Price transmission in the Swedish pig production

How do current price increases in an era of COVID-19 affect Swedish pig production?

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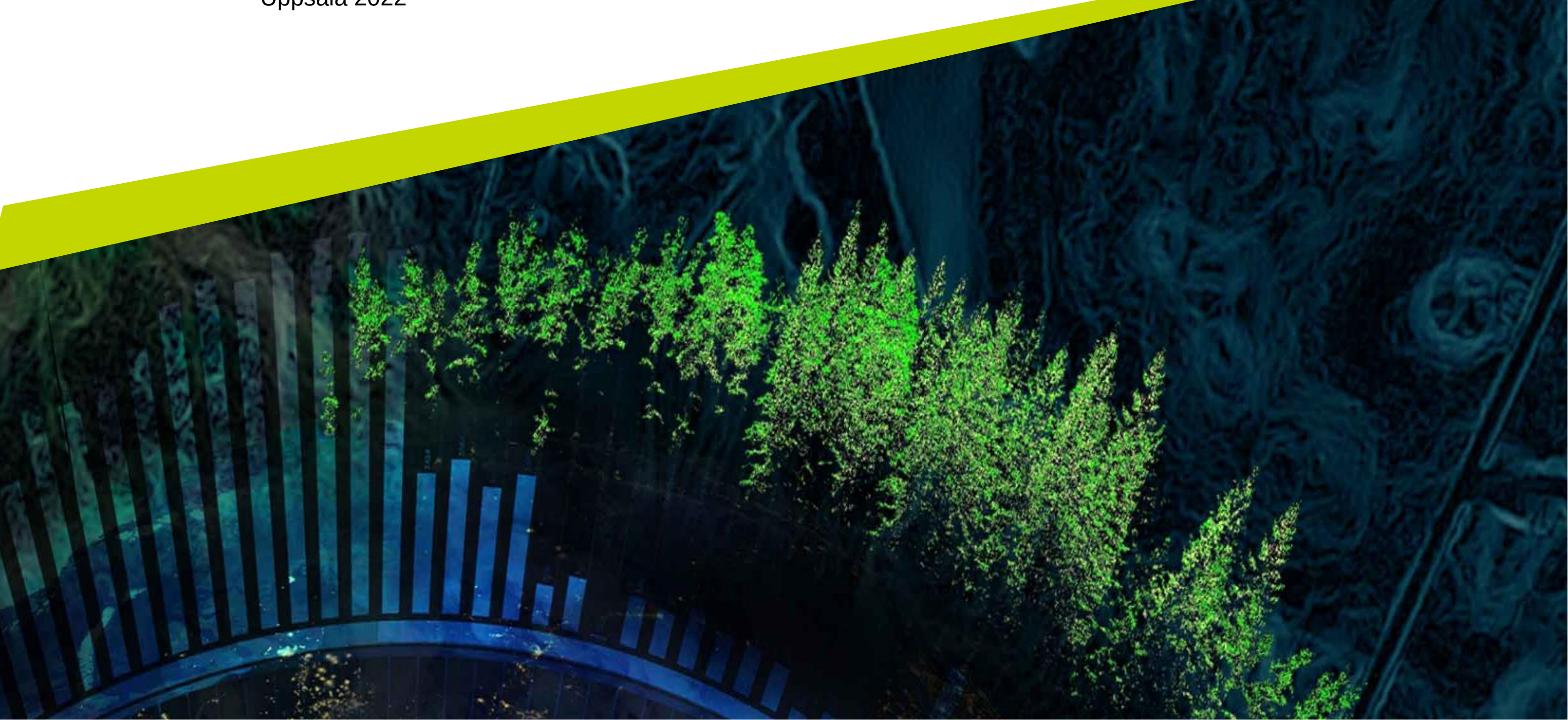

Price transmission in the Swedish pig production. How has current price increases in an era of COVID-19 affect Swedish pig production?

Prisöverföring i den svenska slaktsvinsproduktionen. Hur har de senaste prisökningarna under COVID-19 pandemin påverkat svensk slaktsvinsproduktion?

Charlott Häggman Othzén

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Abstract

This thesis presents a price transmission analysis within the Swedish pig production sector. The aim of the study is to see if and how the recent years price increments of input prices has affected the Swedish slaughter prices, and consumer price index in Sweden, both in short and long term. The study uses secondary data from different sources, over the time period 2000-2021. This thesis helps to fill the gap in the literature regarding how Swedish pig production are affected by recent years increases in input prices.

The study conducted unit-root, ADF-test and VAR model to establish if co-integration exists in the short-run. The results showed that there was no co-integration between markets in the short run.

Johannsen’s approach for co-integration analysis was chosen for the long run, results showed co-integration in long run between input prices for both slaughter price and CPI. To examine how the input prices affect slaughter price and CPI, a VECM approach was used. For slaughter price, the input variables shown to have a positive impact were energy, soy and piglet. The price for fuel was shown to have negative impact on slaughter price. However, for CPI energy, soy, fodder and piglet price shown to have a negative impact, whilst fuel shown to affect CPI positively.

A log-log model was used to establish the output elasticity for Swedish Pig Production, showing that energy, fuel and piglet was elastic whilst fodder was inelastic.

Keywords: Price transmission, VECM, Swedish pig production, Slaughter pigs

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Abbreviations

ADF test - Augmented Dickey Fuller test

CAP- Common Agricultural Policy

CPI- Consumer Price Index

EU- European Union

VAR- Vector autoregressive model

VECM- Vector Error Correction Model

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1. Introduction

The problem background for the thesis, aim and research question, delimitations and contributions are all presented in this chapter.

1.1 Background of the study

Due to recent years large fluctuations in world prices of agricultural commodities, the interest in how consumer prices respond to changes in price at agricultural and processing levels has received more attention. How a change in price for an agricultural commodity affects the price further down in the market chain can be studied with price transmission analysis. When the markets are well functioning the price transmission is symmetrical, what is meant by this is that when a price change occurs the change is in the same parity as the commodity's significance in the production, that the change occurs in the same way regardless of an increase or decrease in price. However, most retail stores and processing industries are characterized by asymmetric price transmission. This means they increase their prices when the price for commodities increase, but do not decrease prices as the commodity price goes down. The European parliament has payed attention to this problem, as it showed the competitive conditions between the retail stores and the agricultural sector. The EU-parliament stated that food prices have increased with 3.3% per year since 1996. During the same time period the price farmers take has only increased with 2.1% per year (European Parliament, 2010).

A consequence of this type of price transmission is that consumers are unable to take advantage of decreases in the agricultural or processing led. Same goes for the farmers, they cannot accommodate these price increases in the processing or retail line. According to the Federation of Swedish Farmers (LRF, 2022), one of the biggest problems with agriculture in Sweden is to get profitability (LRF, 2022). Recent years fluctuation in world market prices for agricultural commodities, has led to rapid increments in prices of agricultural inputs. This has considerable short term and long-term effects on farm profitability in Sweden.

One of the causes for this is that agriculture in Sweden is dependent upon many inputs that are produced abroad and priced according to the global market, such as fuel, energy, fertilizers, fodder and seeds. A report from Agrifood economics centre (2022) states that the price for wheat on the French trading place MATIF increased with 20% between the time period 1st of February 2021 and 1st of February 2022. The biggest part of the change occurred during the fall of 2021, important factors that have affected the wheat prices are high prices on fuel and fertilizers.

Most farmers in Sweden have been affected by the rapidly increasing prices. Farmers with crop cultivation have been affected by the rapidly increasing prices of fuel, fertilizers and pesticides. Whilst animal producers have been affected by the high price increases of fodder, soy, electricity and fuel. Pig production will be highly affected by the high increases in input prices. As stated in a report from Agrifood economic centre (2022) the high prices for cereals benefit the crop producers, because the increased cereal prices can lead to better profitability for crop producers, ceteris paribus. Whereas for animal producers, especially pig, egg and poultry where the majority of feed consists of cereals, the high prices lead to higher production costs which are not matched in higher consumer prices. The report argues that beef and milk producers are not affected quite as much due to the fact that cattle also eat a substantial amount of grass and hay, which is not as affected by high increases in price. It should also be added that Swedish animal producers have higher production costs than other European animal producers, this is because Sweden has tougher animal welfare legislation. Pig production included, which means that pig producers in Sweden also compete against other European producers. These competing producers have lower animal welfare and therefore also can produce at a lower cost than Swedish pig producers are able to (Jordbruksverket, 2022).

With the aspects of today´s geopolitical times and talk about the need to increase Sweden’s self-sufficiency due to recent pandemics and the fear of trade barriers because of war or lockdowns. The need for a greater understanding of how prices transfer from the agriculture to consumer increases. More research on how farmers are affected by market fluctuations and price transmission between the different chains is thus an important contribution to the literature.

1.2 Aim and Research question

The aim of this study was to examine whether or not there is any occurrence of price transmission in the Swedish pig production. Therefore, a price transmission analysis was conducted to see how and if recent years increased input prices has affected the Swedish pig production in the short and long run. Furthermore, the study will also calculate the output elasticity for the Swedish pig production. Hence, the following research questions are stated for this thesis:

1. *What are the short run effects of the current increases in input prices on Swedish pig production?*
2. *What are the long run effects of the current increases in input prices on Swedish pig production?*
3. *What is the Swedish pig productions output elasticity?*

To answer the research questions stated above, a price transmission approach was used in general. The approach of vector autoregressive model (VAR) was used to analyse the short run consequences of the price increments. In the long run analysis, the vector error correction model (VECM) was used as the approach, to see the price increments long run effects. A non-linear regression model also known as log-log model was used to estimate the output elasticity for the Swedish pig production. A time series data set consisting of five inputs working as independent variables was regressed upon three different dependent variables. The data used in the study is measured over the time period 2000–2021.

