during the sample period was ranged 0.18-0.30 reflecting a long-run equilibrium (Thompson & Bohl 1999).

Price transmission has been a periphrastic topic across economic literature. For instance Conforti (2004) collected price data from sixteen countries worldwide to provide evidence of price transmission in several agricultural markets. He concluded geographical regularity such as African countries tent to have a lower degree of price transmission compared to other countries. In order to get a better understanding of such cases infrastructural gaps, physical barriers and limited market sizes must be further investigated. Among other countries, Latin America exhibited mixed results while countries in Asia have a relatively complete transmission.

In the same way as Dawe (2008) reasoned Conforti (2004) found that the degree of price transmission depends on the type and characteristic of commodity. Fast and high transmission is generally more frequent for grains, followed by oilseed but poorer for livestock. Whether the products are homogenous have an important roll for the degree of integration.

3 A theoretical perspective

This chapter explains how markets are integrated based on a theoretical perspective. It introduces the fundamental concept of the law of one price (LOP), market distortions caused by trade barriers and market efficiency. The last section gives an understanding of time series data that is used in the estimation procedure.

3.1. Market integration and the Law of One Price

Because the commodities are tradable, they are subjected to considerable interventions with world prices (Krueger et al. 1988) Prices on national level are becoming more integrated with other countries. In the European Union and Former Soviet Union, current domestic prices are more connected to the global market than they were 20 years ago (FAO 2014). Food crisis of 2007-2008 enhanced the empirical research on agricultural price transmission between markets. In this study the research is subjected to horizontal price transmission, which refers to the price linkage across different markets, hence co-movement of prices of wheat (spatial price transmission). Assuming that the global wheat prices is linked to the Swedish wheat prices the basic representation of a price transmission equation can be written as:

$$P_{St} = \beta_0 + \beta_S P_{Gt} + \beta_G T_t + \varepsilon_t \qquad (1)$$

where P_{St} and P_{Gt} are the Swedish and Global wheat prices at time t, respectively. T represents the transaction costs and ε_t the disturbance term (Listorti & Esposti 2012). The degree of integration is explained by the extent and speed to which shocks are passed through, as well as the strength of interdependence among prices (Sanjuán & Gil 2001). If the markets are perfectly integrated $\beta_S = \beta_G = 1$ and $\beta_0 = 0$.

Fundamental theoretical explanation of spatial price transmission is the spatial arbitrage and the law of one price. The spatial arbitrage condition is the key concept of co-movement of prices of a specific product in different markets. It finds that the transaction cost can never exceed the difference between prices in separate markets, otherwise profiting opportunities by arbitrageurs would occur. Marshall derived the consequence of spatial arbitrage, also called the law of one price. It indicates that homogenous good, expressed in the same currency, on integrated markets will have unique prices, net transaction cost. LOP is a restrictive assumption and unlikely to hold in practice. This is because the market is dynamic while the LOP is a static concept stating that prices always are in equilibrium. Furthermore the concept of market integration is explained by the tradability of

products in different markets without taking efficiency and spatial market equilibrium into account (Listorti & Esposti 2012).

3.2. Trade barriers

Incomplete pass-through of price changes from global market to the Swedish is caused by several kinds of barriers. Literatures on spatial price transmission stress the impact of transaction cost, imperfect competition and trade policy mechanism. Referring to the two first mentioned causes, their occurrences may depend on bad poor communication infrastructure and transport. Thus for a perfectly competitive market all actors are assumed to have perfect information about prices. When economic agents lack of price information it can lead to inadequate decisions making and contribute to inefficient outcomes (Rapsomanikis et al. 2006).

Trade policies comprehend mechanisms like tariff rate quotas, import tariffs, exchange rate policies and export subsidies and can isolate the domestic market (Acosta 2012). Barriers to trade can be assigned to different participants such as the government, international institutions and private actors. The government regulate trade project and can chose to encourage trade or operate against it. Not only is the government playing a decision-making role but the deliberation process will also bring about transaction cost that can work as a trade hindrance. Private parties, such as small farm holders, have to bear internal cost due to adaption of project development, management and interaction with the government representative (Michaelowa et al. 2003).

Efficient allocation of agricultural products is due to trade liberalization and enhanced by WTO (Rapsomanikis et al. 2006). Another example of improved trade is the common agricultural policy of agriculture in Europe. According to Dacian Cioloş, the European commissioner for Agricultural and Rural Development, Cap is the link between an increased urbanised world and an increasingly strategic farming sector (CAP 2012).

3.3.Market efficiency

Many political leaders and economists share the opinion of having a government that operate in line with the Pareto principal, suggesting allocations by which an individual is made better off without making anyone else worse off. Henceforth the governments should encourage competition, allow voluntary trade and try to deplete problems that are related with trade and reduced efficiency (Perloff 2007 pp. 349).

During the Uruguay round in 1993 it was concluded that reductions of quotas, tariffs and other distortions to global trade are desirable. On the other hand national government and constitutes were reluctant to fully embrace the concept of free trade thus the actual reduction process of quotas and tariffs is not easily realized. Meade (1955), Lipsey and Lancaster (1956) professed that in case of trade policy reform there is a general problem of the second best. Reduction of market distortions assigned to the first best may not lead to welfare improvement due to negative spill-over effects in other markets (Turunen-Red &Woodland 1995). For instance Sweden is a small price taking country on the world market and produces wheat. In a perfectly competitive market welfare in Sweden will be greater if open to free trade with other countries. Having a lower price than world price P_w Sweden can export wheat and a higher price will stimulate import.

