Price clusters in the European pork industry

From Piglet to Pork Ham

Thesis report

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Wageningen, April 2012

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Code:	MCB-80433	
Thesis title:	Price clusters in the European pork industry	
Period:	September 2011 - April 2012	
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Preface

This Master thesis is the result of seven months of research at the Marketing and Consumer Behaviour group of the Wageningen University. The report gives insight in the spatial integration process of the European pork sector. To start, I would like to thank a few people for their input or assistance.

First, I want to thank my supervisor of the Landbouw Economisch Instituut (LEI), Dr. Marcel Kornelis, for his contribution. By working in a stepwise matter, Marcel helped me to understand the basics of time series analysis. Due to his assistance, I grasped the methodology that is being used in this research. Second, I would like to thank Ynte van Dam. Due to his cheering words, I gained the strength to succeed. He has been very helpful by providing me good insights and assistance, especially in the starting and ending phase. Third, I would like to thank Dr. Frank Bunte, for providing data to conduct the research.

In addition, I would like to thank my family for their continuous support during my studies. Moreover, I thank my girlfriend and fellow students from the Leeuwenborch, for their interest and insightful words and the litres of coffee we drunk together.

It has been a very interesting and informative period for myself, which has given me good insights on future steps I would like to take. Therefore I'm positive, you will hear more from me in the future.

To end, I hope that you enjoy reading this Master thesis.

Henk-Jan Lesker
Wageningen, April 2012

Abstract

Citatation: Lesker, H.J. (2012). Price clusters in the European pork industry; from piglet to pork ham, Wageningen University.

Objective: The purpose of this research is to analyse whether there are multiple price clusters within the EU market for pork and how they evolved during the first decade of the 21th century.

Methods: The Granger causality concept is used and tested with the help of the joint and sum Wald test. An unit-root test is conducted, to test if the residuals of a pair of non-stationary time series are stationary. An error correction term is added to the linear regression model to investigate if the series were co-integrated. In addition, the time series were split up in two equal subsamples by making use of interaction dummy variables. Here, the individual windows were tested for the Granger causality and co-integration.

Results: Denmark attracts Germany towards a long run relationship for piglets, pig carcasses and pork hams in the EU pork chain. No other long term relationships were found.

Conclusions and implications: This research found a price cluster between Denmark and Germany for export prices of piglets, pig carcasses and pork hams. The EU pork market has a low degree of integration, although mayor efforts have been taken to stimulate EU agricultural integration.

Keywords: price leader, co-integration, European Union, dispersion, convergence, price, marketing, time series, price cluster, Wald test, Engle-Granger.

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1. Introduction

After World War II, European countries have made huge efforts to integrate their national markets. Two milestones in this integration process were:

1. The adoption and implementation of the Single Market (also known as the internal market) in 1993.
2. The start of the Economic and Monetary Union (EMU) in 1999.

The single market removed the remaining physical, administrative and technical barriers to integration. The EMU introduced a common currency and eliminated exchange rate variations between the eleven, later twelve, members of the Eurozone[1]. These two steps were crucial in the integration process towards economic, monetary and political unification in Europe. The European commission's view on the Single Market in 1996 was: "increased price transparency will enhance competition and whet consumer appetites for foreign goods; price discrimination between different national markets (in the EU) will be reduced" (Commission, 1996). In 1999 when the EMU became reality, the European commission anticipated that it would: "squeeze price dispersion in EU markets" (Commission, 1999)[2].

During the last decades a growing number of scientific papers have been published regarding the subject of price convergence (dispersion) within the EU, see for an overview Allington *et al*. (2005). The studies can be distinguished in modelling approaches, sample time, area covered whether countries or cities and the source and characteristics of the data. The outcomes of these studies are diverse, some studies found evidence in favour of price convergence (Beck and Weber, 2001) others found mixed results (Parsley and Wei, 2001) or did not find any price convergence (Goldberg and Verboven, 2004)[3]. So, what EU policymakers have anticipated has not always been depicted in reality. In practice, prices within the EU have not always been equalised, as one would anticipate according to the "law of one price". What those studies have in common is that the vast majority of these papers studies price levels in the final stage of the supply chain. These price levels depict what end consumers are facing. However, at this stage in the supply chain, no spatial arbitrage is taken place, except by consumers who live sufficiently close to borders to shop abroad or through the use of electronic marketplaces (Bunte, 2012). If price dispersion has been reduced in EU markets, as anticipated by the European Commission (1999), one has to research price dispersion before the end-consumer stage. Spatial arbitrage activities can be observed, for example, between sales of processing companies and purchasing departments of retail companies, but not between end consumers.

1.1 Spatial price arbitrage

Spatial price arbitrage is an equilibrium concept, where in a well-functioning market, transactions between spatially dispersed agents will ensure that price shocks occurring in one market evoke responses in other markets (Serra *et al.*, 2006). In theory, prices of homogeneous goods in two

[1] The 1999 members were: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain. Greece joined in 2001.
[2] The EMU became reality in 1999, the euro appeared in physical form on the first of January 2002.
[3] The authors found converging prices between 1990 and 1992, but divergence thereafter.

separate locations will differ by, at most, the cost of moving the commodity form the cheapest market to the most expensive one. This arbitrage condition is equivalent to the weak version of the law of one price (LOP) (Fackler and Goodwin, 2001). Numerous studies on various concepts such as spatial arbitrage, market integration and market efficiency have been used to describe spatial price arbitrage (Serra *et al.*, 2006; Fousekis, 2007). The majority of the studies on spatial price relationships have been focussed on food markets.

Studies investigating spatial price relationships for agricultural commodities in Europe are rather limited in number (Gordon *et al.*, 1993; Zanias, 1993; Sanjuán and Gil, 2001; Serra *et al.*, 2006; Fousekis, 2007). In the study by Fousekis (2007) spatial relationships of pork and poultry prices amongst 14 EU countries were determined to test if there was a single EU market or multiple markets. Fousekis (2007) concludes that the EU market for pork is far from the ideal one in which prices are uniform. In his research he observes four different price cluster formed by EU member states for pork. However, research by Fousekis (2007) only studied price relationships at one stage in the EU pork chain, namely for monthly prices pig fatteners got at the slaughterhouse. In addition, research by Serra *et al.* (2006), investigating weekly pork producer prices, only studied one stage of the EU pork chain. Moreover, research by Sanjuan and Gil (2001) investigating weekly pork carcass prices, also investigate only one stage. Furthermore, the reasoning and explanations for the price clusters are very slim and not substantial.

Apparently, no published study has addressed the market structure of the EU pork chain, by looking simultaneously at more than one stage along the chain. The present study attempts to fill this gap by investigating spatial price relationship at three stages in the EU pork supply chain, namely for piglets, pig carcasses and for processed pork meat products (hams). One of the first stages along the EU pork supply chain were spatial arbitrage is taken place is the trading of piglets. One of the last stages in the EU pork chain were spatial arbitrage is taken place is the trading of processed pork meat products, like hams.

1.2 European pork market

European Union policymakers have intervened the pork market less in comparison to other livestock products such as beef meat, lamb meat and milk. A high degree of intervention is associated with a low degree of integration in the long term (Zanias, 1993). Since the early 1990s agricultural sector-specific measures have been taken to remove institutional barriers to intra-community trade. The monetary compensatory amounts (MCAs) were eliminated in 1992, these were border measures consisting of subsidies and taxes (Fousekis, 2007). These aspects should provide an environment where smooth spatial price transmission can take place. However, the EU pork industry has been exhibiting up-scaling and concentration trends in all stages of the chain (Trienekens *et al.*, 2009). These trends may have influenced the degree to which price shocks are regionally transmitted and may have resolved in an increase of price dispersion between EU member states. Moreover, the EU meat sector has been effected by major veterinary crises. These crises have had important impacts on both supply and demand for meat products (Serra *et al.*, 2006). Moreover, Fousekis (2007) found multiple price clusters within Europe for producers prices. Still it is unclear whether prices for piglets, pig carcasses and pork hams also depict multiple price clusters.

1.3 Research objective

The purpose of this research is to analyse whether there are multiple price clusters within the EU market for pork and how they evolved during the first decade of the 21th century. Investigating this objective provides European policymakers additional information on the development of spatial market integration within the EU pork markets.

1.4 Research questions

To reach this objective the following main question is formulated:

How did the EU pork market structure evolve during the first decade of the 21st century and in what price cluster(s) has this resulted?

The main question will be answered using the following sub research questions:

1. Which members states are price leaders and which are price takers for piglets, pig carcasses and pork hams?

2. Which price cluster(s) within the EU can be identified for piglets, pig carcasses and pork hams?

3. What shifts in market power between the three chain stages during the first decade of the 21th century can be observed?

1.5 Relevance

The extent in which agricultural markets are being integrated is relevant to policy makers of the European Union. A low degree of integration indicates that, although mayor efforts to achieve a unified market, prices are not perfectly transmitted. Therefore, misallocation of resources and distortions of production and distribution might occur. The higher the degree of integration, the more efficient the interacting markets are working. Pork being the most consumed meat in Europe per capita, is therefore an interesting test case[4].