1.3 Contributions and Delimitations

In terms of research, very little has been done on price transmission in the Swedish pig production in recent years, despite the pandemic and current increases in prices. However, there are a lot of studies regarding especially technical and scale efficiency and in the Swedish agriculture including the pig production. However, very little regarding price transmission especially in the pig sector. Therefore, this study contributes with new knowledge regarding price transmission in the Swedish pig production.

Additionally, this thesis focuses on the Swedish pig production, and therefore are other agricultural activities as well as piglet production and fully integrated pig production excluded from this analysis. Thus, the variables included in the data set are inputs that affect pig production in Sweden.

There are several methods that can be used to conduct price transmission analysis, this thesis has chosen to only use the vector autoregressive model, vector error correction model and non-linear regression (lol-log) model. This thesis will focus on these methods and will not make any comparisons to other models in the field.

1.4 Disposition

Figure 1: Outline of the thesis

As illustrated by figure 1, chapter 1 lays out the necessary knowledge about the background to the increasing input prices that the Swedish slaughter pig production is facing and presents the problem and research questions. Chapter 2 presents a review of the literature as well as a background of pig production in Sweden.

Further on chapter 3 presents the empirical framework, the method is presented and developed together with the description of the data and variables. Thereafter, the study’s results are presented in chapter 4, moving on to chapter 5 where the results are analysed and discussed. Finally, chapter 6 will summarize and conclude the work and give suggestions for further research.

2. Literature review

This chapter will present a review of the existing literature that is available regarding price transmission, the review will focus on studies that have examined the Swedish and Nordic market for agricultural or food products. In this chapter different methods for price transmission analysis will be discussed. The focus is to find the methods best suited for this thesis. The end of this chapter will give some background on the Swedish pig production and its inputs being used.

There is not much research done regarding price transmission on the Swedish market, only three studies have been found. The first one is a study conducted by Asplund et al. (2000) where the authors analyse the fuel prices. The second article to be found is written by Karantaninis et al. (2011) the article investigates the price transmission in the Swedish pork chain. The authors conclude from their results that the asymmetric price transmission for the Swedish pork chain market is due to market power in the long run. The authors also got results that show symmetric results in some of the price series as well. Therefore, the authors mean that more research is needed to be able to draw conclusions about the pork market in Sweden. The third report is very recently published, written by Persson, (2022) from Agrifood economics centre on behalf of the Swedish competition authority. This study analyses the price transmission on Swedish food products and discusses some of the economic aspects behind the asymmetric price transmission found in the markets. This is the first comprehensive study done on price transmission at Swedish food markets. The results from the study show that for pork products, the price transmission is asymmetric. This means that there are much faster adjustments of the price when the price increases than in case of price reductions. However, the Swedish board of agriculture (2009) conducted a study looking at the price changes between different price lines for milk on the Swedish market. The results from the study showed a correlation between increasing producer and consumer prices. However, no such correlation could be found for decreasing milk prices. A study conducted by Durevall (2003) examined the price transmission on the market for coffee in Denmark, Finland and Sweden. The results showed asymmetry in the short run at the Finnish coffee market, whilst in Sweden and Denmark the price transmission is found to be symmetric. Articles other than these have not been able to be found, very little research has been done on price transmission in Swedish agricultural markets. However, price transmission is a well research area. Although, most of the research done is based on the American market which is very different from the Swedish market. Therefore, it is hard to draw conclusions based upon previous research to the Swedish market.

Luoma et al. (2004) has analysed price transmission in the Finnish pork and beef markets, the study examines how changes in price transfer from the producer line to consumer line. The results imply that there is no asymmetric price transmission in either pork or beef markets, but the authors states that both markets did go through structural changes that could have affected their results. Jensen and Møller (2007) conducted a study on the markets for six different agricultural commodities on the Danish market. The study examines price transmission from farmer, via wholesale, to retail line. Their results find positive asymmetry in the short run, which in general happens in the retail line. The study also examines if there is a correlation between asymmetry and the degree of price regulations. The results from the study imply that symmetry tends to be present in a bigger extent for regulated commodities. This is contradictory to the results from Kinnucan and Forker (1987). They mean that price regulations can be a cause of asymmetry in markets. But once again, it is important to mention that the American and European agricultural markets are different in so many ways, which makes it hard to compare results between the two markets. London Economics (2004) has also studied the Danish market together with the markets for Austria, France, Germany, Ireland, the Netherlands, Spain and Great Britain. The report examines the mutual relationship between producer, wholesale and retail prices of fruit, vegetables, meat and dairy products. The results for the Danish markets show symmetry for beef, egg, flour and bread sectors, whilst the dairy sector did not show any signs on price transmission. This means that consumer prices are based independent on the price in the other lines. It should be added that this study showed quite a variation regarding the results of price transmission on different European markets. Meyer and von Cramon-Taubadel (2004) examines 40 articles where a majority of the articles have analysed price transmission in agricultural commodities markets. Many of these articles are written in the 21st century. Meyer and von Cramon-Taubadel (2004) concludes that the existing literature does not contain any unified or conclusive results. Much of the research done is just focusing on method and not on why asymmetric price transmission occurs on the markets or a good discussion of the results.

To summarize this review of existing literature, one can conclude that although the research in the area of price transmission analysis on agricultural commodities is widely spread, is it difficult to give a clear picture of how different agricultural markets act. Although many studies have found asymmetric price other studies have concluded the opposite, symmetric price transmission. There is also no clear pattern between method, countries and commodities, the results still vary. One can also conclude that there is not much of a discussion in the literature regarding the background of the factors behind asymmetric price transmission and why it might occur. Therefore, more research in the field of price transmission is needed for policymakers and researchers to understand the complexity of price transmission at farmers, producers, wholesale and retailers. This is what the article both from Persson (2022) and Meyer & von Cramon-Taubadel (2004) point towards in their articles. These articles mention that it is of importance to keep price transmission analysis that is statistically significant and price transmission analysis that is meaningful in an economic perspective separate. The articles claim that just because there is asymmetric price transmission, does not necessarily mean that actors on the market misapply their market power towards other lines in the chain. Meyer & von Cramon-Taubadel (2004) points towards that because of this, many studies fail to keep apart the empirical result and theoretical result. This is why more research behind the mechanisms of asymmetric price transmission is needed.

2.1 Methods used in previous studies

Meyer and von Cramon-Taubadel (2004) have made an extensive summary of the methods used for analysing price transmission in the articles they have reviewed. Which method one should use depends on what question one will answer and the type of data one is using, but also what kind of market is being analysed. This thesis has chosen to look at what kind of methods the previous literature has used, due to the fact that they have either analysed the Swedish market or the market for pork products.

Asplund et al. (2000) have used error correction model (ECM) as their approach to analyse price transmission. Durevall (2003) also used ECM together with Johansen- approach to test for cointegration before conducting the ECM analysis. In the research conducted by Luoma et al. (2004), the authors have used Dickey Fuller, to examine whether the variables are stationarity or not before using Johansen to test for cointegration. Thereafter they have used a vector error correction model as their approach for the price transmission analyse. The same approach goes for Jensen and Møller (2007), they have also used Dickey Fuller and ECM as their approach for their price transmission analysis. In the article written by Karantininis et al. (2011), ECM was also chose as method for their analysis. In the report written by Persson (2022) for Agrifood economics centre chose the approach Dickey Fuller to test for stationarity and Johansen test was also used to establish if there is cointegration between the variables used.

Another thing that Meyer and von Cramon-Taubadel (2004) mention in their paper is that the use of monthly data can sometimes be of too low a frequency, and therefore suggests using weekly data. However, in the report of Persson (2022), the author mentions that from previous research's results, the frequency of the data does not seem to matter, which is a good thing. This is because many studies use monthly data without it affecting the results to too big of an extent.

After reviewing the methods previous studies have been using, it is clear that the use of Dickey Fuller, Johansen and ECM for this thesis seems to be a good approach for analysing the price transmission in the Swedish pig production.

2.2 Overview of the Swedish pig production

Swedish pig production consists of three business models. First, is a fully integrated production, where the farmer sow´s and breeds the piglets all the way until it is time to slaughter. Second is a semi-integrated production, where the farmer either sow´s or breeds piglets. The piglets are then sold to the third business model, pig production firms. The third production model only has the pigs around 90 days, before it is time to send them for slaughter.

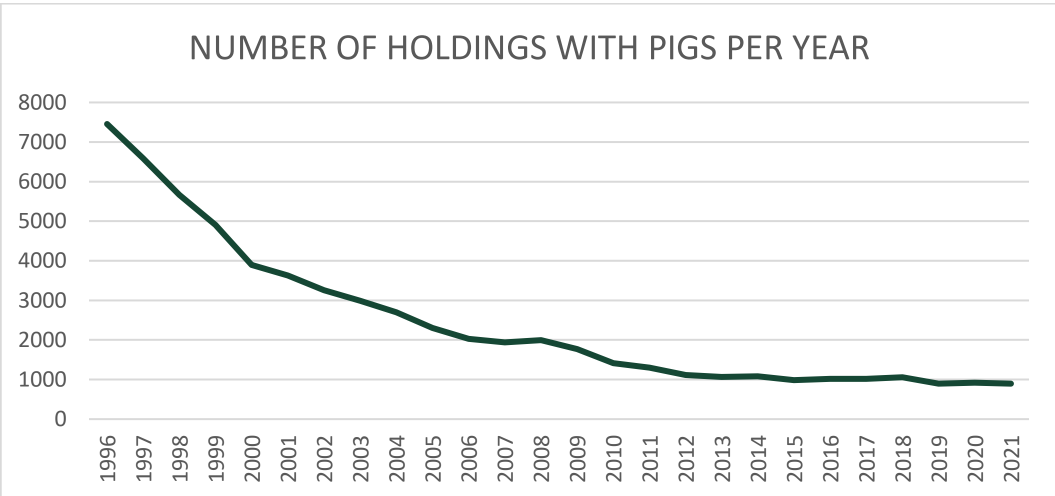

Figure 2: Number of holdings with pigs per year. Source: Swedish board of Agriculture (SBA), Author´s calculations, Year: 2022

During the past 15 years Swedish pig production has declined both in numbers of animals as well as farms, as can be seen in Figure 2 and 3 (Sveriges grisföretagare, 2021). Although, the farms have decreased in numbers, they have instead increased in number of pigs and arable land per farm. Larger farms lead to higher chances of becoming competitive and profitable, which is something that the majority of Swedish farms struggle with (Sveriges grisföretagare, 2021).