As shown in figure 2 (a), a lower P_w but a ban on imports, such as a quota, a deadweight loss will occur. If Sweden is a closed economy the autarky and equilibrium price is e2 and if the economy is open the equilibrium is at e1. An import ban will create a deadweight loss that is represented by area D. In figure 2 (b) the government decides to subsidies the wheat production that will lead to excess production as the farmers are paid more than before. Wheat supply increases and the domestic supply curve will shift down. The free trade equilibrium is e4 and the equilibrium with a ban is e3. Area A+B (without subsidies from the government) is the increased welfare when Sweden lack of bans. Extra expenses of the government due to the subsidy will cost B+C and total welfare falls because are C is greater than A.

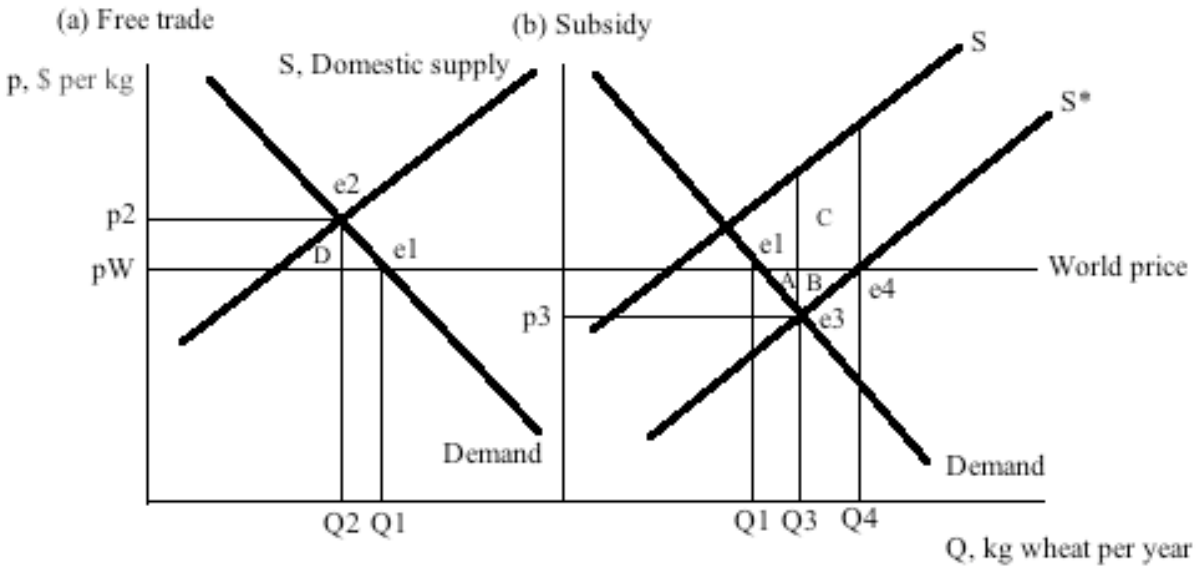

Figure 2. Welfare losses from domestic distortions when free trade.

Hence *theory of the second best* explains that because of domestic subsidy distortion welfare does not have to rise because of free trade. At P_w firms produces at Q_4 while in Sweden the production is Q_1. Swedens excess demand is $Q_4 - Q_1$ (Perloff 2007, pp. 356).

Policies that attempts to reduce quotas and tariffs in a specific country may not induce pareto improvements unless the direction of the reform is prudently chosen. Moreover any trade policy reform in a large open economy will have international resilience and the global prices of traded goods will adapt to new market equilibrium. Consequently the desirability of trade policy reforms must properly be evaluated of each individual country thus all participants should gain from a policy change (Turunen-Red & Woodland 1995).

3.4. Analysis of time series

A time series analysis aim to capture and examine the dynamics of, in this case, monthly price data in chronological order. Thereof explain the simultaneous relationship between the dependent variables, Swedish wheat prices, and the explanatory variables, global wheat prices. Because previous events can influence future movements, lagged variables are necessary to explain the dynamic aspect of time as time series are usually related to their recent history. Most economic series are trended and slow to adjust to shocks, therefore the adjustment process must fully be captured to understand the structure of the economy. Furthermore certain frequencies of monthly time series might exhibit a seasonal pattern (Asteriou & Hall 2011, pp.16).

Equilibrium can stay indefinitely because the variables in a supply and demand function are hold constant. If one of the constant variables changes –here, price and quantity- a shock to the equilibrium occur, and there will be a shift in either the supply or the demand curve. Shocks comprehend environmental variables (i.e. exogenous variables) such as income, prices of inputs, complements and prices of substitutes. Comparative statics refers to a static equilibrium at a certain time compared to a change in equilibrium; consequently a shock is associated with the before- and after equilibria. Suppose ceteris paribus among all other environmental variables except the price of wheat that has increased 25 cents. The production cost has then increased because of the mayor input wheat is more expensive. This is however not an argument to the demand function and the consumers desire will not change. Figure 3 shows the upward shift in the supply curve has created excess demand (Asteriou & Hall 2011, pp. 16).