1.6 Structure of thesis

The thesis is structured as follows. The report starts with presenting a literature review on price dispersion. Amongst other things, factors that influence price dispersion are presented, as well as what possible price dispersion scenarios do exist. In chapter 3 the methodology used in this research has been described. A detailed description of the data is being presented in chapter 4. The results of the research can be found in chapter 5. Finally, in chapter 6 and 7 the conclusion and discussion are being presented.

[4] "From farm to fork - food chain statistics" - Statistics Explained (2012/4/1) <http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/From_farm_to_fork_-_food_chain_statistics>

2. Literature review

2.1 Price convergence research

Empirical studies investigating price convergence show a dichotomy of data analyses, either from a micro or macro perspective. To ensure the homogeneity of the products as the representativeness of the prices of a product or category of products, it is probably best to use a micro perspective analysis. Results of micro studies might be more reliable than studies that depict developments from a macro perspective, so researching a large number of goods. In addition, a potential drawback is that macro-economic impulse are obscured by sector or product specific effects. As a result, the displayed pattern is untypical for all tradable goods. These micro and macro studies differ in modelling approaches, sample time, area covered, whether investigating countries or cities and the source and characteristics of the data. Therefore, results of micro or macro studies cannot directly be compared. However, the vast majority of the studies investigates convergence for prices which end-consumers face. No spatial arbitrage takes place between end-consumers, except by consumers who live sufficiently close to borders to shop abroad or through the use of electronic marketplaces (Bunte, 2012).

There have been numerous studies conducted that examine the converging of prices at a macroeconomic point of view. For example, price dispersion between the EMU countries already converged close to U.S. levels before the introduction of the euro (Faber and Stokman, 2009). In a study conducted by Engel and Rogers (2004), most of the price convergence is observed in the early part of the 1990, concurrent with the implementation of the Single Market Programme.

In addition, a number of studies took a microeconomic, single or multi-product approach to price convergence. For example, price convergence is found for 119 goods sold in stores operated by the Swedish retailer IKEA in twenty-five countries (Haskel and Wolf, 2001). The European automobiles market provided evidence in favour of the LOP (Lutz, 2004). For a literature review of studies investigating price convergence, see Allington *et al*. (2005).

In the paper of Allington *et al.* (2005) the relevance of these papers is questioned. Most of the empirical findings are non-comparable and, therefore, present snapshot pictures of price convergence, in different periods and across different countries and cities. Due to differences in data, an evolving picture of price convergence is not built up.

2.2 Factors affecting price dispersion

Numerous factors with different effects amongst countries and produce can be given for price dispersion. In this paragraph, several factors are presented and explained on how they might effect price dispersion. A dichotomy is made on factors that companies can and cannot exploit influence on. According to the marketing literature, the international marketing environment is a set of forces that either directly or indirectly influence the firm's acquisitions of inputs or generation of outputs (Omar, 2009). Kotler defines it as follows: "the actors and forces that affect the company's ability to develop and maintain successful transactions and relationships with its target customers" (Kotler, 2006). The marketing environment can be broken down into components, including the micro and macro environment, see figure 1.

2.2.1 Macro environmental forces

The macro environment, also known as the wider marketing environment, consists of those elements that are external to a company (Omar, 2009). These macro environmental forces might influence price differentials between companies. Companies are not able to directly influence these macro forces, but these could have a major effect in the day-to-day business. To categorize the factors, a marketing model will be used that displays the macro environmental forces for a company (Kotler, 2006). This model holds six macro environmental forces namely: demographic, economic, natural, technological, political and cultural (figure 1). Normally this analysis is a marketing tool to identify which opportunities and threats a company needs to take into account. In this research however, the macro environmental forces hold macro factors, which might influence price dispersion at country level. In the following section several macro factors are presented which possibly influence price dispersion between countries. These macro factors are, for example, distance, borders and currency union. Moreover, the effects of the factors on price dispersion might differ between industry branches. For example, an environmental force like climate, might impact price dispersion differently, between industries or countries.

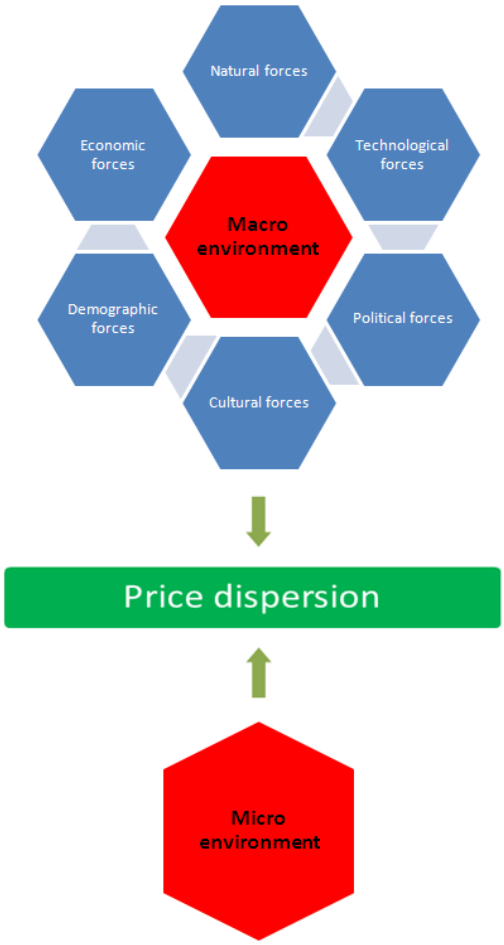

Figure 1. International marketing environment

Distance

An increasing transportation distance affects transport cost. If transport costs are relatively high, arbitrage is probably not worthwhile. An article by Engel (1996) found evidence that distance, as a convenient control for transport cost, explains relative price dispersion amongst ten United States and nine Canadian cities. This finding is confirmed by several other studies (Parsley and Wei, 1996; Cecchetti *et al.*, 2000; Parsley and Wei, 2001; Fan and Wei, 2006; Bergin and Glick, 2007). On the contrary, if transport costs are low, arbitrage might be worthwhile. If this occurs, price variability amongst countries declines, so prices converge.

Border

Next to distance, borders can explain price dispersion between nations. Firms exploit and adapt their price strategies to the characteristics of local or national markets. Within countries, price variability is significantly smaller than between countries (McCallum, 1995; Engel, 1996; Anderson and Van Wincoop, 2001; Beck and Weber, 2001; Goldberg and Verboven, 2004). The “border-effect” is more crucial than distance, also when both countries share similar cultural and political traditions and language (Engel, 1996). Research confirms that national borders still are an important determinant for relative price volatility, even in a monetary union (Beck and Weber, 2001). By segmentation,

markets within EMU may differ, as may products, which leads to price dispersion. Due to e.g. cultural differences, variations in the elasticity of demand can occur across different locations.

Technological advances (information gathering)

Search engines on the Internet erode information barriers, so that consumers can analyse prices. The relative ease, in which products can be compared on the Internet, increases the importance of the variable price in a buyer's decision-making process, thus forcing prices to drop to relatively similar levels. Lower buyer costs in electronic marketplaces, promotes price competition among sellers (Bakos, 1998), this is especially the case in low differentiated markets. If consumers are well informed, e-marketplaces cannot ask high prices and prices convergence. On the contrary, uninformed consumers get charged high prices and price dispersion stays present. In a study on airline tickets, price divergence is found (Clemons *et al.*, 1998).

Currency union

The intention of a currency union is to increase price transparency, as this ideally fosters competition, locational arbitrage and cross-border trade, which can result in price convergence. A currency union reduces trade barriers associated with national borders, which leads to substantial increases in welfare and trade (Rose and Van Wincoop, 2001). A national currency can be a significant barrier to trade. Research by Frankel and Rose concludes that currency unions triples trade with their partners in question (Frankel and Rose, 2002). By introducing a common currency, possibilities for price discrimination should decline. Evidence is found that a pair of countries that joined a currency union experienced a doubling in trade (Glick and Rose, 2002). However, papers by (Persson, 2001), (Tenreyro, 2001) and (Nitsch, 2002) discuss the currency union effect and conclude that the impact of a currency union is far more limited.

Taxing

Harmonizing indirect taxes between countries might decrease price dispersion, because it will increase competition and reduce potentially harmful distortions caused by different forms of government intervention (Faber and Stokman, 2009). By harmonizing, for example, VAT and excise duties, prices become more transparent amongst countries, which achieves a degree of fiscal neutrality (Tyc, 2008). If tax rates are disharmonized, price transparency will be negatively affected and price dispersion increases. However, evidence is given that sales tax is not a significant factor for explaining price differences (Engel *et al.*, 2003).

Exchange rate

If there are flexible exchange rates, this leads to high volatility and has negative effects on trade and investments. If exchange rate movements are not fully anticipated, an increase in exchange rate volatility, increases risk and will lead risk-averse agents to reduce their import/export activity. These agents will reallocate production towards domestic markets. By eliminating exchange rate variations, one reduces exchange rate uncertainty to promote trade and investments. In a study by (Dell'Ariccia, 1998) a negative effect of exchange rate uncertainty on trade is found.