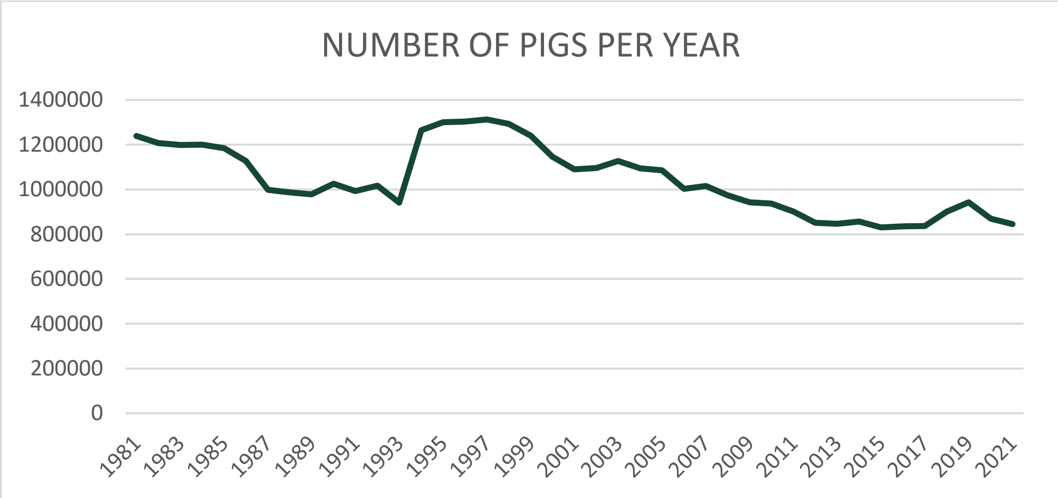

Figure 3: Number of pigs per year. Source: Swedish board of Agriculture (SBA), Author´s calculations, Year: 2022

Pork is the meat that Swedes consume the most, beef is second and chicken comes as third (Naturvårdsverket, 2021). However, consumption of pork has decreased from 34.52kg/year per person in 1980 to 29.56kg/year per person in 2020, compared to the consumption of beef that is around 24kg/year per person in 2020 (Jordbruksverket, 2021). Compared to the USA, EU and China Sweden has a lower consumption of pork, some of the reasons as to why this has occurred is the debate regarding the environment and eating more plant-based food (Sveriges grisföretagare, 2021).

The level of Sweden’s self-sufficiency of pork meat is 70% (LRF, 2022). This means that Sweden needs to import pork from other countries to meet domestic demand. Most of the pork is imported from Germany and Denmark (Sveriges grisföretagare, 2021). This results in Sweden importing pork from countries where animal welfare is not as high as in Sweden. Sweden has tougher animal welfare regulations than Germany and Denmark for pig production (WWF, 2022).

2.2 Inputs in pig production

The majority of Swedish pigs are produced by conventional pig farming regulations. This means that there is no grazing or absence requirements for the pigs. Therefore, many farms specialise in producing pigs and therefore do not have the land required to be self-sufficient on fodder for the pigs (Jordbruksverket, 2021). The fodder for the pigs consists of many ingredients which is all put together at farm level. The fodder often consists of cereals, soybean powder or field bean as protein fodder, by-products from milk or ethanol production (Ivarsson, 2021). In a study conducted by different branch organisations in 2020, they looked into what an average Swedish pig eats. The study concluded that 45% of the fodder is water, 27% is by-products from milk and ethanol production, 21% is cereals and 4,5% is protein fodder, where field bean is the biggest and followed by soybean powder (Karlsson, 2020). Farmers can produce and be self- sufficient on cereals grown in proximity to the farm, but besides that many of the ingredients needed to produce the fodder have to be bought from other producers.

To be able to mix the different ingredients together the farms have big mills and fodder tanks, which are powered by electricity. Also, the stables have ventilation systems which allow them to control air and temperature inside the stables, which are in use around the clock. Neuman (2008) looked at the energy use in Swedish agriculture, the report investigated the use of different types of energy used and which part of the operation of production or equipment that demanded the most energy. In the report, Neuman (2008) looked at the energy consumption of pig producers. He compiled which parts of the operation that consume most electricity. Neuman found that ventilation is the most electricity consuming system and the second most consuming were the fodder systems. Thirdly, the heating systems, which vary between electricity and oil.

Many pig producers don’t breed the pigs by themselves, instead they buy the pigs from producers’ who specialise producing piglets. The pig producers then keep them until it is time for slaughter. The price of the piglets is often determined by the slaughterhouses (HKscanagri, 2022). Thus, the price for the piglets affect the final profit per pig as this is decided once all the costs from the slaughter price have been deducted.

2.3 Changes in input prices during 2021

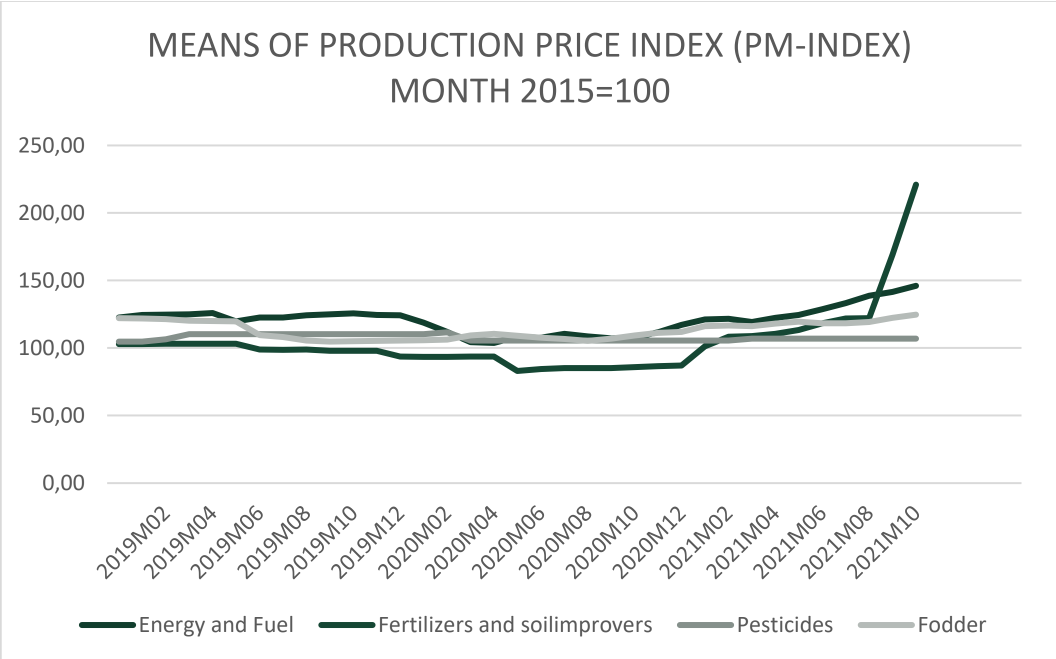

Figure 4: Means of production price index (PM-index) month 2015=100. Source Jordbruksverket, own processing.

As mentioned in the previous chapter, many of the input prices for pig producers have increased rapidly during 2021. The background of the price increments is both due to national and international circumstances. Fuel is an input whose price has risen sharply, when countries open up again from covid-19 lockdown, the demand for oil and fuel increases fast (Holmström, 2022). That's one reason for the increase in fuel and oil prices. Another reason is because Sweden has a very high taxation on fuel. The tax consists of three parts, carbon dioxide tax, energy tax and vat. Around 60% of the price for fuel consists of tax today (Holmström, 2022). Another underlying reason for the price increase is the so-called reduction duty that was introduced in July 2018 (Holmström, 2022). It is a policy instrument that forces Swedish fuel suppliers to mix in biofuel into diesel. The production cost of biofuel is higher than the production cost of its equivalent in fossil fuel. Therefore, has the reduction duty a price increasing effect (Holmström, 2022).

During the late summer of 2021 Sweden had one of its lowest energy prices ever. However, the price started to vary during 2020 between the north and south of Sweden, something that has continued under 2021 (Freid, 2021). The background to the increased prices is due to several factors, one of them is that Sweden is part of the European energy market. This means that the prices in Sweden are influenced by the prices in Europe. Why European energy prices have increased so much during 2021 is largely due to the fact that the demand for fossil fuels as an input to electricity production has increased. Drought is also one reason to increased demand for fossil fuel, as hydroelectric energy has decreased (Freid, 2021). Also, the price for coal has increased rapidly during 2021. All these factors have driven up the European electricity price (Freid, 2021). Another issue that affects the energy prices in Sweden is the limited transmission capacity from north to south, and the low production in south of Sweden has led to higher prices in the southern part of Sweden than in the northern part (Freid, 2021).

