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The Relevant Markets for Meat Production and Processing in the Czech Republic: Analysis of the Price Movements

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Abstract The objective of this article is to apply empirical methods to delineate the relevant market for various types of meat in the Czech Republic during the period of 2006–2010. This procedure may be useful when there is little availability of micro-data and the complete SSNIP test approach is not feasible, but when the prices can be obtained at an aggregated level. The methods employed ranged from the visual assessment, simple correlation analysis and testing of the law of one price, to the more complex cointegration analysis and testing of Granger causality. The application of the methodology is used both for the geographical delineation and for the product delineation. We reach the following conclusions: For the chicken meat, the market in the Czech Republic can be considered independent both geographically and by product. For the pork meat, the relevant market includes, apart from the Czech Republic, also Germany and Slovakia. The relevant beef meat market includes the Czech Republic and Germany.

Keywords Market delineation, meat prices, relevant market, cointegration, causality
JEL classification C32, L40, L66

1. Introduction

Recently, European Competition Network has conducted a report on the European competition law enforcement and market monitoring activities in the food sector (ECN 2012). As documented by this report, we can record quite a number of competition investigations in the food industry. Since 2004, there were more than 180 antitrust cases, and roughly 9% of them concerned meat, poultry and eggs markets. In the meat markets, most competition infringements affected the primary production level and were all related to horizontal infringements. The results of the inquiry also contributed to the establishment of the European Commission's Food Task Force, with the goal of monitoring the food sector with more scrutiny.

The importance of the food sector is apparent. The consumers, especially low-income households, spend a significant part of their budget on food. Of these expenditures, the report shows that about 25% of total household expenditures on food is spent

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on meat, poultry and eggs. The demand for food is also typically rather inelastic (see e.g. Andreyeva et al. 2010 for the review of studies regarding demand for food elasticity). Andreyeva et al. (2010, p. 218) point out that 'the consumer demand for meat has received substantially greater attention than demand for any other food'. Combined with an increased volatility of prices, and with some of the recent quality-related scandals, the problems related to the competition and regulation in the food industry have gained a significant public attention.

In order to assess the competition or market power in the competition investigation, it is necessary to define the market. As argued in the actual legal cases, the definition of the relevant market is of high importance. Farrell and Shapiro (2010) point to the difference between the market as per the hypothetical monopolist test—which includes only enough substitutes so that a hypothetical monopolist could impose a price increase—and the actual court declaration regarding the market definition. For instance, in the case of 253 F.3d 34: United States of America v. Microsoft Corporation in 2001[1] (also used e.g. in 533 F.3d 869: Federal Trade Commission v. Whole Foods Market Inc. in 2008), the court declared 'the relevant market must include all products reasonably interchangeable by consumers for the same purposes.'[2]

This analysis is dealing with such identification of relevant markets. Specifically, we investigate the meat production and processing market delineation for the Czech Republic by the means of cointegration and causality testing among the various prices of meat products.

The market delineation might be considered a necessity for the competition authority to perform before it moves forward to the actual competition regulation (see for instance Church and Ware 2000, p. 599 onwards). The actual reasoning for its necessity, e.g. as per the Horizontal merger guidelines of the U.S. Department of Justice and the Federal Trade Commission (2010), is two-fold.

First, the market delineation or definition allows to specify the line of commerce and section of a country or countries in which the competitive concern arises. Second, it allows to identify market participants and measure market shares and market concentration, and thus in the context of potential abuse of dominance to identify one or more relevant markets in which the merger may substantially lessen competition. As such, it is usually (though not necessarily) one of the first steps the competition authority makes and it is also the step that greatly influences consequent arguments and reasoning of the decision.

The application of market delineation will be most often related to either approving a merger or assessing the possible abuse of market dominance. In this article, we focus on the use of relatively simple and logical way using the well established econometric methods to assess the market delineation. This corresponds to the recent increase of the econometric methods usage in the market and competition issues (Rubinfeld 2010; Németh and Niemeier 2012) and may serve as an inspiration for the actual competition authority when there is little availability of micro-data. For instance, it may serve when

[1] See http://law.justia.com/cases/federal/appellate-courts/F3/253/34/576095/.