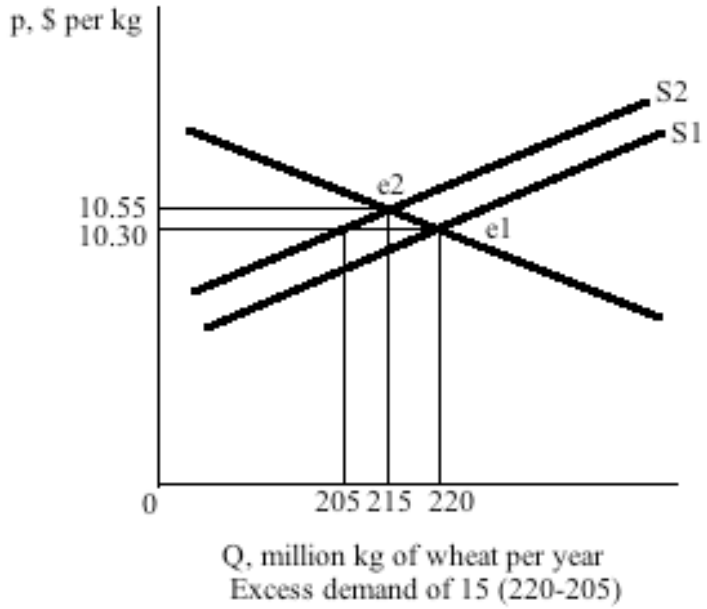

Figure 3. Price effect on a partial equilibrium model.

A price increase of $0.25 of wheat will shift the supply curve up from S1 to S2, driving the market equilibrium from e1 to e2, and the new market price is $10.55. Market pressure forces the wheat prices up to the new equilibrium. According to the characteristics of time series the adjustment process reaching the new price is tedious (Asteriou & Hall 2011, pp. 24-25).

Since 2000 the global stock of grains has been declining (Schnepf 2008). During the last 5-10 years the cereal production has experiences disequilibrium on the world market, in which the growth in demand overtook the growth in production. Because of the rapid income growth in China, India and recently Sub-Saharan Africa the demand has been growing at two percent per year. Meanwhile, the imbalance between demand and supply is caused by a decline in yield growth from a two to five percentage range in 1970 and 1980 to one to two percentage in the middle of the 1990s (Minot 2011).

As introduced in section 3.1. LOP is a static concept and corresponds to a static equilibrium. We already know that the economic process is dynamic and temporary deviation from equilibrium often is present. Moreover long-run equilibrium might co-exist with temporary arbitrage opportunities (disequilibrium). The assumption of a unique price, for homogenous goods in linked markets, will be violated because of factors like volatile transaction cost, policies, market power, exchange rate risks and domestic and border regulation (Listorti & Esposti 2012).

Typically in economic models these factors are unobservable and captured in the disturbance term. Empirical analysis is subjected to strong assumptions of the behaviour in the disturbance term and exposure of the estimated parameter that add up the combined effect influencing price transmission. Furthermore increased knowledge about the deviation drivers will help when estimating the results using empirical specification and interpretation (Fackler & Goodwin 2001).

4 Econometric framework and limitation of the model

This chapter describes the three fundamental steps to carry out the analysis. Initially the concept and testing for non-stationarity are explained followed by the cointegration theory and whether the two times series are long term cointegrated. Lastly the vector error-correction model is represented hence the interpretation of cointegration vectors.

4.1. Non-stationary – unit root

Macroeconomic time series are most likely trended thus experiencing an underlying growth rate such as increasing prices at a regular annual rate (Asteriou & Hall 2011, pp. 338). A trended price series is not stationary and has a mean that is rising over time, even if the variance and covariance are constant (Wooldrige 2006).

The standard ordinary least squares (OLS) regression procedure will only generate best linear unbiased estimator (BLUE) of the coefficients if all the assumptions of classical linear regression model are satisfied (Asteriou & Hall 2011, pp. 149). Both the dependent variable Y_t and the explanatory variable X_t need to have constant and zero variance to be stationary, in order to generate a consistent OLS regression. Shocks in stationary time series will disperse over time and converge to unconditional mean while in non-stationary time series they will not diminish thus be eliminated. Consequently time is an essential determinant to the variance and/or mean of non-stationary time series (Asteriou & Hall 2011, pp. 335-339).

Non-stationary price behaviour is equivalent to the presence of unit root in univariate time series, which is indicated by its autocorrelation coefficients. Time series are said to contain a unit root if the autocorrelation coefficient is equal to 1, denoted I(1), and need to be differentiated to become stationary, I(0). Granger and Joyeux (1980) proposed the idea of fractional integration where $0<d<1$, I(d), which implies that the price series keep the memory of a shock for a long period, thus not behaving as random walks (Listorti & Esposti 2012). For example if a subset of variables are I(1), the first difference will be stationary. However if the first differences are taken from all the

variables, the error process will also be differentiated, which can result in a loss of important information and estimation difficulties. The variables can be I(1) when taking individually but a linear combination of the variables may exist without differencing (Asteriou & Hall 2011, pp. 335).