Another input whose price has risen and will continue to rise is fodder. The background for this increase is price increments for the inputs that is needed to produce the crops used to make fodder of. Crop producers have also been hit by the price increments for fuel, energy, fertilizers and transportation costs (Lantmännen, 2021). In addition, the weather during the 2021 cropping season varied a lot, which led to a significantly lower harvest than the year before, both in Sweden but also in countries such as Russia, USA and Canada, this has led to price increments on the global market (Lantmännen, 2021). The price for soy has also increased rapidly over the past year, compared to the same period 2020 where the price increased with almost 25%. The background for the price increments is lower harvests and an increased demand for GMO free soy in Europe. The increased demand for GMO free soy in Europe affects Sweden very much, this is because it is a legal requirement in Sweden to use GMO free soy (Nilsson, 2021).

3. Data and Method

This chapter presents the econometric methods for solving the research questions described and composed. Data for both the dependent variables and independent variables will be presented.

3.1 Data

The study uses data from several databases such as the Swedish board of agricultural statistical database, Eurostat, Swedish energy inspection, Drivkraft Sverige and Agronomics. The use of several databases is due to there not being a single website that could provide statistics for all of the variables. All data is secondary data.

The majority of data is measured as the total average prices for Sweden. The study has time series data spanning over the time period of 2000-2021, some variables were missing data for some of the years, this was corrected by using moving averages with plus or minus standard deviation. The motive of using more of an aggregated approach in this thesis is because farm level data is not publicly available. Given the time frame of this thesis it would have taken too much of the time to collect monthly data, although it would have made the analysis better.

3.2 Input variables and data description

This section gives a background to how the data was measured for every variable used in the study. To estimate price transmission and be able to answer the research questions, two models were specified with one output (Y) and five input (X) variables were specified. The dependent variables for this work were chosen based on their ability to represent the different markets.

Y_1= Consumer price index year for pork meat (CP-Index for 2000=100, 2005=100 and 2015=100)

The consumer price index is the standard measure for compensation and inflation calculations in Sweden. The consumer price index measures the average price trend for private domestic consumption, the index is based on prices consumers actually pay. However, this data measures the consumer price index for pork in Sweden (SCB, 2022). The data is collected from the Swedish board of Agriculture, which is the authority responsible for this type of data.

Y_2 = Slaughter price kr/kg (Price including transportation, price increments and price reductions regarding classification of the carcass)

The Swedish board of Agricultural have compiled the mean prices for slaughter prices in Sweden. The slaughter mean price includes transportation costs, increments and reductions in price due to the classification of the carcass. The slaughter price is measured in Swedish crowns per kilo of meat. The data set starts from 2002 and goes on to 2021.

Y_3 = Number of slaughtered pigs at slaughterhouses (measured in total number of carcasses)

The number of pigs being slaughtered every year is measured in number of carcasses. The data is collected from the Swedish board of agriculture. They have complied the number of slaughtered pigs that are slaughtered for the purpose of going to human consumption, therefore animals that are being slaughtered for other reasons are not part of the data. In this data set there are missing values, the years that data is available from are 2000, 2005, 2010, 2015, 2018, 2019 and 2020.

The five input variables are based on the typical production characteristics of Swedish pig production that are connected to costs of the production, and are defined as following:

X_1 = Mean electricity prices in öre/KwH

As mentioned in the beginning of this chapter the data is measured as the mean price at the stock market for electricity between the years of 2000-2021. The electricity variable for the time period between 2000-2011 is measured as the average price at the stock market for electricity. After this time period Sweden divided the country into four energy areas (Freid, 2021). After 2011 and forward, the prices are divided into the different areas, but to make it simpler for this thesis the mean of the four areas have been calculated for the time period 2011-2021. Also, the electricity prices consist solely of the cost of electricity, no tax, vat or fee for the network is included. The data is collected from statistics provided by the Swedish energy inspection.

X_2 = Mean fuel prices over the year in SEK/L

The cost of fuel is the mean price per year for diesel in Sweden, in the price the CO2-tax, energy tax and vat are included. The data is collected from Drivkraft Sweden, which is a branch organization for the fuel industry in Sweden. Here all the Swedish fuel producers are customers and therefore provided with facts and statistics regarding fossil fuel in Sweden.

X_3 = Soybean powder SEK/ton (measured every February from the stock market in Hamburg)

The price for soybean powder is collected from Agronomics.se, which is a website that provides information about the stock market prices for agricultural commodities. This thesis uses the price for soybean powder due to the lack of price information on field bean. The data regarding the soybean powder is measured in Swedish crowns per ton. However, the price for soybean powder is read from a diagram, which may lead to inaccurate prices. To facilitate the reading of prices, this thesis chose to use integers only, as well as the prices chosen in this thesis being the prices for soybean powder in February of each year.

X_4 = Fodder price (Measured in PMI-index)

Eurostat was used for the price development of fodder. The data was only available in the measure of purchasing manager´s index (PMI-index). The index describes whether the price is the same, higher or lower than last year. The index gives an overview of the price fluctuations. Eurostat data is based on data from the European nations own agricultural institutions. Therefore, Eurostat is considered as a secondary source, because they do not produce the data themselves.

X_5 = Piglet price SEK/ piglet (Mean price for a 30kg piglet)

The Swedish board of Agriculture have compiled the mean prices for piglets' prices in Sweden. The piglet price is measured in Swedish crowns per 30kg piglet. The data set starts from 2002 and goes on to 2021.

3.3 Descriptive statistics of variables

Table 1 presents the descriptive statistics over the variables that were used in the studies. The statistics that are presented consists of a number of observations, mean, standard deviation, minimum value and maximum value.

Table 1: Descriptive statistics over the variables used in the study

Variables	Observations	Mean	Std. deviation	Min	Max
Mean electricity prices in öre/KwH	21	34	12	12	59
Mean fuel prices over the year in SEK/L	21	13	3	8	15
Soybean powder SEK/ton	21	2741	754	1500	4000
Fodder price (Measured in PMI-index)	21	113	15	96	169
Piglet price SEK/ piglet	21	629	118	458	829

Slaughter price kr/kg	21	15	3	11	20
Number of slaughtered pigs at slaughterhouses	21	2811582	298	2554014	3204411
Consumer price index year for pork meat	21	114	7	100	129

3.4 Method used for price transmission analysis

This section describes the procedures and methods used in this thesis. As was mentioned in previous chapter VAR and VECM were used as the approach in this thesis. The VAR approach was used to answer the research question regarding; *What are the short run effects of the current increases in input prices on Swedish pig production?* As the VAR model has proven to be the best method for analysing price transmission in the short run, which is the background for the choice of model.

As described on the previous page, the VECM approach was used as a consequence of the many authors using it to conduct long run price transmission analyses. Therefore, the VECM approach was used to be able to answer the second research question; *what are the long run effects of the current increases in input prices on Swedish pig production?*

For the third research question non-liner regression (log-log model) was used as the approach; *what is the Swedish pig productions output elasticity?* This model is known as the best model to use when calculating and analysing elasticities.

3.5 Analytical and Empirical approach

Cointegration is a timeseries analysis technique that is used in a variety of price transmission studies. To find cointegration, there are different methods being used, one of them is the Engle-Granger methodology. This method is a regression performed between integrated series and residual tests for stationary (Alexander, 1999). Other relevant stationary tests include Philips and Perron 1988, Dickey and

Fuller 1979, Choi 1992 and Schmidt and Philips 1992, by far the most popular method is the Augmented Dickey-Fuller (ADF) test. However, (Alexander, 1999) it is to be noted that Ordinary least of squares (OLS) can only be performed when two log prices of x and y are specified using the Engle-Granger method. Thus, the results of the regression will only be valid if log prices on log prices are cointegrated.

The estimation using OLS effectively minimizes the variance of the residuals, but they can occur as stationary even when they are non-stationary. If standard Dickey-Fuller distribution was used, the null hypothesis of no cointegration would be over-rejected. On the variables that involve the error term (dependent and independent), structure of the model and sample size, the Engle-Granger test differ on the numbers (Bilgili, 1998). To attain the relevant level of significance and consider the deterministic structure, MacKinnon´s table are used. When more than two variables are considered, the exclusiveness of the cointegrating vector is no longer possible to show. The Engle-Granger method lacks a way to systematic estimate multiple cointegration vectors separately (Bilgili, 1998).

Cointegration can also be investigated using Johansen´s methodology; this method is considered as significantly better than the Engle-Granger method as more than two variables are involved (Alexander, 1999). Considering these limitations, the Johansen (1988) test is a better choice of method. This is because Johansen test can forecast and estimate the presence of several cointegrating vectors. The test can also assess the constrained iterations of the cointegrating vectors as the speed of the correction constrains are corrected. Thus, it is of importance to analyse whether economic theories can be established by imposing limits on the strength of the regression analysis. The strength of the Johansen test is that it helps with identification of multiple cointegration vectors among various variables. Johansen´s method is for many equation scenarios, such as this study, the best method to use. It hereby allows for the empirical assessment of the maximum number of cointegration vectors and relationships. Therefore, this study chose to adopt the method of Johansen´s cointegration test.

3.6 Time series data

Nonstationary is when mean and variance change over time while stationarity is when mean and variance remain constant over time. To formally detect stationary in time series data, unit root tests are used (Gujarati & Porter, 2009). Prior to running the model or performing any econometric analysis, it is recommended to verify the stationarity of the time series data (Gujarati & Porter, 2009). Invalid regressions will occur when the variables are nonstationary (Granger & Newbold, 1974). It is therefore of to do further investigation to change nonstationary time series data to stationary time series data. The intention is that the mean and variance need to be steady over time. Thus, the length of lag among two periods in time is what the significance of the correlation relies on, not the time where the correlation is calculated upon at (Gujarati & Porter, 2009). Bonds among nonstationary variables can be significant but make no economic sense (Wooldridge, 2013) and as a consequence leads to invalid and misleading results.