[2] The latter part of the quote is a reference to the U.S. Supreme court declaration in United States v.E.I. du Pont de Nemours & Co. – 351 U.S. 377 from 1956.

a complete SSNIP (the small but significant and non-transitory increase in price) test approach is not feasible but the prices can be obtained at an aggregated level, using wholesale or retail price indices.

The aim of this article is related to the horizontal market delineation for the purpose of the competition investigation in the meat market in the Czech meat industry. It applies the price-based analysis using econometric methods as a tool for the geographic and product market delineation. The analysis focuses on the existence of mutual relationship in price movements among the prices of a given meat product in different countries. Furthermore, since we are dealing with rather homogeneous and divisible agricultural products, we also examine the well-known tests of the law of one price and furthermore the existence of relationships between various types of meat products in the relevant market.

This article focuses on two types of market delineation. The first is the geographical delineation. The second is the product delineation. In both, we will employ similar means to analyze whether there are separate national markets for the beef, pork and the chicken meat. The working hypotheses is that each type of the market is independent unless there is an evidence for the opposite.

The article is composed as follows: In Section 2, we provide the description for the models used, along with some discussion for their validity. In Section 3, we present the empirical estimations along with comments. In the conclusions in Section 4, we provide the main findings on the given meat products' market delineation.

2. Model discussion

2.1 The techniques and the purpose of market delineation

For the market definition, it is necessary to determine the boundaries, both in terms of the product and the geographic area. For this purpose the antitrust agencies frequently use the hypothetical monopolist test—also recommended e.g. by the U.S. competition authority merger guidelines (2010). On its basis the relevant market should include all products on the geographic area in such a way that, if they were owned by a sole supplier, this hypothetical monopolist would be able to exert the significant market power on the market. The exertion of the market power is reflected in the price increase.

Among the most popular methods for the hypothetical monopolist testing are the Critical loss analysis, the SSNIP test or tests based on merger simulations, such as the FERM (full equilibrium relevant market) test. More detailed survey of the methods can be found e.g. in Elizalde (2012). In spite of its appeal, the hypothetical monopolist approach is often difficult to empirically implement due to the limited data availability for these data-demanding methods (Coe and Krause 2008).

In the initial stages of their inquiries, the antitrust practitioners typically do not have such datasets on costs and quantities. Typically, only the data on prices are available. In such situations, the antitrust market delineation strategy is limited to the approach based on the available data, i.e. price-based methods.

The basic approach for the market definition based on prices can be found e.g. in Stigler and Sherwin (1985). The authors build on the logical premise that if two

goods are in the same market, their prices should demonstrate some mutual linkage and that the test of the market is the similarity of price movements within the market. This is the core idea of all the price-based analyses, even in subsequent developments focusing on Granger causality tests (Uri et al. 1985; Uri and Rifkin 1985; Slade 1986) or cointegration (Ardeni 1989; Walls 1994).

The price-based approach is typically concerned with identification of the price movements similarities. The case when a good sells for the same price in all locations is the definition of the law of one price. The testing of the law of one price was for the purpose of market delineation proposed e.g. by Shrieves (1978). The actual testing of the law of one price is typically based on the equality of means. Typically, the law of one price is a consequence of the horizontal (spatial) arbitrage, where, if the markets are integrated and the price adjustment is without barriers, the homogeneous goods will exhibit the same price in different areas or countries (Fackler and Goodwin 2001). However, the existence of some arbitrage costs might lead to a price differences, even if the goods belong to the same market and their prices exhibit strong influences to each other. In such a case, the cointegration and causality testing are more appropriate.

The correlation analysis was present even in the early approaches and while rather basic, it should perform well with instantaneous price adjustments. The cointegration approach is most appropriate for the situations with the stable equilibrium between two or more prices and the tendency to return into this state in case of shocks. The Granger causality testing is appropriate in cases where the price adjustments proceed with some delay—typically this would be the case if the producers do not possess the perfect information regarding each other's costs.