Trade barrier (governmental policies)

Trade barriers exist as a result of uncertainty regarding the possible level and growth implications of liberalization (Ben-David and Loewy, 1998). Removal of trade barriers leads to substantial increase of trade. Removal of barriers to trade, e.g. trade quota, stimulates trade between nations. Markets will work more "perfect", as this decreases price dispersion. Due to, for example, a better exploitation of scale economics, can lower price variability amongst products.

Product life cycle

Over time, buyer learning and competition amongst a narrow defined product form, tend to drive prices down and closer together. These price declines are also often accompanied by clear improvements in product quality within the product form (Curry and Riesz, 1988). How longer the product life cycle (in all stages) is active amongst time, how more price variability is narrowing. If on the contrary a product form is in a starting point of a life cycle, price variability increases as to the end of the life cycle.

Income

The "Penn-Effect" refers to the tendency that consumer price levels in wealthier countries are higher than those in poorer ones (MacDonald and Ricci, 2001; Dobrinsky, 2003). Given that considerable inequality of real per capita incomes still exists in the world, price dispersion is still present. In a study focussed on the product group meat, the "Penn-Effect" holds true (Fousekis, 2009). A higher per capita income raises prices and this effect is stronger on more labour intensive products, but weaker on more tradable products (Lipsey and Swedenborg, 2007).

Self-sufficiency

Some countries depend on imports, for example, in the case of fruits, to supply their inland demand. Due to e.g. climate some food products only grow in specific areas, for example, coffee. If countries are not self-sufficient in their demand, they need to import and import increases the price of the product. Therefore, these products might depict high price dispersion levels between countries.

Preferences/Culture

The preferences consumers have differ between countries. The country origin of a product is a consumer selection criterion for (food) products. Studies by (Orth and Firbasová, 2003; Lopez *et al.*, 2006) confirm that consumers typically prefer domestic food products. Consumption patterns vary greatly among countries; for example, the consumption of bottled water in Northern Europe in contrast to Southern Europe is quite small.

Tradability

Products differ in the degree that they are tradable. These differences arise due to the nature of the good (perishability) or country specific taxes, which discourage arbitrage (Allington *et al.*, 2005). Products that are "less tradable" increase price dispersion between countries. According to (Balassa, 1964; Samuelson, 1964) higher productivity in the tradable goods sector will bid up wages in that sector and, with labour being mobile, wages in the hole economy will rise. Therefore, producers of non-tradables will be able to pay the higher wages only if the relative price of non-tradables rises.

All in all, this paragraph presents several macro factors which possibly influence price dispersion. The effect of these factors might differ quite a lot depending on the sector or produce of investigation. Moreover, some factors might intersect with each other. In addition, there are probably numerous other macro factors that can influence price dispersion. However, in this paragraph, the main macro factors found in the literature are presented. An overview of macro factors is presented in table 1.

Table 1. Overview of macro environmental factors

Macro environmental forces	Factors effecting price dispersion	Empirical review
Demographic	Border	McCallum (1995), Anderson and Van Wincoop (2001), Beck and Weber (2001), Goldberg and Verboven (2004)
Economic	Income	MacDonald and Ricci (2001), Dobrinsky (2003), Lipsey and Swedenborg (2007), Fousekis (2009).
	Exchange rate	Dell'Ariccia (1998).
Natural	Distance	Parsley and Wei (1996), Cecchetti *et al.* (2000), Parsley and Wei (2001), Fan and Wei (2006), Bergin and Glick (2007).
	Tradability	Balassa (1964), Samuelson (1964), Allington *et al.* (2005).
Technological	Internet	Bakos (1998), Clemons *et al.* (1998).
	Product life-cycle	Curry and Riesz (1988).
Political	Trade barrier	Ben-David and Loewy (1998).
	Taxing	Tyc (2008), Faber and Stokman (2009).
	Currency Union	Persson (2001), Rose and Van Wincoop (2001), Tenreyro (2001), Frankel and Rose (2002), Glick and Rose (2002), Nitsch (2002).
Cultural	Preferences/Culture	Orth and Firbasová (2003), Lopez *et al.* (2006).

2.2.2 Micro environmental forces

Next to macro environmental forces, there are forces which companies have more influence on. The microenvironment concerns aspects that stand close to an individual company and over which it has some control (Omar, 2009). In this paragraph factors are presented which possibly influence price dispersion from a micro environmental view.

Market power

a) Collusive behaviour

By collusive practices, firms exert market power they would otherwise not have and artificially restrict competition and increase price dispersion (Motta, 2007). Firms can engage in collusive behaviour through implicit or explicit agreements to set prices or segment markets. Due to horizontal mergers the number of independent companies declines and industry concentration increases. Moreover, by vertical integration one company is engaged in different parts of a supply chain. So, by making use of vertical and horizontal integration firms control markets and affect price dispersion. The cost of collusive behaviour is confirmed and is substantial (Slade, 1995; Scherer, 1996; King, 1997).

b) Price transmission

Price transmission refers to the way prices at one level in the product chain react to changes at another level. Market power can explain how price changes at one level of a chain are not transmitted to other levels. In a "perfect" market, price changes are instantly and evenly transmitted from one node to another (Bunte, 2006). In the case of the pork sector a clear case of price asymmetry at the retail level at the expense of farmers is found (Bunte *et al.*, 2003). Strong and clear evidence is found supporting asymmetric pricing behaviour on part of retailers (Abdulai, 2002). Due to asymmetric price transmission, prices between EU member states could differ, which restricts prices to converge.

Product differentiation

Price is not the only parameter that affects consumers on consumption decisions. Next to price other factors, such as quality, brand awareness and brand image, should be taken into account. Differentiation is one of the three main strategies a firm can adopt to counter competition (Porter, 1998). It involves changing enough features on a firm's product to distinguish it from the competition, without altering its core nature. A firm can use differentiation to establish a product brand or company image for which they can ask a premium or "psychological price" on its products. This increases price dispersion and prices will, therefore, not converge.

Market structure

The market structure of an industry also affects price levels. According to the European Commission the price level of food is lower in countries where the concentration of supermarkets and discount shops is high (Commission, 2001). Retail is becoming more concentrated and retailers combine buying activities. These concentration trends can especially be observed in Northern and Western Europe (Dawson, 2010). Due to economies of scale, a lower cost base could be achieved, therefore, lowering prices. On the contrary, less competition may increase prices. So if market structures differ quite significant between countries, this probably influences price dispersion.

All in all, in addition to the macro factors, there are micro factors that might influence price dispersion. In this paragraph the four most prevailing factors found in the literature, are presented. In addition, there are probably numerous other micro factors that influence price dispersion. For example, in the case of the EU pork market, input of feedstuff is an important cost for production. Therefore, the presence of for example a harbour is important for feedstuff supply. In table 2 an overview of the four micro factors is presented.

Table 2. Overview of micro environmental factors

Factors effecting price dispersion	Empirical review
Collusive behaviour	Slade (1995), Scherer (1996), King (1997), Motta (2007).
Price transmission	Abdulai (2002), Bunte (2006).
Market structure	European commission (2001), Dawson (2010).
Product differentiation	Porter (1998).

2.3 Dispersion scenarios

In this paragraph an overview of the possible dispersion scenarios is presented. In addition, all possible convergence patterns are graphically displayed and empirical evidence for these patterns is given.

According to the Oxford dictionary the term dispersion means: "the extent to which values of a variable differ from a fixed value such as the mean"[5]. In this research dispersion means the following:

the difference between two values of a variable in a certain point in time.

The literature presents three stages for variable levels of dispersion (Bernard and Durlauf, 1996). In the first stage, the values of a variable follow a path of convergence called "catching-up convergence". According to this path, the stochastic trend in at least one of the values of a variable converges to a "common" stochastic trend in both variable values. In the second stage, called "steady-state or stochastic convergence", variable values have already been converged and hence, at least one of the two prices exhibit error-correcting behaviour, probably conform a band-threshold error-correction model (Lo and Zivot, 2001). Next to these two possibilities a third stage exist, where the values of a variable are diverging and the dispersion increases. There are thus three possible scenarios, namely:

1. Catching-up convergence
2. Steady-state convergence
3. Divergence (convergence is absent)

In figures 2, 3 and 4 the three dispersion scenarios are displayed with the help of seven possible dispersion patterns. To make the patterns well understandable, the graphs show a very simplistic dispersion patterns between two variable values. In real life, the variability of a dispersion variable can be more violent. The dispersion patterns can be used for many different variables, like price or

[5] From http://oxforddictionaries.com/definition/dispersion

income levels, by displaying the dispersion levels between, for example, companies, cities, regions, countries. In addition to price and income dispersion, infinite other real live illustrations (variables) can be thought of, which depict a dispersion pattern. One could display, for example, how quality, employment and tax levels are converging or diverging. In figures 2, 3 and 4 the example of price dispersion between two countries are displayed, to graphically depict the three dispersion scenarios.