If non-stationary or trended macroeconomic time series are used in OLS regression it can lead to incorrect conclusion such as a very high value of R^2 and high t-ratios (Asteriou & Hall 2011, pp. 335-339). A time series is stationary if the process has a constant mean, a constant finite variance and a finite covariance (Sharp 2010). The existence of structural breaks (shocks) will also reduce the ability to reject false unit root null hypothesis (Listorti & Esposti 2012). Moreover a spurious regression shows a significant relationship between non-correlated variables (Asteriou & Hall 2011, pp. 339).

A Dickey-Fuller test tests for the existence of unit root in the time series hence the augmented version also includes extra lagged terms of the dependent variable (Asteriou & Hall, 2011, pp. 343). There are two motives behind testing for unit-root. First, it is crucial to know the order of integration when making inference and drawing conclusions from an econometric model. Secondly, economic theory imply that certain variables should be integrated, a martingale process or a random walk (Sjö, 2008). The test will examine whether the time series are non-stationary with a null hypothesis of a unit-root; $H_0: \phi = 1$, alternatively $H_1: \phi = 0$. The most simple time series model is the autoregressive of order one model, AR(1) model:

$$Y_t = \phi Y_{t-1} + u_t \qquad (2)$$

where $Y_t$is mainly determined by its own value in the previous period, $|\phi| < 1$, and u_t is a white noise error term. The time series behavior in t is mainly dependent of what happened in t-1and t+1 is determined of t. Then if ϕ is equal to 1 there is a unit root (Asteriou & Hall 2011, pp. 343). The result will tell if the variables are stationary, integrated or deterministic stationary (Sjö 2008).

The augmented Dickey-Fuller (ADF) test observe if the dependent variable is autocorrelated with more than one lag and assume the error term to be correlated. Furthermore the number of lagged difference terms is the determined in the empirical testing and aim to include enough terms so that the error term is serially uncorrelated thus the following regression is represented:

$$\Delta Y_t = B_1 + B_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-1} + \varepsilon_t \qquad (3)$$

where ΔY_{t-1}=Y_{t-1}-Y_{t-2}, ΔY_{t-2}=Y_{t-2}-Y_{t-3} etc and ε_t is the pure white noise. The added lagged value eliminates the serial correlation. Thereafter a cointegration test will explain the relationship among a group of variables, where each has a unit-root (Gujarati 2004).

4.2. Cointegration

Not all regression analysis shares the requirement of stationarity if the time series are cointegrated. Consequently it is feasible to test for cointegration if both time series contain a unit-root. As most time series appear to be first order integrated, I(1), the error can be represented as a combination of two cumulated error processes, also called the stochastic trend (Asteriou & Hall 2011, pp. 356). If the time series are integrated they follow the same stochastic trend and share the same unit-root. Moreover a long-run relationship or equilibrium will exist between Y_t and X_t. To see if Y_t and X_t share a linear combination the residual can be taken from the following regression:

$$Y_t = B_1 + B_2 X_t + u_t \qquad (4)$$

to obtain

$$\widehat{u_t} = Y_t - \widehat{B_1} - \widehat{B_2} X_t \qquad (5)$$

If $\widehat{u_t}$ ~I(0) Y_t and X_t (both I(1)) are cointegrated and connected in the long run, though it can diverge from it in the short run (Asteriou & Hall 2011, pp. 357).
The global wheat price and the Swedish wheat price are cointegrated if they both are integrated of order one but their linear combination is I(0). With that said the two variables would have an equilibrium relationship between them hence vary around a specific mean (Gujarati 2004).

Because there are more variables in the model there can be more than one cointegration vector. Furthermore several equilibrium relationships can exist determining the joint evaluation of all the variables. In this case there are 168 monthly transfer price observations (14 years multiplied with 12 months) thus the number of cointegration vectors can only be 168-1. Consequently if n=2, the existing cointegration vector would be unique. Hendry and Richard (1982) and Hendry (1987) advocated a test based on the coefficient of the lagged dependent variable, Y_{t-1}, in an autoregressive distributed lag (ADL) model. Furthermore the process depends on the significance of the lagged dependent variables. In 1983 Engle proved the sufficient condition of weak exogeneity of the regressors for the parameters in order for OLS to provide asymptotically efficient parameter estimates in the conditional ADL model (Banerjee et al. 1998).

4.3. Error correction model

Complex interaction and simultaneous determination of market prices can be described within a multivariate framework thus a vector error correction model is most suitable to study spatial price linkages between the global and Swedish market (Stock & Watson 2007). Transaction costs are not incorporated into the model and are assumed to be constant. VECM estimates price adjustment caused by deviations from the long-term equilibrium (Meyer 2004).

Given that the time series data of the two markets are cointegrated the VECM can reveal both long-run and short-run information among the variables (Stock & Watson 2007). Realistically, a long-run relationship has to allow for potential short-run disequilibrium that VECM incorporates (Cottrell & Lucchetti 2012). Nonetheless, according to the economic theories of spatial arbitrage and LOP we would expect an equilibrium relationship between global and Swedish wheat prices (Listorti & Esposti 2012).