Regarding the price-based analysis, we feel it is appropriate to stress the necessity of the existence of mutual trade relationships, showing the evidence of goods being exchanged. Obviously, this condition by itself is insufficient for the market delineation and we need to examine if prices also exhibit the mutual linkages. The importance of mutual trade was also pointed out by Gonzalez-Riviera and Helfand (2001). If we find the evidence for a mutual causality or even cointegration among the market participants, then we can reasonably assume the trade is the sign of an arbitrage taking place and therefore a sign of the goods being in the same relevant market.

However, the price-based approach also faces several drawbacks, notably the potential for a spurious correlation, unclarity on the causality and also a unclarity on what should or should not be considered a strong enough relationship. A critique of the price-based approach can be found in Coe and Krause (2008). They explored the empirical performance of the price tests derived from the theoretical model simulation with differentiated product. Their conclusion is that price based tests are not fruitful research in the antitrust analysis. However, the poor quality is unilateral in the sense, that it is mainly related to the small power of tests and not on the bigger size.

As is also often the case with time series, and especially the time series regarding price movements, there is a high chance of non-stationarity of time series. Therefore, the price analysis proposed by Stigler and Sherwin (1985) proposed needs to be extended by the unit root testing and the cointegration analysis.

2.2 The literature review

The focus of the literature review is mainly on the studies dealing with the price transmissions, predominantly in the agriculture or food industry. In most of the studies, we can find similarities in the applied methodology. For instance, Sirolli (2006) examined the occurrence of the price transmission asymmetries in the beef, pork and broiler industry in the USA, based on the industry structure and concentration. He employed the Granger causality testing in VAR model and the price transmission asymmetry testing. This was based on the comparison of the size of the reaction on the price increase and the price decrease. He concludes with the evidence for the transmission from farms to retailers. With respect of the market structure and rising concentration, he also confirms the reverse direction of transmission.

In a similar fashion, Jiménez-Toribio et al. (2007) examined the long-term price relationships on the clam market in Spain by the cointegration and causality testing. They focused on the short-run and the long-run causalities and establish the equilibrium between two of the examined clam types. Forni (2004) focused on the milk market in Italy. His method relied on the unit-root testing of relative prices, and can be viewed as a simplified alternative to cointegration testing. Weinhagen (2012) evaluated the effects of the price transmission through three stages of food production. Again, the method was based on the VAR modeling with Granger causality testing. Furthermore, the price transmission was analyzed with the impulse responses and the variance decomposition.

Among the studies regarding the horizontal price transmission, Hayenga et al. (1996) examines the spatial price integration in the fed cattle market, in terms of what plants compete with each other. Besides the analysis of the strength of the spatial competition, they try to identify the price leadership and the price followers in the geographic cattle market. Their analysis is again based on the cointegration and the Granger causality testing. Saran and Gangwar (2008) employed cointegration approach to examine wholesale egg prices in various Indian regions. They attribute the evidence for price cointegration to the market intelligence service provided by Indian National Egg Coordination Committee institutional (NECC), enhancing the arbitrage. Esposti and Listorti (2013) investigate cereal price transmission during price bubbles. Their model approach is interesting, as it comprises of compact representation of both cross market and cross commodity price dynamics in one reduced form VECM representation. Goychuk and Meyers (2013) investigates the short-run and the long-run price dynamics of the wheat price among the largest world exporters. Apart from the cointegration analysis, he performs a threshold error correction techniques to include the possibility of the asymmetric price adjustment.

Finally, the studies that are closest to ours deal with the horizontal price transmission with the objective to delineate antitrust market. Asche et al. (1997) delineate the market of high-valued seafood products, using the data on the fresh and frozen salmon and crustacean. They use dynamic system of demand equations and the cointegration analysis. Their conclusion that the cointegration analysis is in line with other market delineation techniques, is also supported by Fotis (2012) who investigated relevant market of production and distribution of white milk in Greece. Further Haldrup et al. (2008) apply purely price-based approach to define the relevant market for salmon in

Norway and Scotland.

Bada and Rahji (2010) is another application of price cointegration analysis in the sea-food industry. The authors examined if catfish is in the same relevant market with other imported species in Nigeria. For this purpose they performed cointegration tests and subsequently estimated error-correction model. They concluded that all the species are in the same relevant market, and that the price of catfish is influenced by the price of imported species, but the reverse causality does not hold.