3.7 Testing for Unit-root and Stationery

When a parameter includes a unit root, nonstationary occurs. This leads to error in statistical inference. Therefore, to ensure that time series data is steady, unit root tests are of importance (Gujarati and Porter, 2009). When stationarity is achieved, the results will be valid. For this reason, the Augmented- Dickey Fuller (ADF) is one of the most common procedures to test for unit root, it is based upon an autoregressive model (AR). The null hypothesis suggests nonstationary while the hypothesis against the null hypothesis suggest stationary of the data.

Stationary was verified by using the ADF-test as mentioned above. The test evaluates the null hypothesis of nonstationary against the other. If it can be proven that the variables are nonstationary, traditional analysis becomes invalid. What this means is that the "t-ratios" are not following the t-distribution. Hypothesis tests cannot be done on regression parameters, therefore, even if they are not connected if one parameter is regressed upon the other, this can lead to a high R^2 if the parameters change over time. As previously stated, stationary can be described as constant mean, constant variance and constant covariance. In a stationary series, there is no unit root i.e. the series are integrated of order zero (I(0)).

$$y_t = \rho y_{t-1} + \varepsilon_t \text{ with } |\rho| < 1 \quad \text{(Eq. 1)}$$

For nonstationary series, the first difference is specified and integrated of order 1 i.e I(1).

$$y_t = \rho y_{t-1} + \varepsilon t \text{ with } |\rho| = 1 \quad \text{(Eq. 2)}$$

A second difference is specified if a series is nonstationary at the first order, and thus we integrate at order 2 i.e. I(2). Meaning the series becomes stationary after differencing twice.

$$y_t = \rho y_{t-2} + \varepsilon_t \text{ with } |\rho| > 1 \quad \text{(Eq. 3)}$$

3.8 Augmented Dickey Fuller (ADF) -test

The ADF test helps to determine if there is trend and intercept, intercept and no trend and intercept in the variables. The hypothesis that is tested is the following:

$$H_0: (\rho\text{-}1) = 0 \equiv |\rho| = 1 \equiv y_t \text{ is nonstationary} \quad \text{(Eq. 4)}$$

$$H_A: (\rho\text{-}1) < 0 \equiv |\rho| < 1 \equiv y_t \text{ is stationary} \quad \text{(Eq.5)}$$

H_0 is rejected if $\rho \leq \alpha$ where $\alpha = 0.10$, 0.05 or 0.01 (the statistical significance level). If H_0 is rejected, then it can be concluded that the series is stationary and therefore stop testing. If the null hypothesis cannot be rejected, then the series is non-stationary. The next step is to identify if the series is nonstationary, integrated of order one e.g. I(1), or integrated of order two e.g. I(2). This is done by differentiating the series ($\Delta y_t = y_t - y_{t-1}$) and then testing again, where if H_0 is rejected then nonstationary at I(1) can be concluded. If the test fails to reject, the series is most likely nonstationary at I(2). Afterwards, it is necessary to difference again and retest to confirm. When ADF tests are done and the variables are showed to be integrated in same order, in the following step is to test for cointegration.

3.9 Co-integration analysis

Cointegration is an empirical approach that is used to identify any possible relationship amongst economic time series in the long run (Engle & Granger, 1987). However, cointegration analysis also allows the determination of short-run disequilibrium relationships by using the calculated long-run parameters (Rao, 2016). Furthermore, if variables are cointegrated, that means they move together and the lack of cointegration implies that variables do not move close together. The aim of cointegration analysis is to test for long-run relationships between nonstationary time series. In this study, Johansen´s approach towards cointegration analysis is adopted to examine the relation between Consumer Price Index (CPI) and input prices, and slaughter prices and input prices. The following cointegration equations will be used for estimating the long-run relationship between CPI and input prices and slaughter prices and input prices.

$$CPI = \alpha_0 + \beta_i\, Energy_{price} + \beta_i\, Soy_{price} + \beta_i\, Fuel_{price} + \beta_i\, Piglet_{price} + \beta_i\, Fodder_{price} + \varepsilon_t \quad \text{(Eq.6)}$$

$$Slaugther_{price} = \alpha_0 + \beta_i\, Energy_{price} + \beta_i\, Soy_{price} + \beta_i\, Fuel_{price} + \beta_i\, Piglet_{price} + \beta_i\, Fodder_{price} + \varepsilon_t \quad \text{(Eq.7)}$$

3.10 Error-correction model

To evaluate the speed of which market price responds to price shocks at farm-level, the Vector Error-Correction model was used. The error-correction model describes the long-run patterns of price-series (P_{t}). The model allows for short-run-differences between prices but presumes a stable long-run relationship. To estimate the effect different variables, have on each other, econometric estimation is used. For this study CPI and slaughter prices will be the dependent variables. The equations for the VECM are specified below:

$CPI_t = \alpha + \Sigma_{i=1}^{k-1}\beta_i\, Energy_{price} + \Sigma_{t=j}^{k-1}\theta_j Fodder_{price} + \Sigma_{m=1}^{k-1}\sigma_m Soy_{price} + \Sigma_{t=l}^{k-1}\varphi_l Fuel_{price} + \Sigma_{t=n}^{k-1}\gamma_n Piglet_{price} + \lambda_1\, ECT + \varepsilon_{1t}$ (Eq.8)

$Slaug\_price_t = \delta + \Sigma_{i=1}^{k-1}\beta_i\, Energy_{price} + \Sigma_{t=j}^{k-1}\theta_j\, Fodder_{price} + \Sigma_{m=1}^{k-1}\sigma_m\, Soy_{price} + \Sigma_{l=1}^{k-1}\varphi_l\, Fuel_{price} + \Sigma_{n=1}^{k-1}\gamma_n\, Piglet_{price} + \lambda_2\, ECT + \varepsilon_{2t}$

(Eq.9)

$\boldsymbol{k-1}$ = The lag length is reduced by 1

$\boldsymbol{\beta, \theta, \sigma, \varphi}$ ***and*** $\boldsymbol{\gamma}$ = Short run dynamic coefficients of the model´s adjustment long run equilibrium

$\boldsymbol{\lambda}$ = Speed of adjustment, with a negative sign it is important to mention that in Johansen's approach, the sign λ is reversed.

$\boldsymbol{ECT}$ = The error correction term is the lagged value of residuals obtained from the cointegration regression of the dependent variable on the regressors. Contains long-run information derived from the long run cointegration relationship.

$\boldsymbol{\varepsilon}$ = Residuals (stochastic error terms often called impulses, or shocks)

3.11 Non-linear regression (log-log) model

Elasticities are estimated in order to see a relationship between variables, elasticities are shown in percentage. In this thesis, the function that is obtained from the time series analysis will be derived with respect to the quantity being produced. Hence, the dependent variable will be slaughtered pigs per year. This study will use a non-linear log-log regression model:

$lnQ_{slaughtered} = \beta_0 + \beta_1 \ln(Energy_{price}) + \beta_2 \ln(Fodder_{price}) + \beta_3 \ln(Soy_{price}) + \beta_3 \ln(Fuel_{price}) + \beta_4 \ln(Pigglet_{price}) + \varepsilon$

(Eq.10)

When all the variables are in logarithmic form, the results are easy to interpret, thus a one percent change in the independent variables will show how the depended variable is being affected, the effect is shown by a certain percentage change in the depended variable (Stock, 2020).

4. Results

In this chapter, the empirical findings of the cointegration relationships between inputs and CPI together with slaughter prices are outlined according to the methods described in previous chapter.

4.1 Results for unit roots test

Table 2 presents the results of the ADF test for unit roots. The results point towards that all test statistics are statistically insignificant. However, the null hypothesis that states that variables are nonstationary cannot be rejected and therefore, concluding that the variables have a unit root, the test results for the ADF test shows that the price variables are nonstationary.

Table 2: ADF test results

Variable	Lags	Test statistics
CPI	4	-1.38
Slaughter price	4	0.54
Energy price	4	-3.62
Fodder price	4	-2.04
Piglet price	4	-0.35
Soy price	4	-0.53
Fuel price	4	-1.47

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

Since the results in table 2 point towards that the price series do not have unit-root and therefore are non-stationary, differencing them is crucial to determine stationarity. That’s why the ADF test is further conducted in form of first difference. Results are presented in table 3:

Table 3:ADF test results in first difference

Variable	Lags	Test statistics
CPI	2	-2.89**
Slaughter price	2	-3.95**
Energy price	2	-2.78*
Fodder price	2	-3.48*
Piglet price	2	-3.54*
Soy price	2	-3.55*
Fuel price	2	-3.14**

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

Table 3 show the results for all the variables after differentiating them to first difference form, as can be seen above all variables become stationary, indicating integration in order *I*(1). The ADF test indicates that the variables are statistically significant at 5% and 10% level, which means that the null hypothesis about nonstationary can be rejected, and stationarity among the variables can be concluded. Furthermore, if a unit root test on price series shows that all variables are stationary and integrated of same order, then the next step is to test for cointegration.

4.2 Results for cointegration test

To determine the number of lags for the analysis, the study conducted a diagnostic test using the unrestricted Vector Autoregressive (VAR) model. The criteria that was used were FPE, AIC, HOIC and SBIC, respectively. The number of lags that were identified for CPI/Energy price was 1, CPI/Soy price was 2, CPI/Fuel price was 4, CPI/Piglet price was 3, and CPI/fodder price was 1. The number of lags identified for Slaughter price/Energy price was 4, Slaughter price/Soy price was 1, Slaughter price/Fuel price was 1, Slaughter price/Piglet price was 1, Slaughter price/Fodder price was 3.