As noted in the theory section, equation (1) represents the basic price transmission equation. However the estimates of the coefficient will lead to a spurious regression due to the fact that the time series data is trended and I(1). After testing for cointegration and finding that the time series are cointegrated by definition $\hat{u}_t \sim I(0)$ a new relationship with an ECM specification can be expressed as:

$$\Delta P_{St} = a_0 + b_1 \Delta P_{Gt} - \pi \hat{u}_{t-1} + e_t \qquad (6)$$

where b_1 represents the short-run effect (the impact multiplier) that has an immediate impact on P_{St} when P_{Gt} changes. π is the adjustment or feedback effect and indicates how much disequilibrium is being corrected, that is to what extent the previous disequilibrium affects any adjustment in P_{St} (Asteriou & Hall 2011, pp. 359).

4.4. Empirical procedure

Estimation proceeds in three stages. Initially the presence of it unit-root is tested using the ADF-test. If any of the time series turn out to be non-stationary they have to be differentiated for further testing. Accordingly, time series are assumed to follow a trend, because of increasing prices at a regular annual rate.

The ADF-test incorporates the number of lags that will be included when testing for cointegration, thus a long-run relationship, which is the second step. It is important to choose an appropriate lag length as explanatory variables. If the number of lags is too small the serial correlation in the errors will cause a bias test. And if the lags are too many the power of test will suffer. Monte Carlo experiments suggest that more lags are better than too few (Ng & Perron 1995). Short-run dynamics is estimated in the third step with least squares thus an error correction model.

5 Method

In this chapter the economic data is applied to the econometric method and aim to link theory to result and analysis. Initially it is described how price data has been collected followed by adaption of the data for consistent results. Finally the time series are incorporated into software of econometric analysis.

5.1. Data

In this research the material comprises 168 monthly transfer price observations over the period 2000 (01) to 2013 (12) from the Swedish and global market. For which relations between Swedish and global wheat prices were statistically (quantitative) and practically (qualitative) established. A transfer price is the price the farmer receive when selling its products to the purchaser. The chosen period of price data originates from the decline of global grain stocks in 2000, incorporates the recent food crisis and ends in 2013 where global price of wheat was still volatile. Fourteen years of price data aim to give an overview of a volatile global period and at the same time capture the reforms of CAP reflecting the development of Swedish wheat prices.

Swedish price data was gathered from the homepage of the Swedish Board of Agriculture that is a public authority with expertise in animal welfare and cultivation of food products. The authority is responsible for the official Swedish statistics within the agriculture and aquaculture area, with the aim to follow the average price trends. Since 1970 the statistics is declared with price-index system and when entering the European Union, in 1995, the index system has become more adapted to the

corresponding Input Price Index and Output Price Index. In Sweden, trade organizations, sole proprietorships and other authorities use the statistics. It is also used by the EU-commission to evaluate markets. Every month the price quotation is collected from a large group information provider to cover a greater part of the market. Wheat prices belong to a transfer price index that shows the development for agricultural average transfer prices (Enhäll, 2013).

Corresponding global wheat prices were collected from the World Banks database. The World Bank has accessible, free and comprehensive data for all users with the aim of allow advocacy groups and policymakers to make rational decisions. The database is also used as tool for journalist, research, academia and others. Furthermore the World Bank holds data for major commodity markets to developing countries. At the beginning of each month 70 monthly price series are published (World Bank, 2014).

5.2. Estimation procedure

Estimation of long- and short-run relationship is based on collected price indices over a thirteen-year period. The data was incorporated into *Microsoft Office Excel* and to the econometric software package, *Gretl*. Because the Swedish prices were declare in Swedish currency (krona) per 100 kilogram and the global in dollar per metric ton, the final price indices were converted into dollar per kilogram using the historical exchange rate from Organization for Economic Co-operation and Development (OECD) statistical database.

Initially the presence of unit root in Swedish respectively global time series is examined using the ADF-test. To avoid spurious regression if the time are series are non-stationary but stationary in their first differences, I(1).

5.3. Test of time series

The data set is approached by determine if the Dickey-Fuller regression ought to contain, constants, trends or squared trend. Figure 4 is illustrating four graphs with the price in dollar per kilo wheat on the y-axis and the years from 2000 to 2013 on the x-axis. The two graphs to the left in figure 4 are indicating non-stationary processes and evidence of volatility, hence Swedish and global prices levels have a changing mean and fluctuating variance. The graphs to the right are showing the time series in their first difference that is stationary. Because of both times series have a nonzero mean; the ADF-regressions will contain a constant and quadratic trend.