The first scenario, catching-up convergence, is displayed by three possible dispersion patterns (figure 2). A possible pattern is that one value of a variable declines in the direction of the other value. A second possibility is that value of a variable increases in the direction of the other value. In both examples one variable value is setting a pattern, which the other follows. There is thus a price leader and a price follower. When observing the third pattern, one variable value is decreasing whereas the other variable value increases. In all these catching-up patterns the dispersion between both variable values is decreasing and the values are converging. However, a steady-state where the variable values converged is not visible yet. The majority of scientific research studying dispersion levels makes use of the variable price or income. There are many real-world illustrations of and explanations that describe these catching-up patterns. Reviewing the literature on price convergence numerous studies pop up. In a study by Allington *et al*. (2005) evidence is given for a reduction in price dispersion across EU-countries after 1995 at an aggregate level. The European car market shows significant lower price dispersion since 1995 (Gil-Pareja and Sosvilla-Rivero, 2008). Research on absolute price level for US cities since 1918 finds strong evidence that city price levels converge over time and the price dispersion is decreasing (Chen and Devereux, 2003). Next to price level dispersion a number of studies provides evidence for convergence of income across countries. Solow (1956) predicted that per capita income of different economies will equalize over time (Solow, 1956). In studies by (Li and Papell, 1999; Strazicich *et al.*, 2004; Dawson and Sen, 2007; Dawson and Strazicich, 2010) empirical findings provide significant evidence that incomes amongst countries are converging. Moreover, during the time period 1911-1993 strong and robust evidence for per capita income convergence is found across the twenty-four Swedish counties (Persson, 1997). Empirical analysis also found evidence of per capita income convergence amongst Canadian provinces, since the 1960s (Coulombe and Lee, 1995).

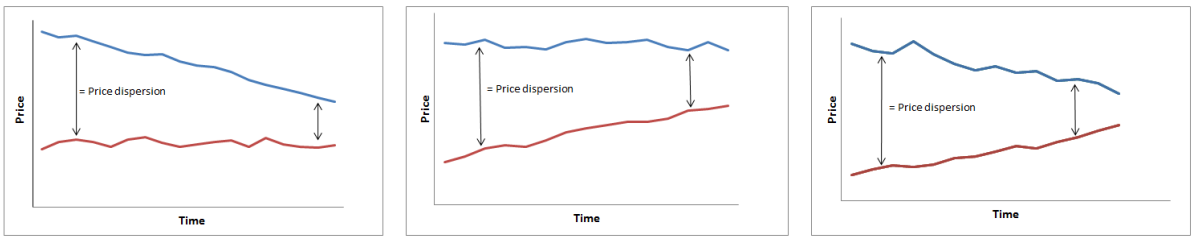

Figure 2. Catching-up convergence patterns

The second scenario, steady-state convergence, is displayed by one dispersion pattern (figure 3). Here the values of a variable are converged and, at least one of the two values exhibits error-correcting behaviour, probably conform a band-threshold error-correction model (Lo and Zivot, 2001). The dispersion between the variable values tends to be rather stable over time. There are many real-world illustrations of and explanations that describe this steady-state dispersion pattern. However, when looking at the variable price, empirical evidence is limited in numbers. For example, price clusters where identified in the EU pork sector (Fousekis, 2007). Moreover, the pattern can also

be displayed by quality levels of products. Empirical results on steady-state convergence are very limiting. An explanation here for are methodology issues.

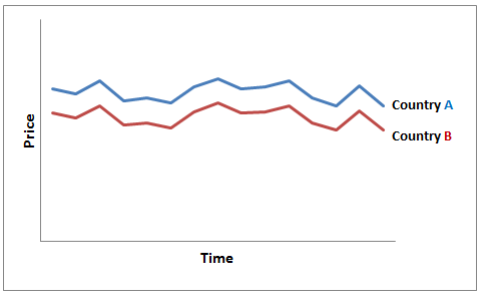

Figure 3. Steady-state convergence pattern

The third scenario, divergence (convergence is absent), the dispersion between variable values increases over time. This divergence scenario is displayed by three possible dispersion patterns. A possible pattern is that one value of a variable declines out of the direction of the other value. A second possibility is that the value of a variable increases out of the direction of the other value. In both patterns the dispersion between these variable values increases. When observing the third pattern, one variable value is decreasing whereas the other variable value increases. In all these divergence patterns the dispersion between both variable values increases amongst time, and the values are diverging. The dispersion patterns depicted by the catching-up scenario shows similar patterns as the divergence scenario. However, there is a reverse graphical image of the patterns depicted by both scenarios. Real-world illustrations describing catching-up patterns can also be used for divergence patterns. For example, instead of decreasing price dispersion, which happens with catching-up convergence, divergence patterns depict increasing price dispersion. Research on income dispersion found evidence that Indonesia, China, Malaysia, Thailand and the Philippines exhibit divergence with respect to Japan's income per capita (Liew and Lim, 2005). Besides finding convergence patterns, Goldberg and Verboven (2004) found divergence patterns in the European car market for specific time periods and countries. In figure 4 this is graphically depicted. Here the price dispersion increases (divergence) over time. So, in the context of this research, price differences between countries become bigger.

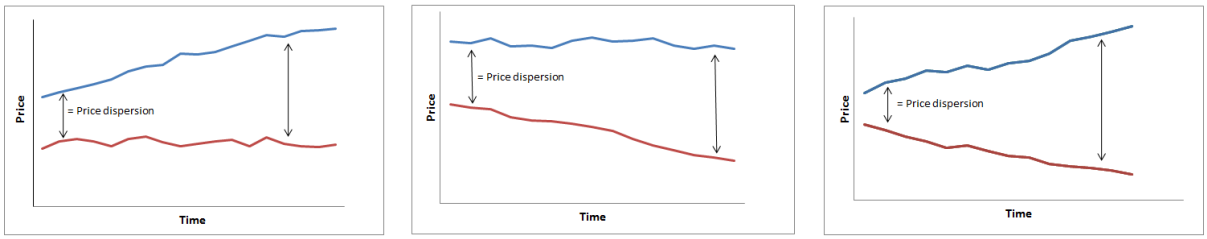

Figure 4. Divergence patterns

The three scenarios depicted in this paragraph, show all possible dispersion patterns. An infinite amount of variables can be used, depicting these dispersion patterns. However, the gross of the previous research on dispersion patterns makes uses of the variables price or income.

2.4 Price leader / follower

Previous research investigating competitive interaction between firms can be divided in three forms: non-nested model comparisons, conjectural variations and time series causal approaches (Putsis and Dhar, 1998). Keeping in mind the level of the present research, the focus is on time series causal approaches. This form employs time series data and causality tests to derive causality in interaction. In addition, previous research defined three forms of competitive interaction: independent (Nash), leader-follower (Stackelberg) and collusive (Raju and Roy, 1997). Independent competitive interaction means that each individual player takes its rival's strategic actions as given. Under the leader-follower behaviour, one firm acts as a leader (it does not react to its rival actions), while the rival follows the changes of the price leader. If companies work collusive, they act to maximize profits (Raju and Roy, 1997). In the paper of Putsis and Dhar (1998) it is stated: "if firm two reacts to changes in firm one's marketing actions, then firm two's reaction will be observed after firm one's behaviour". The sequence of events implies that firm one is the leader and firm two the follower. Moreover, a positive one-way causal flow by Granger causality, is a good sign for Stackelbergs leader-follower relationship between two competitors (Roy *et al.*, 2006). This is especially the case when there are limited data points. Testing for Granger causality identifies the existence of causal relationships between variables of time series data, without specifying the type of this causality (Granger, 1969).

The concept of price leader and follower is a frequently occurring phenomenon. For example, General Motors acted as a price leader for many years and its prices were followed by Chrysler and American Motors (Carpenter *et al.*, 1988). In the PC market, Dell has been identified as a price leader, followed by Compaq (Roy *et al.*, 2006). The United States can be identified as a price leader in the world wheat market, where Australia followed (Sniekers and Wong, 1987). Moreover, other markets where price leadership pattern have been found are air travel, turbo generators, consumer packaged goods and breakfast cereals (Roy *et al.*, 1994).

This research investigates if individual states follow a identified price leader. In the integrated market of the EU, demand or supply shock will feed through to all markets. If the price of a member state is exogenous it does not respond to changes in other member states. The price is determined by supply and demand conditions in its own domestic market, which is exogenous to the system. Supply and demand shocks in the leading market, feed through to the other member state markets, because of the market integration (Asche *et al.*, 2007).

2.5 Price clusters

Research investigating price clusters within the integrated EU market are limited in number. Fousekis (2007) defines a price cluster as: "a group of countries in which prices obey the LOP". In a single market, like the EU, all localized markets must be members of the same price cluster. Although the importance of the topic, there is a scarcity of formal studies on spatial price arbitrage for agricultural commodities in the EU, especially for investigating price clusters. Multiple price cluster within the EU for pork and poultry have been found (Fousekis, 2007). Although it is not an agricultural commodity, evidence is found that the LOP did not hold for motor fuels (Sassi and Hall, 2012).

3. Methodology

In this chapter the methodology used in this research is explained. First, a general introduction into the methodology steps is given. The three following paragraphs provide the methodologies that are used for each individual research question. Finally, subsection 5 resumes the methodology chapter.