Finally, it is noteworthy that the cointegration price analyses as the means of product market delineation have indeed been employed in other areas such as in the natural gas market in the U.S. (Walls 1994), or the electricity market in Finland, Sweden, and Norway (Juselius and Stenbacka 2011). The cointegration analysis has also been a popular method in the studies regarding the petroleum and petroleum products markets, as evidenced in Wlazlowski et al. (2009), Asche et al. (2003), Indejehagopian and Simon (2000), Gjølberg and Johnsen (1999) or Serletis (1994).

In developed countries, the market delineation is typically applied for the purpose of economic analysis, mainly examining the vertical price transmission or antitrust analysis, with the aim of applicability in further competition research.

But the question of market integration has also gained a somewhat different position in the developing countries. This mainly concerns the potential for the policy action, regarding the existing government intervention in the markets and/or geographic liberalization of the markets (Alexander and Wyeth 1994; Sekhar 2012). The key idea is the producers and the consumers will not realize the gains from the trade liberalization unless the markets are integrated. Some of the world's largest agriculture commodities exporters are however subject to various restrictions, and government actions can possibly influence world commodity pricing. (For instance, recall the turmoil in the world rice market after the Indian ban on the rice export in 2008.) In many developing countries, there are geographic trade restrictions or the government prevents the direct arbitrage on the international level. Sekhar (2012) argues the reasons in favor of the continuing state interventions can range from the lack of domestic market integration, risk mitigation, insufficient institutional capacity and foreign exchange constraints to imperfect nature of world agricultural markets or a higher volatility of agricultural prices in the international markets. The established absence of the market integration in a given country is then used as an argument why the trade liberalization would not, in fact, be beneficial for the local residents.

As evidenced by this rich variety, the market identification can find its place in various problem settings, and might be considered highly relevant not only for the activities of competition authorities, but also for the market participants themselves.

2.3 Model setup

Cointegration analysis has become a very popular method in the studies of price transmissions regardless of the objective of the paper. Cointegration analysis examines the existence of a long-run relationship between the time series. If the products or geographical areas in question actually do belong on the same relevant market then there should be an observable pattern of a corrections of deviations from a long-run rela-

tionship between two (or more) prices. In other words, under equilibrium conditions of the interconnected markets, it should not be possible for a given company to maintain a higher price than its competitors (as in the merits of the SSNIP test). In such a case we assume existence of a market mechanism based on the price arbitrage, working in such a way that a deviation from the stable long-run equilibrium will eventually get corrected and the time series values will return to their values described by the equilibrium equation.

In practice, the perfect price arbitrage can be affected by many impediments, including the delivery lags, the transportation and transaction costs, or contracting arrangements to hedge against the business risks. For our methodological concept, we have accepted the assumptions that all these short-run deviations are stationary because of the aforementioned costs and impediments. This type of behavior allows, at the same time, to differentiate a cointegrated prices from the false conclusion that two products belong to the same relevant market if they exhibit high correlation in prices (as might be the case of highly trended series).

Another important case is when the price change in one of the markets will cause the adjustment in the other products or areas with a delay. This influence might be uni-directional, representing a leading position of a given product or area in the price formation. Typically, we might be able to observe this unidirectional relationship with the price hike of the inputs being reflected into the prices of outputs. More relevant case for the market delineation, however, would be if such delayed price adjustments would act in both directions. For the cases like these, we also consider the so-called Granger causality (Granger 1969) for the delineation of a relevant market in the case of no cointegration or stationary series. The Granger causality is employed to establish a manner of causality that remains unclear in the common regression analysis, i.e. the direction of the causality if observing the significance of the relation between the explained and the explanatory variables. The Granger causality is based on the assumption that events of the future cannot have an impact on the events in the past. If the explanatory variables represent the events that happened in the past, the aforementioned assumption means the events in the past could not be caused by the events in the present but rather the events in the past caused the current events.

This testing is especially relevant for two types of cases. One of them is when the time series of prices exhibit stationarity, e.g. highly volatile price fluctuations without influential trending. The other one is for the cases where we are unable to observe a stable long run relationship between non-stationary prices, but when the first differences of the prices of one product (or in one area) exhibit influential capacity on the prices of other product (or the same product in different areas). Recall that the testing of the influential capacity of the lagged prices, in different areas or products would be also valid for non-stationary time series that are cointegrated. However, as the cointegration itself requires causality process taking place between the series, the cointegration property itself speaks for the inclusion to the relevant market.