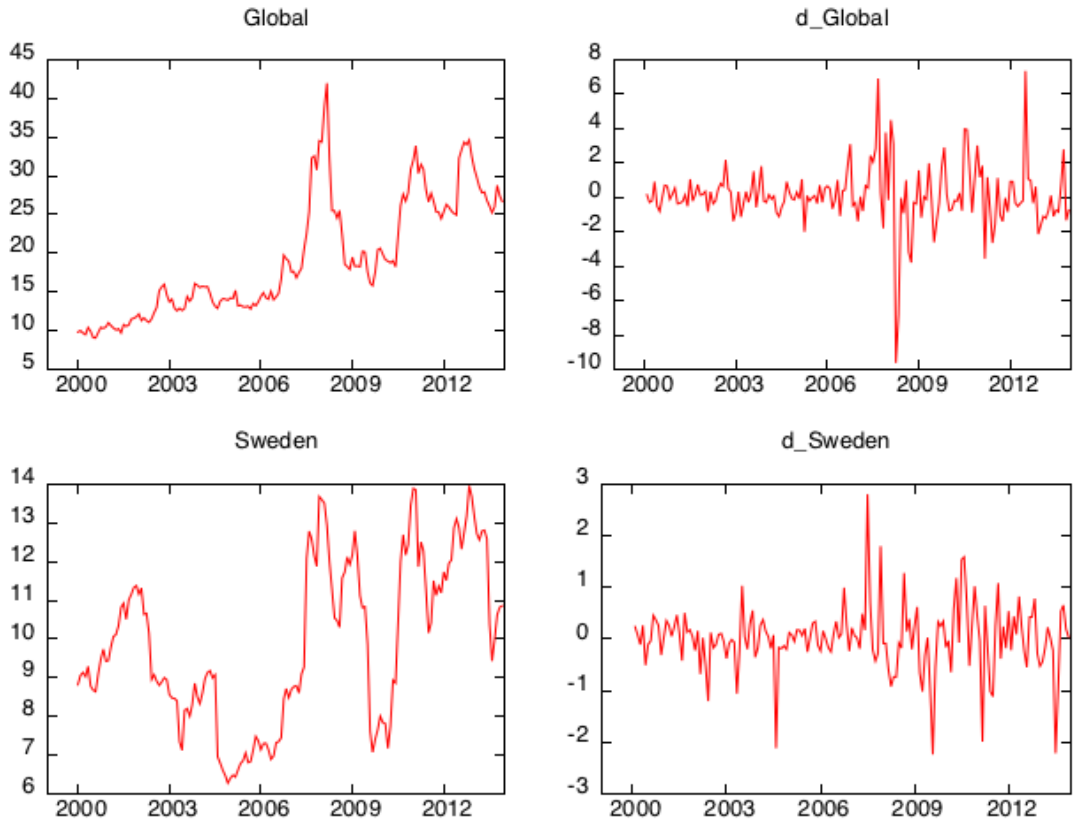

Figure 4. Multiple graph showing time series trend and firs differences. **Source: Author**

Augmented Dickey-Fuller test has a null hypothesis of a unit-root, H_0: $\phi = 1$, and selected number of lags accordingly with the previous estimation. Alternatively the time series have generated a stationary process, H_1: $\phi = 0$.

Table 1. Unit root test

Variable	Test	Lags	t-stats at 1% level	P-value H_0: $\phi = 1$	P-value H_0: $\Delta\phi = 1$
P^{Sweden}	ADF	2	-2.7	0.45	0.003**
P^{Global}	ADF	2	-3.1	0.24	0.02**

***** p<0.01, ** p<0.05, p<0.1**

The number of lags[1] that will make the residuals a white noise in the ADF regression is 2 on global and Swedish level respectively under Akaike Information Criterion[2]. Null hypothesis of non-stationarity is accepted at both levels. However, running the ADF-test when the variables are

[1] Coefficients of the lag terms assure that each single price series is stationary hence a random walk.
[2] AIC percentage of correct specification to meet specification database

differentiated the result show strong rejection of the null hypothesis thus the variables have become stationary.

With the knowledge that both time series are non-stationary and therefore integrated of the same order we can proceed with the cointegration test that is the long-run integration. To do so first order least square are estimated as below:

$$P^{Sweden} = \beta P^{Global} + e_t \ (7)$$

$$\Delta\hat{e}_t = \gamma\hat{e}_{t-1} + u_t \ (8)$$

Table 2. Cointegration test

Variable	Coefficient	Std. error	T-ratio	P-value
$\boldsymbol{\Delta\hat{e}_t}$	-0.0545243	0.0237932	-2.292	0.0232 **

***** p<0.01, ** p<0.05, p<0.1**

$$\Delta\hat{e}_t = -0.0545243\hat{e}_{t-1} + u_t$$

Null hypothesis of no cointegration is rejected on a 5% level, suggesting that there is a long-run relationship between Swedish and global wheat prices.

Because of the significance of previous estimation the short-term dynamics between the markets can be assessed using VECM with a constant.

Table 3. VECM

Dependent variable	Variable	Lags	Coefficient	Std. error	T-ratio	P-value
$\boldsymbol{P^{Sweden}}$	Constant	3	0.518965	0.213408	2.432	0.0161 **
$\boldsymbol{P^{Sweden}}$	$\boldsymbol{\Delta\hat{e}_t}$	3	-0.0830434	0.0336445	-2.468	0.0146**
$\boldsymbol{P^{Global}}$	Constant	3	0.0204675	0.602026	0.03400	0.9729
$\boldsymbol{P^{Global}}$	$\boldsymbol{\Delta\hat{e}_t}$	3	0.0115526	0.0949116	0.1217	0.9033

***** p<0.01, ** p<0.05, p<0.1**

The chosen number of lags for the final model is three due to the Durbin Watson statistics[3]. Sweden has a negative adjustment coefficient (-0.08) of the error correction term and is significant at 5% level (-2.46). The global market does however not respond to disequilibrium between the two markets due to insignificant t-statistics (0.12). It indicates that Swedish wheat prices are responding to a change of global wheat prices. Because the adjustment coefficient is negative Sweden is catching up with price changes on the Global market. Wheat production on Swedish level is dependent on wheat production globally in the short-run but not vice versa.

$$\Delta P_t^{Sweden} = \underset{(2.432)}{0.518965} + \underset{(-2.468)}{-0.0830434\hat{e}_{t-1}} \quad (9)$$

$$\Delta P_t^{Global} = \underset{(0.03400)}{0.0204675} + \underset{(0.1217)}{0.0115526\hat{e}_{t-1}} \quad (10)$$

The two estimates of the error correction model (9) and (10) show the adjustment process to a temporary disequilibrium.