4.3 Cointegration test

Table 4 and Table 5 present the results from the Johansen test for cointegration between CPI and inputs (Table 4) as well as slaughter price and inputs (Table 5). Thus, the cointegration analysis tests the following hypothesis:

H_0: No long term cointegration between variables exists

H_1: Long term cointegration between variables exists

The null hypothesis states that there is no cointegration between the variables. However, rejection of the null hypothesis means that the residuals are stationary for the cointegration function, this means that there is a long-run equilibrium relationship for the prices.

Table 4: Results from Johansen cointegration, with CPI as dependent variable

Johansen tests for cointegration
Trend: constant — Number of obs = 20
Sample: 2002 - 2021 — Lags = 2

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	42	-456.12	.	196.99	94.15
1	53	-415.57	0.99	115.75	68.52
2	62	-392.52	0.90	69.64	47.21
3	69	-376.32	0.80	37.25	29.68
4	74	-364.92	0.68	14.44*	15.41
5	77	-357.87	0.51	0.342	3.76
6	78	-357.70	0.017		

The results from the Johansen test where cointegration between CPI and the inputs are tested indicates that there is cointegration up to rank four. Therefore, one can conclude from the results that there is a long-run relationship between CPI and input prices. These findings are consistent with what the study had as *priori* expectations.

The null hypothesis regarding no cointegration can therefore not be accepted, proposing that CPI is moving together with prices for inputs in pig production in the long run.

Table 5: Results from Johansen cointegration test, with slaughter price as dependent variable

Johansen tests for cointegration					
Trend: constant				Number of obs = 20	
Sample: 2002 - 2021				Lags = 2	
maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	42	-420.50		238.98	94.15
1	53	-360.94	0.10	119.87	68.52
2	62	-328.42	0.96	54.83	47.21
3	69	-317.21	0.67	32.41	29.68
4	74	-308.24	0.59	14.48*	15.41
5	77	-301.52	0.49	1.03	3.76
6	78	-301.01	0.05		

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

Table 5 presents the results from the Johansen test of cointegration between slaughter prices and input prices, the test indicates that there is cointegration up to rank four. The results show that there is a long-run relationship between slaughter prices and input prices. These findings are in line with what the study had as *priori* expectations. The null hypothesis about no cointegration can therefore be rejected, proposing that slaughter prices are moving together with prices for inputs in pig production in the long run.

Table 6: Short-run effects of input prices on CPI

Variables	Coefficients	Std.Errors	Z-statisitc	P -value
Adjustment term	-0.31	0.08	-3.65	0.000***
CPI	-0.20	0.22	-0.92	0.36
Energy_price	0.07	0.11	0.64	0.52
Soy_price	0.01	0.01	0.98	0.33
Fuel_price	-3.27	1.52	-2.15	0.03**
Piglet_price	0.03	0.02	1.46	0.14

Fodder_price	0.08	0.07	1.18	0.24
Constant	-11.54	3.43	-3.37	0.00

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

Table 6 shows that in the short run fuel price is significant at 5% level and has a negative impact on CPI in the short run. The other variables are not statistically significant and can therefore not be interpreted. The adjustment term (0.31) is statistically significant at 1% level, indicating that previous years errors have been corrected for within the current year at a convergence speed of 31%.

Tabell 7: Short-run effects of input prices on slaughter prices of pigs

Variables	Coefficients	Std.Errors	Z-statisitc	P -value
Adjustmen term	0.28	0.16	1.79	0.07*
CPI	-0.29	0.40	-0.72	0.47
Energy_price	-0.02	0.02	-1.24	0.21
Soy_price	0.000	0.000	0.18	0.86
Fuel_price	0.11	0.21	0.48	0.64
Piglet_price	0.01	0.01	0.37	0.71
Fodder_price	0.01	0.01	0.86	0.39
Constant	0.18	0.19	0.96	0.34

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

Table 7 indicates that in the short run the variables are not statistically significant and can therefore not be interpreted. The adjustment term (0.28) is statistically significant at 10% level, suggesting that last year´s error is corrected for within the convergence speed at 28%.

The results from Table 6 and 7 are in line with *priori* expectations of this study, the results indicate that in the short run CPI and slaughter prices do not move with the prices of inputs in pig production.

4.4 Error Correction model for Price transmission

As the long run relationship between CPI and input prices together with slaughter prices and input prices has been established, the next step of the analysis is to examine the long-run effects of adjustment. The results of the ECM analysis for CPI and slaughter prices were presented below. Important to mention is that the long run coefficients are the equilibrium relationship between prices in the long run.

Table 8: Long-run effects of changes in input prices on CPI

Variable	Coefficient	Std error	Z-statistic	P value
Adjust.Coefficent				
CPI	1	.	.	.
Energy_price	0.62***	0.10	6.06	0.000
Soy_price	0.04***	0.00	18.48	0.000
Fuel_price	-15.55***	0.77	-20.18	0.000
Piglet_price	0.16***	0.01	10.46	0.000
Fodder_price	0.44***	0.05	9.02	0.000
Johansen normalization restriction imposed				
Number of obs	20			
Log likelihood	-415.57			
AIC	46.86			
HQIC	47.37			
SBIC	49.50			
LM-test	36.24 (p=0.457)			
Jarque-Bera test	18.54 (p=0.100)			
Eigenvalue	1			
Modulus	1			

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

The results in Table 8 show that energy price has a negative impact on CPI with 0.62 at 1% significance level. Soy price also shows a negative impact on CPI with 0.04 at 1% significance level. However, fuel price shows to have a positive impact on CPI with 15.55 also at 1% significance level. Piglet price shows the opposite though and has a negative impact on CPI with 0.16 at 1% significance level. In addition, fodder price is significant at 1% level and shows a negative impact on CPI with 0.44. There is no autocorrelation, the errors are normally distributed, and the model shows stability.

Tabell 9: Long-run effects of input prices on slaughter price

Variable	Coefficient	Std error	Z-statistic	P value
Energy_price	0.14***	0.003	-41.13	0.000
Soy_price	0.01***	0.000	-57.23	0.000
Fuel_price	-1.31***	0.024	52.63	0.000
Piglet_price	0.03***	0.000	-55.49	0.000
Fodder_price	0.0007	0.002	-0.41	0.681
Johansen normalization restriction imposed				
Number of obs	20			
Log likelihood	-360.94			
AIC	41.40			
HQIC	41.91			
SBIC	44.03			
LM-test	31.77 (p=0.670)			
Jarque-Bera test	18.25 (p=0.108)			
Eigenvalue	1			
Modulus	1			

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

Table 9 shows that energy price has a positive influence on slaughter price with 0.14 at 1% significance level. Soy price also has a positive impact on slaughter price with 0.01 at 1% significance level. Thus, fuel price shows a negative impact on slaughter price with -1.31 at 1% significance level. However, piglet price has a positive impact with 0.03 towards slaughter price at 1% significance level. Fodder price shows to be non-significant and can therefore not be interpreted. The results from diagnostics test shows that there is no autocorrelation, the series are normally distributed, and the model is also stable. These results are in line with the results from Karantaninis (2011).

4.5 Results from output elasticity analysis

Table 10 shows that the logarithmic energy price is not statistically significant, which means that the results cannot be interpreted. However, the elasticity for fuel on output is showing a negative influence with –0.31% and is statistically significant at 1%. The elasticity for piglet price is also negative with -0.20% impact on output, thus significant at 5% level. However, the elasticity for the fodder price shows to have a positive impact on output with 0.13%, and with a statistical significance level at 5%. The VIF test results showed a mean VIF of 3.81, which implies that there is no multicollinearity in the model (see appendix 1).

Tabell 10: Results from Output elasticity analysis

lnQslaugthered_pigs	Coefficient	Robust Std error	t-value	P-value	95% Conf.Intervall
lnEnergy_price	0.04	0.03	1.35	0.19	-0.02 - 0.11
lnFuel_price	-0.31***	0.07	-4.47	0.000	-0.46 – 0.16
lnPiglet_price	-0.20**	0.90	-2.16	0.05	-0.38 – 0.01
lnFodder_price	0.13***	0.04	3.00	0.01	0.031 – 0.22
Number of obs F (4,17) Prob > F R-squared Root MSE	22 63.20 0.0000 0.93 0.03				

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

5. Discussion and Analysis

The results presented in previous chapter will be discussed together with the limitations of the study.

The results from Table 3 showed that the variables are stationary at I(1), which means that the variables are stationary after differentiating once. That the variables are stationary means that variation of time does not impact the change of the variables. Furthermore, in Table 3 the lag-length is two instead of four as was shown in Table 2. This is in line with what this thesis examines, if the era of the COVID-19 pandemic has had any impact on input prices. Because a lag-length of two means that the past two years (2021 and 2020) has had an impact on the change of the variables. The optimal lag-length has also been tested as described in the previous chapter; the results showed that a lag-length of two is the best.

Furthermore, the results from the Johansen co-integrations test indicates that there is a long run relationship between both CPI and input prices and slaughter price and input prices. This was expected as prior studies such as Karantaninis (2011) and Persson (2022), found in their studies that the Swedish market for pork is co-integrated in the long term. This means that both CPI and slaughter prices move along with input prices in the long run. Shocks in the short run may affect the series individual movements, however they converge in the long run.

Thus, short run analysis shows that the only variables affecting CPI is fuel. For slaughter prices none of the variables where statistically significant in the short run. Implying that price shocks in the short run does not affect CPI or slaughter prices. No cointegration in the short run between markets indicates that farmers are affected negatively. As the farmers are faced with higher costs, one would assume that they would get paid higher for their products. But as can be seen in Table 7, input prices do not affect the slaughter price in the short run. If the slaughter price does not increase, then the CPI does not increase either in the short run.