How does cointegration relate to the the market delineation? Assuming the actual market size and demand potential in different countries, it is possible that movement in prices in one country represent a price setting scheme for a different market, by

the availability of supply and arbitrage capacity. The markets are then said to be integrated. When the physical limitations and arbitrage costs are not prohibitive, especially if combined with the influence of multinational companies, supplying several markets on a large scale, then on the two interconnected markets, producers will react to the price movements in the relevant market. In such settings, the price movements in one country will be determining the price movements in other country and vice versa even though long-run cointegration relationship cannot be found. That is not the necessary condition for market integration. If we can not find the evidence for the price cointegration, it means that there does not exist a competitive market equilibrium. Nevertheless, if the price movements occur, they may exhibit sufficient enough a pressure to have significant impact on other prices. Thus, we expand the definition of the relevant markets not only on the cointegration relationship, but also on the cases, where the two countries (or products) exhibit mutual Granger causality in prices.

Before we proceed with the model estimation, we have to find out whether the examined series are stationary or not. We will use Augmented Dickey-Fuller (ADF) test and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test to examine the stationarity.

ADF test works with the null hypothesis of the presence of the unit root (non-stationarity), while the KPSS test works with the null of stationary series. For the actual determination of the (non)stationarity of the series, it is beneficial to consider the outcome of both tests. The unit-root testing is an important step for two reasons. First, the cointegration is defined as the property of $I(1)$ variables, therefore it is necessary to find out if the series considered for the cointegration testing are non-stationary in levels and stationary in the first differences. The second reason relates to the possibility of the spurious results, if the Granger causality was performed in the VAR model in levels and the variables in VAR are non-stationary.

To test Granger causality, we employ several standard F-tests. In each of the estimated equations, we perform an F-test for each of the examined countries for all the corresponding lagged values. In the matrix notation, the VAR model has the following form:

$$P_t = \alpha + \beta T + \Pi \sum_{j=1}^{m} P_{t-j} + \varepsilon_t,$$

where P denotes the matrix of prices, T is the time trend and Π is the matrix of parameters for the lagged prices. Note that we will obtain the correct estimates of the parameters only if all of the time series used in the VAR model are stationary or cointegrated. In the case of non-cointegrated $I(1)$ series, it is appropriate to work with the model in differences.

If the time series exhibit a unit root, we can proceed to test whether two or more series have common stochastic trend—i.e. whether they are cointegrated or not. We can test this hypothesis of the so-called Engle-Granger test (Engle and Granger 1987) by performing the auxiliary cointegration regression of the form:

$$p_{1t} = \alpha + \beta p_{2t} + \varepsilon_t.$$

If the two series cointegrate with a vector $(1, -b)'$ (where b is the estimate of the

cointegration vector β from the previous equation) then the error terms ε_t should exhibit a stationarity. The aforementioned ADF test of the cointegration regression residuals is commonly the second step. The Engle-Granger test allows only pairwise comparisons of a potential cointegration. In the case of multiple time-series it is often more convenient to use the so-called Johansen procedure (Johansen 1991) which makes possible to jointly investigate the associations among multiple time series. This procedure is based on a matrix equation representation called error-correction form:

$$\Delta P_t = \Pi P_{t-1} + \sum_{j=1}^{m-1} \Gamma \Delta P_{t-j} + \varepsilon_t .$$

It can be shown that the number r of cointegration relationships present among the variables is equal to the rank of matrix Π. This amount corresponds to $k-r$ common stochastic trends, where k represents the number of columns of P (the number of explanatory variables).

Furthermore, $k-r$ corresponds to the number of zero eigenvalues. Based on this fact, Johansen test consists of the sequence of test statistics with the null hypothesis $H_0 :\ rank\,(\Pi) = r$, $H_1 :\ rank\,(\Pi) = k$. This type of the test is known as the trace test. Sometimes the alternative test, known as lambda-max test, is used with the alternative hypothesis $H_1 :\ rank(\Pi) = r+1$. We begin with $r = 0$, and continue testing until we cannot reject the null hypothesis. Finally, associated eigenvector to the non-zero eigenvalues represents respective parameters of the observed cointegration relationships.