5.4. Sensitivity analysis

The estimation procedure resulted in many weaknesses due to the sensitivity of the test. To begin with the selected lag length from the ADF-test was rather suboptimal because of the weak Durbin Watson statistics in the VECM. On the other hand only one lag was enough to distinguish a temporary disequilibrium when Sweden being the dependent variable. Subsequently the cointegration test had to include a constant or the OLS regression would be spurious and show opposite result than expected. Moreover the Swedish wheat market did not respond at all to shocks from disequilibrium on the world market. When including an intercept thus a constant to the OLS regression for short-term dynamics the result turned out logical. Because prices are the only estimates in the model, other factors are expected to end up in the intercept thus including a constant is necessary. At last the results turned out to have significant and appealing estimates. The concluding outcome is then valid and appropriate for analysing integrated markets.

[3] Durbin Watson tests for autocorrelation in the residuals hence a value of 2 means no autocorrelation.

6 Results

The final results are described in this chapter followed by an analysis. A reflection of the method is presented and finally the conclusion of the research.

6.1. Results and analysis

The final result turned out robust and coherent with my expectations. With that said the two markets are integrated and a wheat prices are transmitted from global to Swedish wheat market. Prices are transmitted in the long run but only the Swedish wheat market responds to disequilibrium in the short run. A prevailing long-run relationship, as indicated from the cointegration test, proves that Swedish farmers are supposed to catch up with changes on the world market. Referring to the literature review the grain market is today a part of the equity market where speculations are important, when for instance the market experience a shortage hence augmented price fluctuations. Figure 5 is illustrating price trends on the wheat market with monthly prices from year 2000 to 2013.

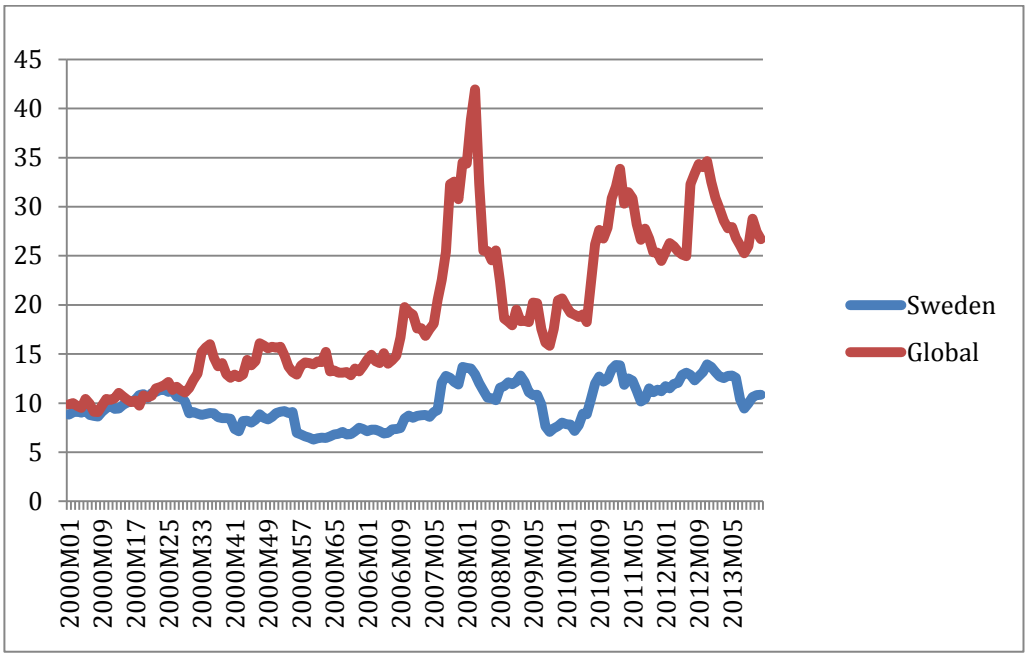

Figure 5. Wheat nominal price trends in Sweden and globally. Source: Author

As we can see the global prices are both higher and fluctuating more than on the Swedish market. The graph is also indicating on a quite independent price relationship except from the beginning of the sample period, suggestion a weak price transmission. Globally the prices have a stronger upward trend and reached the highest value, 41,96$/kg, in connection with the food price spike. Sweden only grasped a number of 13,67$/kg thus being more isolated from the global volatility. Since the last two decades the Swedish wheat market is more exposed to the global market then

before the adaption of CAP. On the other hand CAP secure its members' food security, health, animal welfare and so on, by implementing tariffs and quotas that create market distortion, thereof an explanation why Swedish market has been experiencing a moderate volatility and being "isolated" from the spikes on global level.