When farmers revenue does not increase but instead decrease, many decide to downsize, shift production or close down their businesses. As Adam et al. (1976) concluded in their book, higher prices for diesel in the short run affects farmers net income very negatively. When farmers face higher costs but do not get paid more for their products, their net revenue starts to abate (Adam, et al. 1976). As can be seen from the results in Table 6, higher fuel prices affect CPI negatively. This could be explained by the economic theory of demand and supply. When fuel prices go up, farmers may cut back or change their production, leading to farmers deciding to decrease their herd of pigs or even quit pig production entirely. A larger quantity of pork on the market will cause it to decrease in price. Which in turn leads to a decrease in CPI for pork. As reported from the Federation of Swedish Farmers the increases in input prices that started in 2020 and continues today, have had a negative impact on Swedish farms, due to farmers starting to downsize or considering about downsizing (LRF, 2022).

However, in the long run analysis with CPI as the dependent the results show that all input prices except fodder price are significant at 1% significance level *ceteris paribus*. For slaughter price all variables are significant at 1% level. These results implicate that in the long run input prices do influence CPI and slaughter price. Looking at Table 8, one can see that energy price, soy price, piglet price and fodder price all have a negative effect on CPI, *ceteris paribus*. Which in this case means that these inputs decrease the CPI. Meaning that in the long run pork prices will decrease because of higher prices for those inputs. As brought up in chapter 2, most of the pig producers who buy the majority of their fodder are highly dependent on electricity to keep the stables running and higher piglet prices make the farmers more sensitive to other price increases. All those price increases make it harder for the farmer to be able to profit on each pig. Furthermore, the price increments for crucial inputs for pig production will most certainty lead to a decrease in farms

(LRF, 2022). This is already the trend in Sweden as Figure 2 and 3 shows. However, when the number of pig producers decline the domestic quantity of pork also decreases. This causes the food chains to start to import more pork from other countries, imported pork is often cheaper than the pork that is domestically produced in Sweden, which could cause the CPI to decrease (Svensktkött, 2022). However, CPI is not only influenced by input prices, there are also economic factors that come into play, such as tax and subventions. CPI was used due to the lack of publicly available data from retail stores. For future studies, this study recommends using retail data instead to get more precise results, as retail data allows one to be able to only use prices for Swedish pork products. Therefore, these results should be treated with caution.

However, fuel price is showing a positive impact on CPI with 15.55 units *ceteris paribus*. This means that when fuel prices increase CPI increases and likewise the price for pork. Fuel therefore seems to be the input that raises the CPI in the long run. In conclusion, higher fuel prices give farmers higher costs for their production. In pig production, fuel is often used for heating the stables, how long the heating is needed depends on the weather. Another aspect is that higher fuel prices give higher fodder prices, both for farmers producing their own fodder and for farmers buying fodder from another farmer or producer.

Energy price, soy price and piglet price have a positive impact on slaughter price *ceteris paribus*. This indicates that in the long run high prices on energy, soy and piglets increase the slaughter prices. These findings imply that in the long run prices move vertically, from farmer to food producers. This shows that prices do transfer between markets, however in the event of a shock price increase at the farmers market, prices will recognize a change first in the long run (the price is essentially unchanged in the short run). The results from Karantaninis (2011) also suggests that price increments at farm level increase whole sales and retail prices.

Fuel price is instead shown to have a negative impact on slaughter price in Table 9, *ceteris paribus*. This means that high prices on fuel decreases slaughter price in the long run. However, when fuel prices go up, farmers that have an energy intense production such as pig production many times start to invest in alternative sources of energy. A study conducted by Renberg & Romblad (2010) shows that farmers are willing to invest in their own power plants to reduce their costs when energy prices are high. This is a way for the farmer to develope their buissness and keep it competitive. A power plant is a long term investment and therefore farmers see it as an appropriate way to diversify the farm, but also a way to optimise farm income. If farmers move toward producing their own energy that will ultimately lower their production costs in the long run, leading to a lower energy cost per kg of pork being produced. Hence the relationship between fuel prices and slaughter prices in the long run.

When food prices go up the government is forced to step in, often by economic packages or tax reforms explicitly for farmers. These subsidies or reforms are supposed to cover the loses and help lower the costs for the agriculture (Becker, 2008). So, in the long run, government inference can lower the production costs, and then also the slaughter prices. It is hard for the Swedish government to implement domestic subsidies for agriculture due to the fact that Sweden is a member of the Common Agricultural Policy (CAP). The Swedish government is highly restricted by the European union and CAP, the open EU agricultural market means that member countries are not allowed to set up domestic subsidies that protect or benefit the member countries own agricultural markets.

However, if farmers decide to downsize or quit with pig production, there will be a higher supply of pork meat for a short period of time at the market. But as the supply goes down, the farmers that are left will instead be paid a higher price. This is the base of economic theory about supply and demand. When supply goes down, prices will go up and when supply increases, prices go down.

The results suggest that if input prices would increase with one percent, fuel and piglet price would decrease the quantity being slaughtered. The results imply that the elasticity for fuel is -0.31%, indicating that fuel is elastic and therefore, sensitive to changes in price. For the elasticity regarding piglet price, the results imply the same as for fuel, as the results showed that piglet price has an elasticity at -0.20%. Furthermore, the elasticity for the piglet price is negative, which is in line with the results and analysis of Table 8. A higher piglet price causes the farmer to reduce the number of new piglets and instead downsize his pig production, leading to an output reduction in the long run as suggested by results in Table 10.

The elasticity for fodder price implies that fodder is inelastic, as it has an elasticity at 0.13%. When an input is inelastic, it means quantity used is not reduced when price increases. Farmers need to buy fodder for their pigs as the pigs need to eat even if prices are high, otherwise they will have to send more of their pig herd to slaughter earlier if they cannot get enough fodder. This will instead increase the quantity being slaughtered. The fact that pigs can eat most things, also means that there is more room for the farmer to find other types of feed at a possible lower price.

Due to the lack of previous research investigating the underlaying factors for different types of price transmission in the market for agricultural commotidies, it is hard to argue about the reasons to why the results may show what they show as Persson (2022) states in his report. But without a scientific basis it is difficult to argue that these causes are what actually affects the pork market in Sweden. Therefore should future research focus on the factors behind different types of price transmssion, instead of just establishing it´s exisitence on the agricultural markets.

To develope this study, the use of micro data would be preferred. Most of the previous studies used monthly data instead, but due to the lack of monthly publicly available data this thesis used yearly data. However, with monthly or even weekly data it is easier to capture the variations that may only last a couple of months or weeks. These are very likely to disappear when you base your data on means of the year. Another development of this study would be to look at the price transmission between input market and farmer. At a micro level, how price shocks affect profitability and herd size at farm level for example.

6. Summary and conclusion

The aim of this thesis was to explore the essence of integration between CPI and input prices, and slaughter price and input prices in Swedish pig production. With the background of the rapidly increasing input prices that started during the era of COVID-19 and are still on going. The purpose of the thesis was to try and answer the following research questions:

1. *What are the short run effects of the current increases in input prices on Swedish pig production?*
2. *What are the long run effects of the current increases in input prices on Swedish pig production?*
3. *What is the Swedish pig productions output elasticity?*

The Johansen test for long run cointegration technique was used to establish the long run integration between CPI and input prices, and Slaughter price and input prices. A Vector Error Correction model (VECM) was carried out to analyse the short and long-run cointegration relationships between CPI and input prices and slaughter price and input prices. The results of the VECM indicate that in the short run there is no integration between CPI and input prices, same applies to slaughter prices and input prices. Meaning that farmers will suffer from high input prices but do not get reimbursed for their expenses quickly enough, leading profitability in Swedish pig production to decrease, risking that farmers start to downsize or lay off completely.

However, in the long run, the results are shown to be co-integrated, input prices showed to have both negative and positive impact on CPI and slaughter price.

Implying that price shocks will affect Swedish pig production negatively even in the long run, if the government doesn’t act against those high prices on input. High input prices in the agri-food chain will lead to higher prices for food at the supermarkets, which have negative effects on society.

This thesis therefore recommends farmers to see over their different costs, to find where they might be able to cut back and save a few crowns. But also plan their production around that these higher input prices might increase even more during this year and coming years. However, if you as a farmer are going to invest in your facility, then make sure that it is an investment that can lower the dependence on expensive inputs. Anything that makes the farm more self-sufficient is good, but it is important to calculate the cost of the potential new investment, so the cost does not eat up the net value of the investment.

The results show that in the short run the lack of integration between markets affect farmers negatively, although there is integration between markets in the long run the results indicate that the recent price increments will affect pig producers negatively even in the long run. Therefore, the policy recommendations made from the results of this thesis is to adopt policy measures that support Swedish pig producers’ chance to be profitable in order to maintain a strong domestic production, further work towards self-sufficiency, a sustainable production and high animal welfare. However, in economic theory trade barriers lower the total welfare of an economy. Thus, an open market without market regulations is the best option according to theory if we want to maximize total welfare of the economy, due to the fact that more policy measures would likely induce some negative effects. With this said, more research is needed within the field for self-sufficiency in Sweden, and how to increase it without going against EU regulations and also look into how we can strengthen our domestic production and productivity within the pig production and the agriculture overall.