3.1 Introduction

In this research a linear regression model is used. This model was used to analyse if there is a common stochastic trend in the price series of a member state pair. It is assumed that within Europe, Germany will be a price leader for its neighbouring member states (Hoste, 2012). If Germany is not identified as price leader, then it is assumed that either Denmark or the Netherlands are a price leader. The concept of Granger causality is used to test if these member states are price leaders. This statistical hypothesis test determines whether one time series is useful in forecasting another (Granger 1969). The statistical test is performed with the help of the statistical software package Eviews. A stepwise plan for research question 1 is been presented in appendix I. The relationships are investigated for three levels of the EU pork supply chain. In sum, at research question 1 it was reseached if a price leader could be identified. This means that, shocks in the price of the leader would affect the price(s) of the follower(s).

To investigate if there also exist a long term relationship, a unit root test is applied in research question 2. This unit root test, indicates if time series that are included in the model are stable. If the co-integrating relationship is stable the associated error correction term is added. When the outcome of this error correction is significant, it would imply that, there is a long run relationship between the price pair countries. A stepwise plan for research question 2 is been presented in appendix I.

In research question 3 the dataset sample is split into two equal subsamples. A dummy variable is used to identify the different time spans. This analysis investigated whether differences occured between the split data set, by investigating i) the short term price leadership and ii) long term speed of adjustment. A stepwise plan for research question 3 is been presented in appendix I. A presentation of the testing sequence is given in figure 5.

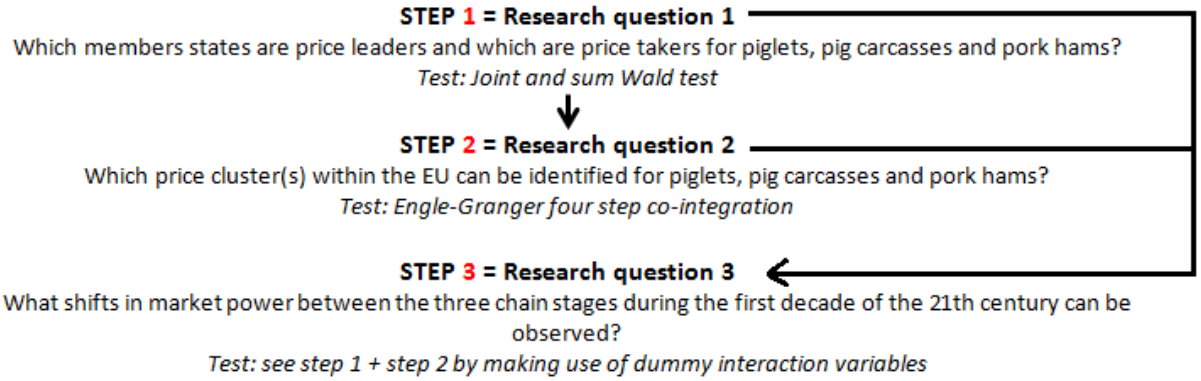

Figure 5. Research testing design

3.2 Methodology research question 1

To investigate if the assumed price leader(s) can empirically be identified, the researcher looked if the potential price leader affects the prices of its neighbouring member states[6]. The Granger causality concept is used to identify a price leader. This concept says that Y_t is causing X_t if it's better able to predict X_t using all available information than if the information apart from Y_t will be used (Granger, 1969). To investigate if there is a causal relationship between a potential price leader and a neighbouring member state, model 1 is used.

Model 1:

$$\Delta X_t = \alpha_2 + \sum_{i=1} a_{21}\ (i)\Delta X_{t-i} + \sum_{i=1} a_{22}\ (i)\Delta Y_{t-i} + \epsilon_{xt}$$

This model captures the past price dynamics of the price leader Y_t as a potential predictor of the current price dynamics of the neighbouring member state X_t. To test whether or not the inclusion of the past price dynamics of the potential price leader has a significant effect on the current prices of its neighbouring member states, the joint significance Wald test is used, see equation 1[7].

$$\textbf{Equation 1}: \quad H_0: \alpha_{22}^1 = \alpha_{22}^2 = \alpha_{22}^3 \ \ldots\ldots\ldots = \alpha_{22}^8 = 0$$

If the joint significance Wald test shows a significant outcome, the sum significance Wald test is additionally performed, see equation 2.

$$\textbf{Equation 2}: \quad H_0: \sum_{i=1}^{8} \alpha_{22}^i = 0$$

It may be possible that the parameters are significant according to the joint test, but in fact cancel each other out (2008). The procedure of Perron is used for the determination of the maximum number of lags, J (Perron, 1989). Starting from J = 8, I will work backwards, from 8 to 1. The first value of *J* will be chosen where the t-statistic is greater than 1,6 in absolute value. In this case, the t-statistic of J_{+1} will then be less than 1,6.

[6] For a stepwise plan, see appendix I

[7] For a more detailed description see page 126 of Kornelis, M. (2002). *Modeling market shake-ups using time series data: an application to the advertising market of the Netherlands*: Labyrint Puublication.

3.3 Methodology research question 2

To investigate if there is a long run relationship, in addition to the Granger causality, co-integration will be tested. The Engle-Granger testing procedure is used to investigate if two price variables are co-integrated. The Engle-Granger testing procedure consists of 4 steps (Enders, 1995).

Step 1 Pre-test the variables for their order of integration

If two variables are non-stationary, it is possible to explain the growth path of one variable by the other. Non-stationary time series have no long-run mean to which the series return. It is assumed that price series used in this research are non-stationary (Huang *et al.*, 2003; Serra *et al.*, 2006).

Step 2 Estimate the long-run equilibrium relationship

In step 1 it is assumed that both Y_t and X_t are integrated in the order I(1). A linear combination of two non-stationary series integrated of the order one I(1) which is stationary are called co-integrated series. When measuring co-integration, it is investigated if a long-term common stochastic trend between non-stationary time series exist. Before model 2 is used, it needs to hold stationary of the series under investigation. To test this, a formal unit root test is applied, namely the Augmented Dickey Fuller (ADF). This ADF test, investigates if the residuals of the linear regression are stable. The procedure of Perron (1989), as discussed in paragraph 3.2, is used. Rejection of the null hypothesis implies that the residuals sequence is stationary. If this is the case, than both Y_t and X_t are I(1) and the residuals are stationary. In this case, it can be concluded that the series are co-integrated or order (1,1) (Enders, 1995).

Step 3 Estimate the error-correction model

If the variables are co-integrated, as being tested in step 2, the residuals from the equilibrium regression are used to estimate the error correction model. Term $a_x \check{e}_{t-i}$ is the error correction which is added to the model if the residuals are stationary. If the t-statistic of the error correction term holds a significant outcome, step 4 is conducted. If the error correction term false out of model 2 , then model 1 arises.

Model 2: $$\Delta X_t = \alpha_2 + \sum_{i=1} a_{21}\ (i)\Delta X_{t-i} + \sum_{i=1} a_{22}\ (i)\Delta Y_{t-i} + a_x \check{e}_{t-i} + \epsilon_{xt}$$

Step 4 Assess model adequacy

The speed of adjustment coefficient a_x is of particular interest in that it has important implications for the dynamics of the model. For any given value of $\check{e}_{t-i}$, a large value of a_x is associated with a large value of ΔX_t. If a_x is zero, the change in X_t does not at all respond to the deviation from long-run equilibrium (Enders, 1995).

3.4 Methodology research question 3

To investigate what differences occurred during the timeframe of the time series, a split subsample approach is used. This research looked at what differences can be identified for i) the short term price leadership and ii) long term speed of adjustment. The time series were split into two equal length.

By making use of dummy variables, which take the values 0 or 1, this research made a dichotomy in the data set. If the dummy explanatory variable holds the value 0, then this will cause the variable's coefficient to disappear. In addition, a dummy variable with the value 1 will cause the coefficient to act as a supplemental interaction term in a regression model. See model 3, were the dummy variables have been added.

Model 3:

$$\Delta X_t = \alpha_2 + \sum_{i=1} a_{21}\ (i)\Delta X_{t-i} + \sum_{i=1} a_{22}\ (i)\Delta Y_{t-i} + a_x \check{e}_{t-i} + \sum_{i=1} a'_{22}\ (i) D * \Delta Y_{t-i} + D * a'_x \check{e}_{t-i} + \epsilon_{xt}$$

First is tested how the price leadership has developed. The Granger causility concept is used and this is tested with the help of the sum Wald test, see equation 2. Due to the split of the time series, three sum Wald test needed to be perfomed. One for each individual window and one over the differences between them. Here, the $a_x \check{e}_{t-i}$ and the dummy $a_x \check{e}_{t-i}$ term droped out of model 3.

Second, the long run co-integration is tested. However, this is only researched if co-integration was indentified in research question 2. The methodology used to research co-integration, is described in paragrapf 3.3. Due to the split of the time series, three sum Wald test are perfomed. One for each individual window and one over the differences between them. Here, the complete model is used (see model 3).

Differences between the windows indicate how the i) the short term price leadership and ii) long term speed of adjustment have evolved. This research looked if the price leader identified at research question 1 gained or lossed strength. Moreover, the development of the co-integration process is depicted, by making use of two subsamples. All in all, by making use of the methodology of research question 3, the integrating process is evaluated.