Unluckily crop yield have not been the best in recent years including Sweden. Consequently changes in exogenous variables such as income and inputs have created distortion to "wheat equilibrium" where prices and quantities are holding constant. Balanced wheat equilibrium happens when supply and demand match and the market is not troubled by exogenous variables. Furthermore external influences are not captured in the econometric modelling though they are important factors to understand the adjustment process back to equilibrium denoted by the short-term relationship in the VECM. Because Sweden is a small price taking country changes in Swedish wheat prices are not influencing on global wheat prices accordingly with the VECM result.

Policy reforms have eased trade barriers and Sweden is today an open small economy protected by the European Union. Not only have Sweden's trade barriers been reduced to the surrounding world, but also in other countries thanks to organizations like WTO and CAP, in hope of more efficient allocations of agricultural products. A competitive world market is growing, markets becoming more integrated and price transmissions more common among homogenous products.

Furthermore Swedes are becoming more environmental friendly and shift oil usage to biofuels. The domestic demand for wheat is increasing as well as in the rest of the world. Industrial countries like Sweden demand wheat for biofuels while developing countries with growing middle classes consume more animal products hence livestock consumes wheat based feed. Consequently the Swedish Government seeks to increase the integration for the ethanol market of what would also be consistent with the overall goals of the Swedish government, to preserve and improve the national environment. However biofuel production will suffer if wheat price remain high, but also trade barriers are contributing to a high price and therefore limiting the trade of wheat. As a result a high wheat price and trade distortions are contradicting to the worldwide environmental goals, which is to reduce greenhouse gas emissions, if the ethanol industry suffers. If then a wheat producing country is troubled with poor harvest like recently in Australia or because of the agitation in Ukraine, the demand will increase in other regions and create a more volatile climate. Due to varied circumstances in other countries like drought or improving lifestyles in China and Kazakhstan the Swedish wheat price will subsequently follow.

Because of the international trend of organically produced food, Swedish wheat is demanded and exported more to the international market. But that does not mean that Sweden also would import more wheat because of the benefits of trade. The reason is the increasing popularity of locally produced food to reduce emissions and avoid pesticides. Accordingly wheat is not a perfectly homogenous commodity, which is contributing to a less integrated wheat market thus price transmission. With that said the quality of wheat is varying, resulting to an imperfect substitute between the two markets studied in the research.

6.2. Reflections on the method

Price transmission mechanisms within a dynamic regression model are often observed with ECM. There are of course many reasons for this although the model has its limitations. First of all it has good economic implications when studying the correction from disequilibrium from previous period. Secondly, because time series are often non-stationary the ECM is explicated in terms of first differences, which eliminates the problem of spurious regression. The third advantage is explained by the ease of assessing ECM both to general and specific approaches in econometric modelling. Lastly, the most important characteristic is that the disequilibrium error term is in fact stationary (in line with the cointegration theory). It induces important implications such that the cointegration processes imply a kind of adjustment that in the long-run prevent errors from becoming larger (Asteriou & Hall 2011, pp. 359-360). Thus even small deviations from the equilibrium will result in an adjustment process on each market.

Drawback with the method is that it ignores transaction cost, which may lead to biased results. The assumption of two markets being fully integrated is not realistic due to obstruction of transaction cost. Obviously transportation cost and other hindrances will limit the transmission of price shocks below a critical level. Consequently a perfect price adjustment will not occur because potential gains from trade cannot offset trade barriers (Meyer 2004).

As previously noted VECM help forecast variables that are cointegrated, and possibly other related variables. However, the same stochastic trend is required for cointegration. VECM will be incorrectly modelled if the variables are no cointegrated, and will result in poor forecast performance (Stock & Watson 2007).

Additionally the frequency of the data can be taken in consideration. In this research monthly data is used to measure the dynamic price relationship. Von Cramon-Taubadel and Loy (1996) call the attention to data regularity that exceeds the frequency of the adjustment process due to for instance arbitrage transaction that belong and interfere price transmission in integrated markets. The data frequency will of course depend on the characteristics of the market and products to avoid misinterpretation of the empirical study (Meyer & Cramon-Taubadel 2004).

6.2. Conclusion

To conclude the wheat markets are integrated because they share common characteristics like trade. Due to several trade barriers the markets are not fully integrated and have a strong interdependence among prices. Eliminating trade distortions would create a smoother price transmission and induce a more efficient coupled market and less deadweight losses thus welfare gains. Food wise wheat is perceived as an imperfect substitute on the world market that restricts integration. However the Swedish government encourage trade of wheat for biofuel production to reduce greenhouse gas emission. In the long run the integration is predicted to increase because of CAP reforms, increased demand and production of biofuels in industrial counties as well as a growing demand in developing countries. By knowing the extent and speed of which the global wheat prices are transmitted to Swedish wheat prices will help farmers making rational decision regarding production and sales, banks when specifying contracts to secure farmers revenue and the government when designing policy agreements with the European Union. The research can be developed with threshold- and asymmetric cointegration models to get more sophisticated representations of how wheat prices respond to disequilibrium in the short run and adjust to their long run equilibrium. However the absence of data on trade distortions remains an unsolvable problem.

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