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Appendix 1

```
varsoc CPI Energy_price , maxlag(4)

   Selection-order criteria
   Sample:  2004 - 2021                        Number of obs
=        18
  +---------------------------------------------------------------------
------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC
SBIC    |
  |----+----------------------------------------------------------------
------------|
  |  0 | -127.842                      6319.14   14.4269
14.4405*  14.5258* |
  |  1 | -123.766  8.1512    4  0.086  6304.31*  14.4185*  14.4594
14.7153  |
  |  2 | -121.476  4.5803    4  0.333  7806.22   14.6085   14.6767
15.1031  |
  |  3 | -120.441  2.0707    4  0.723  11481.7   14.9379   15.0333
15.6304  |
  |  4 | -117.847  5.1883    4  0.269  14995.9   15.0941   15.2168
15.9844  |
  +---------------------------------------------------------------------
------------+
   Endogenous:  CPI Energy_price
    Exogenous:  _cons


. varsoc CPI Soy_price , maxlag(4)

   Selection-order criteria
   Sample:  2004 - 2021                        Number of obs
=        18
  +---------------------------------------------------------------------
------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC
SBIC    |
  |----+----------------------------------------------------------------
------------|
  |  0 |  -201.15                      2.2e+07   22.5723   22.5859
22.6712  |
  |  1 | -185.023  32.254    4  0.000  5.7e+06   21.2248   21.2657
21.5216  |
  |  2 | -178.017  14.013*   4  0.007  4.2e+06*  20.8907*
20.9589*  21.3854* |
  |  3 | -176.681  2.6707    4  0.614  5.9e+06   21.1868   21.2823
21.8793  |
```

```
  |  4 |  -175.52   2.323    4  0.677  9.1e+06   21.5022    21.625
22.3926  |
  +---------------------------------------------------------------
------------+
   Endogenous:  CPI Soy_price
    Exogenous:  _cons

. varsoc CPI Fuel_price , maxlag(4)

   Selection-order criteria
   Sample:  2004 - 2021                        Number of obs
=        18
  +---------------------------------------------------------------
------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC
SBIC    |
  |----+----------------------------------------------------------
------------|
  |  0 | -97.4383                       215.547   11.0487   11.0623
11.1476  |
  |  1 | -80.4307  34.015    4  0.000  51.1075   9.60341   9.64433
9.9002  |
  |  2 | -78.8974  3.0666    4  0.547  68.8347   9.87748   9.94569
10.3721  |
  |  3 | -70.3973      17    4  0.002  44.1737   9.37748   9.47297
10.07  |
  |  4 |   -61.22  18.355*   4  0.001  27.7628*  8.80223*
8.925*   9.6926* |
  +---------------------------------------------------------------
------------+
   Endogenous:  CPI Fuel_price
    Exogenous:  _cons

. varsoc CPI Piglet_price , maxlag(4)

   Selection-order criteria
   Sample:  2004 - 2021                        Number of obs
=        18
  +---------------------------------------------------------------
------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC
SBIC    |
  |----+----------------------------------------------------------
------------|
  |  0 | -167.711                        530300   18.8567   18.8704
18.9557  |
  |  1 | -151.274  32.874    4  0.000   133972   17.4749   17.5158
17.7717  |
  |  2 | -146.982  8.5841    4  0.072   132805   17.4424   17.5106
17.9371  |
  |  3 | -137.726  18.512*   4  0.001  78360.8*  16.8584*
16.9539*  17.5509* |
  |  4 | -135.126  5.1998    4  0.267   102280    17.014   17.1368
17.9044  |
  +---------------------------------------------------------------
------------+
   Endogenous:  CPI Piglet_price
    Exogenous:  _cons
```

```
. varsoc CPI Fodder_price , maxlag(4)

   Selection-order criteria
   Sample:  2004 - 2021                        Number of obs
=       18
  +-----------------------------------------------------------------
------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC
SBIC    |
  |----+------------------------------------------------------------
------------|
  |  0 | -129.506                      7602.38   14.6117   14.6254
14.7107  |
  |  1 | -123.702  11.607*   4  0.021  6259.54*  14.4113*
14.4523*  14.7081* |
  |  2 | -122.879  1.6457    4  0.801  9123.22   14.7644   14.8326
15.259  |
  |  3 | -121.216  3.3259    4  0.505  12514.9    15.024   15.1195
15.7165  |
  |  4 | -121.107  .21806    4  0.994  21543.4   15.4564   15.5791
16.3467  |
  +-----------------------------------------------------------------
------------+
   Endogenous:  CPI Fodder_price
    Exogenous:  _cons

. varsoc Q_slaughtered Energy_price , maxlag(4)

   Selection-order criteria
   Sample:  2004 - 2021                        Number of obs
=       18
  +-----------------------------------------------------------------
------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC
SBIC    |
  |----+------------------------------------------------------------
------------|
  |  0 | -193.895                      9.7e+06   21.7662   21.7798
21.8651  |
  |  1 | -173.626  40.539*   4  0.000  1.6e+06*  19.9584*
19.9994*  20.2552* |
  |  2 | -172.277  2.6971    4  0.610  2.2e+06    20.253   20.3213
20.7477  |
  |  3 |  -169.59  5.3754    4  0.251  2.7e+06   20.3989   20.4944
21.0914  |
  |  4 | -167.029  5.1217    4  0.275  3.5e+06   20.5588   20.6815
21.4491  |
  +-----------------------------------------------------------------
------------+
   Endogenous:  Q_slaughtered Energy_price
    Exogenous:  _cons

. varsoc Slaughter_price Energy_price , maxlag(4)

   Selection-order criteria
   Sample:  2004 - 2021                        Number of obs
=       18
  +-----------------------------------------------------------------
------------+
```

```
  |lag |    LL      LR      df    p      FPE       AIC      HQIC
SBIC    |
  |----+--------------------------------------------------------------
------------|
  |  0 | -109.829                      853.973   12.4254   12.4391
12.5244  |
  |  1 | -86.2067  47.244    4  0.000  97.0977   10.2452   10.2861
10.542* |
  |  2 | -81.8712   8.671    4  0.070  95.7883   10.2079   10.2761
10.7026  |
  |  3 |  -78.834  6.0746    4  0.194  112.791   10.3149   10.4104
11.0074  |
  |  4 | -71.1272  15.413*   4  0.004  83.4708*  9.90303*
10.0258*  10.7934  |
  +-------------------------------------------------------------------
------------+
   Endogenous:  Slaughter_price Energy_price
    Exogenous:  _cons

. varsoc Slaughter_price Soy_price , maxlag(4)

   Selection-order criteria
   Sample:  2004 - 2021                        Number of obs
=       18
  +-------------------------------------------------------------------
------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC
SBIC    |
  |----+--------------------------------------------------------------
------------|
  |  0 |  -173.37                       994526   19.4855   19.4992
19.5845  |
  |  1 | -149.097  48.546*   4  0.000   105186*   17.233*
17.2739*  17.5298* |
  |  2 | -148.639  .91591    4  0.922   159652   17.6265   17.6947
18.1212  |
  |  3 | -144.618  8.0411    4  0.090   168535   17.6242   17.7197
18.3168  |
  |  4 | -144.047  1.1416    4  0.888   275609   18.0053    18.128
18.8956  |
  +-------------------------------------------------------------------
------------+
   Endogenous:  Slaughter_price Soy_price
    Exogenous:  _cons

. varsoc Slaughter_price Fuel_price , maxlag(4)

   Selection-order criteria
   Sample:  2004 - 2021                        Number of obs
=       18
  +-------------------------------------------------------------------
------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC
SBIC    |
  |----+--------------------------------------------------------------
------------|
  |  0 | -70.1319                      10.3722   8.01465   8.02829
8.11358  |
```

```
  |  1 | -43.4858  53.292    4  0.000  .842772*  5.49842*
5.53934*  5.79521* |
  |  2 | -43.1026  .76627    4  0.943  1.28984   5.90029    5.9685
6.39494  |
  |  3 | -36.8125   12.58*   4  0.014  1.05811   5.64584   5.74132
6.33835  |
  |  4 | -34.9006  3.8239    4  0.430   1.4908   5.87784   6.00061
6.76821  |
  +---------------------------------------------------------------
------------+
   Endogenous:  Slaughter_price Fuel_price
    Exogenous:  _cons

. varsoc Slaughter_price Piglet_price , maxlag(4)

   Selection-order criteria
   Sample:  2004 - 2021                          Number of obs
=        18
  +---------------------------------------------------------------
------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC
SBIC    |
  |----+----------------------------------------------------------
------------|
  |  0 | -128.732                      6976.34   14.5258   14.5394
14.6247  |
  |  1 |   -104.8  47.864    4  0.000  766.349*  12.3111*
12.352*  12.6079* |
  |  2 | -104.052  1.4959    4  0.827  1126.28   12.6725   12.7407
13.1671  |
  |  3 |   -97.35  13.404*   4  0.009  882.598   12.3722   12.4677
13.0647  |
  |  4 | -93.6019  7.4962    4  0.112  1014.02   12.4002    12.523
13.2906  |
  +---------------------------------------------------------------
------------+
   Endogenous:  Slaughter_price Piglet_price
    Exogenous:  _cons


. varsoc Slaughter_price Fodder_price , maxlag(4)

   Selection-order criteria
   Sample:  2004 - 2021                          Number of obs
=        18
  +---------------------------------------------------------------
------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC
SBIC    |
  |----+----------------------------------------------------------
------------|
  |  0 | -115.679                       1635.8   13.0754   13.0891
13.1743  |
  |  1 | -91.7875  47.782    4  0.000  180.513   10.8653   10.9062
11.1621* |
  |  2 | -89.6941  4.1868    4  0.381  228.457   11.0771   11.1453
11.5718  |
  |  3 | -83.0208  13.347*   4  0.010  179.602*  10.7801*
10.8756*  11.472
```

```
|  4 | -82.4495  1.1427    4  0.887   293.69   11.1611   11.2838
12.0514  |
  +-----------------------------------------------------------------
------------+
   Endogenous:  Slaughter_price Fodder_price
    Exogenous:  _cons
```

Appenix 2

vif

Variable	VIF	1/VIF
LnFprice	6.84	0.146240
LnPprice	5.13	0.195046
LnEprice	1.99	0.503526
Lnfdprice	1.28	0.779212
Mean VIF	3.81	