3.5 Methodology résumé

In sum, this chapter provided the methodology that is conducted in this research. For research question 1 the Granger causality concept is used and tested with the help of a joint and sum Wald test. By making use of a unit-root test at research question 2, it is tested if the residuals are stationary. If this was the case, the error correction term is added to the model and if the final model holds a significant outcome, then the series are co-integrated. By splitting up the time series at research question 3, differences in i) the short term price leadership and ii) long term speed of adjustment are identified. Here, the development of price leadership and the long term speed of adjustment are displayed.

4. Data

Within the European pork chain, a distinct separation of chain stages can be made. In general, the chain has the following stages: breeding, farrowing, finishing, slaughtering, processing, sales and consumption. Some stages can be combined, for example, farrowing and finishing, can be performed by one company (Trienekens *et al.*, 2009). According to Trienekens and colleagues (2009) a general trend in the European pork chain is the up scaling and concentration in all stages of the chain. These concentration trends however, differ between EU member states. Concentration can be observed at the pig breeding stage, where two third of the EU-27 production is taken care by six countries. These countries are: Denmark, the Netherlands, Poland, Germany, Spain and France (Marquer, 2010). Furthermore, at the fattening stage of the European pork chain, a clear concentration trend is observable. According to Marquer (2010) three quarters of the pigs are reared by just 1,5% of the largest fatteners. In contrast, the concentration trend at the slaughter stage is more divers. Northern EU-countries show a clear concentration trend, where only a few companies control the market. In addition, in Greece, concentration cannot be observed yet (Trienekens *et al.*, 2009). The EU processing sector is highly concentrated, where a small number of large processors dominates the market, especially due to presence of multinational companies[8]. The last stage before consumption are the consumption channels, for example, supermarkets, butchers and the foodservice industry. This stage is becoming more and more concentrated, partly because retailers have become very large and in part because retailers combine buying activities. Throughout the EU, retailing is increasingly becoming dominated by a small number of supermarket chains (Trienekens *et al.*, 2009). In figure 6, an overview of the different stages in the European pork chain is displayed.

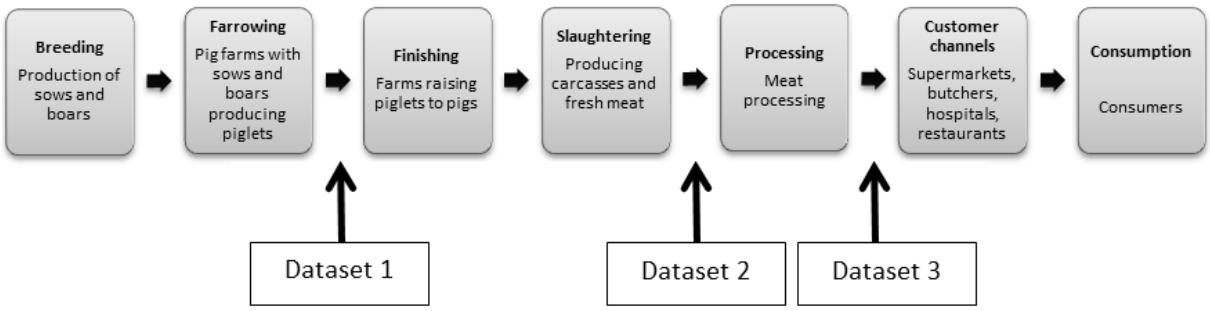

Figure 6. The European pork chain (Trienekens *et al.*, 2009)

In this research, three different datasets are used, containing export prices at three stages in the European pork supply chain. The first dataset includes export prices per ton for piglets. The second datasets holds export price levels per ton for pig carcasses. The last dataset, holds export price levels for processed pork hams, see figure 6.

The data that are used in this empirical analysis were collected by Eurostat, the statistical agency of the EU. These datasets were purchased by the Landbouw Economisch Instituut (LEI), the commercial branch of Wageningen University. The LEI has provided the data for this Master thesis research. The datasets contains monthly absolute export price levels for all EU-27 member states (except Malta). However, the time span of the member states price series differ, see table 3. The export price levels

[8] ec.europa.eu/enterprise/sectors/food/files/report_compmeat_en.pdf

for non-Eurozone members were corrected for exchange rates. The monthly export price levels of the datasets are established by quantitative information (worth and quantity) provided by companies that operate in the European pork chain. These price levels are collected by national statistical organisations and accumulated by Eurostat. The datasets for this research, do not contain the most disaggregate export price levels. However, using a more disaggregated dataset, is less accurate (Bunte, 2012).

As stated in paragraph 3.2 it is assumed that Germany is a price leader for its neighbouring member states, for the three chain stages. However, Germany could not be identified as a price leader. Therefore, Denmark and the Netherlands were also tested. Furthermore, a selection is taken from each dataset, see table 3. This selection of EU member states containes the same time span, namely from January 2000 till December 2010. However, the time span for Poland and the Czech Republic differs. These countries joint the EU during 2004 and probably therefore have a different time span. Four time series had missing or invalid data and were excluded from analysis (table 3).

Table 3. Overview of data for analysis

	Time frame	Missing values / incorrect values	Excluded from analysis
Germany[a]	January 2000 - December 2010	No	-
Denmark[a]	January 2000 - December 2010	No	-
The Netherlands[a]	January 2000 - December 2010	Yes, for piglets	Yes[b]
Austria[a]	January 2000 - December 2010	No	-
Belgium[a]	January 2000 - December 2010	Yes, for piglets	Yes[b]
France[a]	January 2000 - December 2010	Yes, for piglets	Yes[b]
Luxemburg[a]	January 2000 - December 2010	No	-
Poland[a]	May 2004 - December 2010	No	-
Czech Republic[a]	January 2004 - December 2010	Yes, for piglets	Yes[b]

[a] Individual series for piglets, pig carcasses and pork hams
[b] More than 20% of the values is missing and/or invalid.

5. Results

In this chapter the results of the research are presented. For each individual research question the results are displayed by making use of tables.

5.1 Results research question 1

Subsequently, a joint significance Wald test is applied to investigate whether one member state directly affects another (see equation 1). If the joint Wald test outcome was significant, then the sum Wald test (see equation 2), additionally was performed. Tables 4 till 17 display the outcomes of the Wald tests. Consequently, the outcomes are presented for piglets then pig carcasses and finally for pork hams.

As shown in table 4, Denmark directly affects Germany for export prices of piglets. This implies that, in the short run, shocks in the price of Denmark affect the export prices of Germany. So, Denmark is a price leader for Germany. In contrast, no other direct effects were found for piglets[9] (table 5).

Table 4. Denmark as price leader for piglets

Does Denmark directly affect		Joint significance Wald test		Sum significance Wald test		
	Lags	F-statistic	P-value[a]	F-statistic	P-value[a]	Outcome
Germany?	7	3.88	0.00	4.20	0.04	Yes

[a] Significant at the 5% level.

Table 5. Germany as price leader for piglets

Does Germany directly affect		Joint significance Wald test		
	Lags	F-statistic	P-value[a]	Outcome
Denmark?	2	1.92	0.15	No
Austria?	6	2.04	0.07	No
Poland?	1	1.23	0.27	No
Luxemburg?	5	1.82	0.11	No

[a] Significant at the 5% level.

Tables 6 to 8 display the outcomes for pig carcasses, where four significant relations are found. According to the joint significance Wald test, Germany directly affects Poland and the Czech republic. However, the outcome of the sum Wald test is not significant. This indicates that the net effect of Germany on Poland and the Czech Republic is very small (table 6). In addition, Denmark and the Netherlands directly affect Germany for pig carcasses (table 7 and 8). This implies that, short run shocks in the prices of Denmark and the Netherlands affect the export prices of Germany.

[9] Due to missing and or invalid data the following member states were excluded for analysis: France, Belgium, the Netherlands and the Czech Republic. See data chapter for more elaboration.

Table 6. Germany as price leader for pig carcasses

Does Germany directly affect	Lags	Joint significance Wald test		Sum significance Wald test		Outcome
		F-statistic	P-value[a]	F-statistic	P-value[a]	
Denmark?	6	1.41	0.22	NA	NA	No
The Netherlands?	7	1.74	0.10	NA	NA	No
Austria?	No significant lags					No
Belgium?	8	1.29	0.26	NA	NA	No
Poland?	8	2.16	0.05	1.19	0.28	Yes, eventually No
Czech republic?	7	2.59	0.02	0.91	0.34	Yes, eventually No
Luxemburg?	5	1.45	0.21	NA	NA	No
France?	3	1.12	0.34	NA	NA	No

[a] Significant at the 5% level.

Table 7. The Netherlands as price leader for pig carcasses

Does the Netherlands directly affect	Lags	Joint significance Wald test		Sum significance Wald test		Outcome
		F-statistic	P-value[a]	F-statistic	P-value[a]	
Germany?	8	10.82	0.00	20.81	0.00	Yes
Belgium?	No significant lags					No

[a] Significant at the 5% level.

Table 8. Denmark as price leader for pig carcasses

Does Denmark directly affect	Lags	Joint significance Wald test		Sum significance Wald test		Outcome
		F-statistic	P-value[a]	F-statistic	P-value[a]	
Germany?	8	3.52	0.00	8.12	0.00	Yes

[a] Significant at the 5% level.

Table 9 displays the outcome of the direct effect that Denmark has on Germany for pork hams. The table displays how Denmark directly affects its neighbouring member state, Germany. This implies that, Denmark is a price leader for Germany. In addition, no evidence is found that Germany directly affects its neighbouring member states. Furthermore, no evidence is found that the Netherlands and Germany directly affect its neighbouring member states for pork hams[10].

Table 9. Denmark as price leader for pork hams

Does Denmark directly affect	Lags	Joint significance Wald test		Sum significance Wald test		Outcome
		F-statistic	P-value[a]	F-statistic	P-value[a]	
Germany?	3	3.31	0.02	9.81	0.00	Yes

[a] Significant at the 5% level.

All in all, Denmark directly affects Germany at all three chain levels. Both the joint and sum significance tests lead to the same outcome, so the result is robust.

[10] For an overview of these outcomes, see Appendix II.

5.2 Results research question 2

In this research question it is studied if the price pairs found in research question 1 are co-integrated in the long run (see paragraph 3.3). By researching if the price pairs have an unit root, it is investigated that there is no random walk, to exhibit if the series are stable. If the price pairs are stable, the error correction term is added (see model 2). Here it is investigated if there was a significant long term relationship. Consequently, the outcomes will be presented for piglets then pig carcasses and finally for pork hams. Tables 10 to 12 display the outcomes.

Table 10 shows that Denmark attracts Germany towards a long run relationship. This implies that, there is a long-term relationship between the German and Danish price for piglets. The export price of Germany is explained by Denmark in the long run[11].

Table 10. Long run relationship for piglets

Is Denmark the long run attractor for:	Lags	Unit root t-statistic	Stable	Error correction t-statistic	Outcome
Germany	4	-3.57[a]	Yes	-2.38[b]	Yes

[a] Significant at the 5% level, for which the critical value is 1.95 in absolute sense (Dickey and Fuller, 1981).
[b] Significant at the 5% level, for which the critical value is 1.98 in absolute sense (Ott and Longnecker, 2008).

Table 11 displays the outcome for pig carcasses. This table shows evidence that price pair Germany and Poland is stationary, but no significant error correction takes place. This indicates that price shocks of Germany do have an effect on Poland, although this is not a long run relationship. In addition, Denmark displays a long run relationship with Germany. This implies that, the export price of Germany is clarified by Denmark in the long run. In contrast, no evidence is found for price pairs Germany – Czech Republic and The Netherlands – Germany.

Table 11. Long run relationship pig carcasses

Is Germany the long run attractor for	Lags	Unit root t-statistic	Stable	Error correction t-statistic	Outcome
Poland	1	-2.35[a]	Yes	-1.39	No
Czech Republic	8	-1.25	No	-	No
Is Denmark the long run attractor for					
Germany	1	-3.39[a]	Yes	-2.06[b]	Yes
Is the Netherlands the long run attractor for					
Germany	8	-1.77	No	-	No

[a] Significant at the 5% level, for which the critical value is 1.95 in absolute sense (Dickey and Fuller, 1981).
[b] Significant at the 5% level, for which the critical value is 1.98 in absolute sense (Ott and Longnecker, 2008).

[11] For a graphical representation, see appendix III.

Table 12 displays the outcome of the long run effect of Denmark on Germany for pork hams. The table shows that Denmark attracts Germany towards a long run relationship. This implies that, German export prices are clarified by Denmark in the long run. There is a price cluster between Denmark and Germany. So, German export prices react to changes in the export price of Denmark.

Table 12. Long run relationship pork hams

Is Denmark the long run attractor for	Lags	Unit root t-statistic	Stable	Error- correction t-statistic	Outcome
Germany	8	-3.88[a]	Yes	-3.31[b]	Yes

[a] Significant at the 5% level, for which the critical value is 1.95 in absolute sense (Dickey and Fuller, 1981).
[b] Significant at the 5% level, for which the critical value is 1.98 in absolute sense (Ott and Longnecker, 2008).

All in all, Denmark attracts Germany towards a long run relationship at all three chain levels. There are thus price clusters between Denmark and Germany for all three chain stages. Both the unit root and error correction displayed a significant outcome, so the result is robust.

5.3 Results research question 3

The datasets used for research questions 1 and 2 were split up in two equal subsamples (see methodology chapter). Here, it is studied if differences in i) price leadership and ii) long term speed of adjustment can be identified between the split time series. Consequently, the outcomes are presented for piglets then pig carcasses and finally for pork hams. Tables 13 to 15 display the outcomes. The first time series of the split up are displayed by window I, the second by window II.

Evidence proves that the direct effect of Denmark leading Germany decreases between the first and second time series sample (table 13). The direct effect is significant in the first time series, yet it is not significant for the second time series. This implies that, Denmark became a less powerful price leader for Germany. In contrast, the speed of adjustment for the long run relationship between Denmark and Germany, displays no significant difference between the first and second time series. The individual results for the speed of adjustment of the two time series are significant, but the differences between the windows are not. This implies that, Germany was attracted by Denmark in the long run and this relationship did not change significantly during the time span of the two windows.

Table 13. Split in time series for piglets

Denmark leads Germany [a]	Window I	Window II	Differences	Outcome
Direct effect	1.46[a]	0.22	-1.25[b]	DK weaker
Speed of adjustment	-0.19[b]	-0.22[b]	0.03	No change

[a] First series: January 2000 till December 2004 and second series: January 2005 till December 2009
[a] = 5% significance
[b] = 10% significance

Table 14 displays the outcome for pig carcasses. Here, no evidence proved a change in direct effect of Germany on Poland between the split samples. The individual direct effects of both time series are not significant. In addition, no evidence indicates a change in direct effect of Germany on Czech Republic. For both direct effects no significant value is found, probably due the short time span.

Furthermore, no evidence indicates that the split series of Denmark leading Germany are significantly different for each other. Here, the direct effect found for the first window is significant, which the second window is not. The direct effect of Denmark on Germany is decreasing, but this is not a significant decrease. In contrast, the long-term speed of adjustment, only demonstrates a significant outcome for the second window. This implies that the price convergence process turned into a steady state process in the second window, so during the time frame January 2005 - December 2009.

In contrast, the direct effect of the Netherlands on Germany is significant in both series. The first and second series are not significantly different from each other. This implies that, the direct effect of the Netherlands on Germany was decreasing, but this decrease is not significant.

Table 14. Split in time series for pig carcasses

	Window I	Window II	Differences	Outcome
Germany leads Poland [ε]				
Direct effect	0.34	1.00	0.66	No effect
Speed of adjustment	NA	NA	NA	NA
Germany leads Czech Republic [ε]				
Direct effect	1.39	-1.01	-2.40	No effect
Speed of adjustment	NA	NA	NA	NA
Denmark leads Germany [ɜ]				
Direct effect	1.39[a]	0.92	-0.47	DK weaker
Speed of adjustment	-0.06	-0.21[a]	-0.15	DK stronger
The Netherlands leads Germany [ɜ]				
Direct effect	2.74[a]	1.99[a]	0.75	NL weaker
Speed of adjustment	NA	NA	NA	NA

[ε] First series: January 2005 till December 2007 and second series: January 2008 till December 2010
[ɜ] First series: January 2000 till December 2004 and second series: January 2005 till December 2009
[a] = 5% significance

Table 15 displays the outcome of pork hams for the direct effect and the speed of adjustment. The table proves Denmark attracted Germany in the long run, for both time series. The speed of adjustment increased, but this increase is not significant. This implies that, price convergence took place and the Danish and German market became more integrated. In contrast, the direct effect displays no significant values for both series or for the differences. This may imply that, the timespan of the samples might be too short for finding a significant outcome.

Table 15. Split in time series for pork hams

Denmark leads Germany [ɜ]	Window I	Window II	Differences	Outcome
Direct effect	-0.59	-0.57	0.02	No change
Speed of adjustment	-0.41[a]	-0.55[a]	-0.14	DK stronger

[ɜ] First series: January 2000 till December 2004 and second series: January 2005 till December 2009
[a] = 5% significance

All in all, Denmark attracts Germany towards a long run relationship at all researched chain levels and this attracting process became stronger over time. In contrast, the direct effects of Denmark on Germany were decreasing, when the first and second time series were compared.

6. Conclusion

This research assumed that Germany would be a price leader in the EU pork market, at all three researched chain stages. The results of this research provide empirical evidence that this is not the case. Germany could only be identified as price leader of pig carcasses for the neighbouring member states Poland and the Czech Republic. In addition, these relationships are only found when using the joint Wald test. Thus, the relationships are not robust. In conclusion, Germany has an effect on the export prices of Poland and the Czech Republic, but this is not a strong relationship. In addition, no other Granger causality relationships are found that could identify Germany as a price leader. In contrast, the opposite of what was anticipated has been depicted by the empirical results. In other words, Germany does not affect export prices of its neighbouring member states. On the contrary, Germany is being affected by its neighbouring member state Denmark. For the three researched stages of the EU pork supply chain, Denmark is identified as a price leader for Germany. In addition, both the joint and sum Wald test give significant outcomes of these relationships. Therefore, these results are robust. In addition, the Netherlands affects the export prices of Germany, next to Denmark, for pig carcasses.

Moreover, empirical evidence is found for the existence of a long-term relationship between Denmark and Germany. In conclusion, Denmark is a long run attractor for Germany at all three chain levels. There is a price cluster between Denmark and Germany for export prices of piglets, pig carcasses and pork hams. In addition, no other price cluster are found.

For all three chain stages, the direct effect of Denmark leading Germany between the two subsamples decreased. Therefore, Denmark becomes a less powerful price leader for Germany. In contrast, the long-term speed of adjustment became stronger over time. To evaluate the integration process, the long-term speed of adjustment outcome is a good indicator. Therefore, the Danish and German markets became more integrated during the period January 2000 till December 2009.

According to the empirical results provided in this research, the integration process seems to be the highest at the chain stage for pig carcasses. Here, most spatial relationships are identified; therefore, the spatial price linkages for this chain stage might have the highest level of integration. This could possibly be explained in the fact that pig carcasses are easier to transport than living piglets. In addition, pig carcasses are probably less differentiated than pork hams, due to the different preferences member states have in the way the carcasses are cut.

The outcome of this research can be relevant for policymakers of the European Union, because this research shows that the EU pork market has a low degree of integration. This is quite surprising, due to the major efforts which have been taken to stimulate EU agricultural integration. The results found in the present study are in line with the results found by Fousekis (2007). In conclusion, the EU pork markets are not working efficiently, where prices are perfectly transmitted.

7. Discussion

In this chapter the limitations of this research are explained. In addition, indications for future research are pointed out.

The interpretations of the results have to be restricted to the European pork sector and the sample period analysed. Therefore, further research is needed. In addition to methodological refinements, the present study should be extended to other agricultural commodities in Europe.

- In the present study, most of the researched price pairs gave no evidence for either a short or long term relationship, although the presents of major trading flows between the member states.
- This research has focused on the factors distance and borders, which have amongst others influence on price dispersion. As a result, numerous other factors that were not incorporated in this research can influence price dispersion.
- The present study incorporated nine EU member states, but to give a more complete overview of the EU pork market integration, additional member states have to be investigated.
- The relationships between member states price pairs were only researched in a one-way direction. Future research needs to analyse price pairs in both directions.
- In the present research, monthly export prices are used. However, this is not the most disaggregated level possible. Additional research should be conducted using, for example, weekly export price levels.
- The time span of the series used should be extended, which may give additional spatial relationships, which the present study not revealed.
- In paragraph 3.3, at step 1, it is assumed that the price series in this research are non-stationary, but this may not be the case and therefore should this be tested.
- The causal relations found in this research, may be the result of a certain third variable. This so called “spurious regression”, could according to Granger (2004) be resolved using an error-correction model, which is used in the present research (Granger, 2004).
- Four time series, namely France, Belgium, Czech Republic and the Netherlands containing prices for piglets, had false and or missing values and where excluded from analysis. Therefore, potential spatial relationship could not been proved. Inclusion of these time series, could resolved in different conclusions.
- The secondary data used in this research is collected by Eurostat. The formation of these datasets and the validity and reliability can therefore be questioned. Eurostat is depending on the data that EU member states deliver.
- Furthermore, other methodologies, instead of, for example, the four step Engle and Granger testing procedure for integration can be used, which may give different results.

All in All, further research is needed to give a more detailed and completed overview of the integration process in the EU pork market.

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Appendix I

Methodological design research question 1:
Which members states are price leaders and which are price takers for piglets, pig carcasses and pork hams?

It is assumed that within Europe, Germany will be price leader. If not, then it will be assumed that either Denmark or the Netherlands is a price leader. To test if Germany or Denmark or the Netherlands is a price leader (or there is no price leader), the Granger Causality Test will be used. This is a statistical hypothesis test for determining whether one time series is useful in forecasting another (Granger, 1969).

The analysis will start with investigating price series for piglets, then pig carcasses and finally pork hams. Here, a stepwise plan is presented how the analysis will be conducted.

Step 1.
First it is assumed that Germany will be a price leader. Neighbouring member states (Denmark, the Netherlands, Poland, Austria, Belgium, France, Luxembourg and Czech Republic) will then follow the export price level of Germany. If on the contrary, Germany cannot be identified as price leader, go to step 2.

Step 2.
If in step 1 it has been found that Germany is not a price leader, then Denmark will be investigated if it is a price leader. Neighbouring member state (Germany) will then follow the export price level of Denmark. However, if Denmark cannot be identified as price leader, go to step 3.

Step 3.
If subsequently step 1 and 2 have been followed, then the Netherlands will be researched if it is a price leader. Neighbouring member states (Germany, Belgium, United Kingdom) will then follow the export price level of the Netherlands. However, if the Netherlands cannot be identified as price leader, go to step 4.

Step 4.
If subsequently step 1, 2 and 3 have been followed then neither Germany, nor Denmark nor the Netherlands will be a price leader. This means no price leader is established.

Methodological design research question 2:
Which price cluster(s) within the EU can be identified for piglets, pig carcasses and pork hams?

Depending on the outcome of research question 1, it is assumed that the neighbouring member states of the price leader, form a price cluster together. In the following paragraph four options have been presented, depending on the outcome of research question 1.

Option 1: Germany is a price leader
If the outcome of research question 1 is that Germany is a price leader, it is assumed that Germany, Denmark, the Netherlands, Poland, Austria, Belgium, France, Luxembourg and Czech Republic form a price cluster together.

Option 2: Denmark is a price leader
If the outcome of research question 1 is that Denmark is a price leader, it is assumed that Denmark, Germany and United Kingdom form a price cluster together.

Option 3: The Netherlands is a price leader
If the outcome of research question 1 is that the Netherlands is a price leader, it is assumed that the Netherlands, Germany and Belgium form a price cluster together.

Option 4: No price leader has been identified at research question 1.
If no price leader has been identified at research question 1, it is assumed that Denmark, Germany, the Netherlands and the United Kingdom form a price cluster together.

Methodological design research question 3:
What shifts in market power between the three chain stages during the first decade of the 21th century can be observed?

Depending on the outcome found at research question 1 and 2, the price series will be split in two subsamples. For each relationship found at research question 1 and 2, it will be investigated if a difference can be identified between the two sub samples. This analysis will be executed by making use of the methods of research question 1 and 2.

Appendix II

Table 16. Germany as price leader for pork hams

Does Germany directly affect	Lags	Joint significance Wald test		Outcome
		F-statistic	P-value[a]	
Denmark?	4	1.43	0.23	No
The Netherlands?	2	1.31	0.27	No
Austria?	2	0.33	0.72	No
Belgium?	1	0.52	0.47	No
Poland?	2	1.66	0.20	No
Czech Republic?	4	0.17	0.95	No
Luxemburg?	6	0.76	0.60	No
France?	8	1.23	0.29	No

[a] Significant at the 5% level.

Table 17. The Netherlands as price leader for pork hams

Does the Netherlands directly affect	Lags	Joint significance Wald test		Outcome
		F-statistic	P-value[a]	
Germany?	3	0.24	0.87	No
Belgium?	1	3.38	0.07	No

[a] Significant at the 5% level.

Appendix III

Here it is displayed that the fitted and actual line do not differ a lot from each other. This means that the Danish prices do well predict the German prices, in this case for piglets. If this was not the case, then the residual line would be highly fluctuating and not be stable.

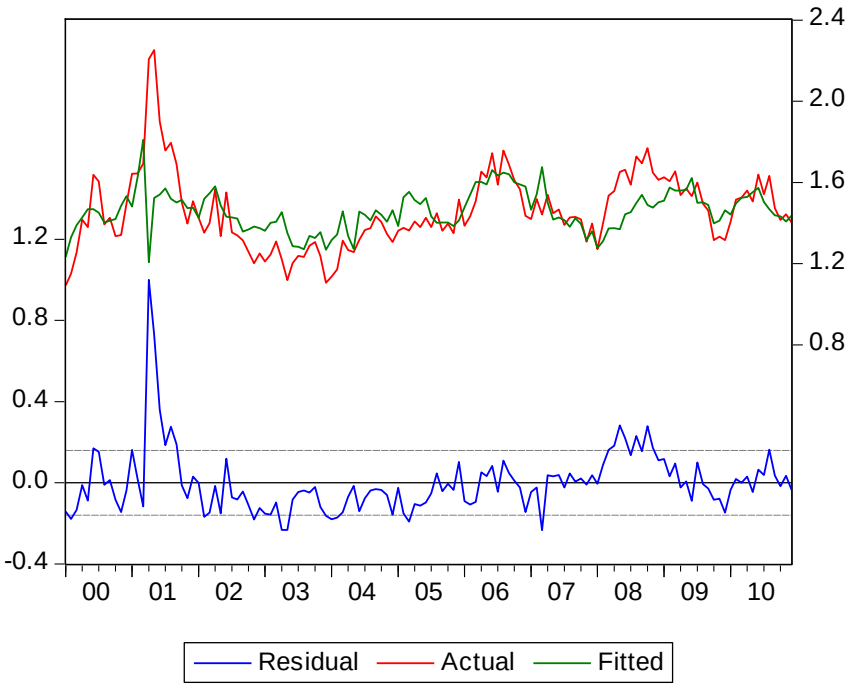

Figure 7. Least squares regression of DK on DE for piglets