We take the VECM model settings as the initial setup. The assumption behind this lies in the formulation of the integrated market, that would be characterized as a market where exogenous shocks will lead to the price adjustment processes taking place among all firms in the relevant market. Therefore, in the integrated market, the prices in the individual sub-sections of this integrated market cannot in the long run deviate from the market equilibrium state. If we look at the error-correction model above, this assumption is satisfied if the matrix Π is not of full rank, and therefore can be expressed as $\Pi = \alpha\beta'$, where the so-called loading parameters α describe the adjustment process, in other words how the prices respond to the deviations from the long-run equilibria described by the cointegration relationships. In case where the cointegration tests do not reveal this type of behavior, i.e. there are no long run equilibrium relationships among the prices, the main attention is focused on the lagged terms. As mentioned above, the market integration would imply there is a bidirectional causality based on the lagged values. This means the price adjustment is taking place with a delay.

Even though the price-correlations approach has some critics, it is usually taken as granted that the delineation is not an end in itself (Carlton 2007) and some care should be taken when dealing with the results. Preferably several methods should be employed to compare the results before taking further steps, as should always be the case when considering an market intervention.

While there is still a valid concern about the chances of some factors other than prices driving the possible existence of mutual relationships, as it is almost always the case in regression analysis, and while the analysis using the micro data might be able

to uncover the details of a demand structure that will remain unexplored in a price-correlation analysis, we feel that a possibly less-than-ideal method is still a reasonable approach if a researcher or a competition authority lacks the data to perform other types of analysis.

2.4 Data description

The data used in this article are in the form of time series with weekly frequency (in EUR/100kg) at the level of the original producers in the selected European Union member countries. Specifically we focus on the time series of the average prices of the beef and pork fatstock meat. The product is offered at these prices by original producers to the meat industry processors, for whom these prices represent input (unit) costs. Both beef and pork meat prices apply to the cold carcase (a slaughtered body, bled and eviscerated, whole or divided down the mid-line). For the chicken meat, the prices represent the average prices of the chicken meat processors of the so-called 65% *chicken*, which means the animal plucked and drawn, without head and feet and without neck, heart, liver and gizzard, whole or divided, where the weight of meat is roughly 65% of the weight of live poultry.

The data on prices cover all the weeks in the years 2006–2010. The original data and data description source come from the SZIF (The State Agricultural Intervention Fund). The data were provided to us by the Office for the Protection of Competition in Brno. If not specified otherwise, we will use the standard level of significance of 5%. All tables in this article are our own.

3. Estimation

This section is organized as follows: We first select the countries exhibiting a non-negligible amount of trade with the given meat product. This is a necessary but not sufficient condition for the arbitrage. Afterwards we examine the initial visual representation of the price series of a given product in various countries. Then we perform the stationarity tests and the causality tests. For each of the examined products or areas the short summary follows.

3.1 Countries selection by trade volumes

The examined period starts in the year of the EU accession, 2004. In the following years, while the domestic consumption of these meat products was relatively unchanged, a significant portion of the domestic supply of the pork meat was replaced by the pork meat imports, with imports of pork meat in 2010 reaching the 300% value of the base year 2004. While significantly less pronounced, the amount of imports of both beef and chicken meat products also increased to nearly 200% and 140% respectively compared to the base year 2004.

The data on the export and import volumes indicate trade volumes allowing for the following arbitrages:

(i) Chicken meat market: Czech Republic and Germany, Slovakia, United Kingdom, Hungary, Poland and Austria.

(ii) Pork meat market: Czech Republic and Denmark, Germany, Netherlands, France and Slovakia.

(iii) Beef meat market: Czech Republic and Slovakia, Germany, Italy, Netherlands, France and Romania.

The initial assessment of the consumption patterns of the different products does not indicate close year-to-year relationships.

3.2 Summary statistics

Table 1 depicts the initial assessment of the law of one price for each of the examined cases.

Table 1. Equality of means and volatility

	Chicken			Pork			Beef	
	p-value	S.E.		*p*-value	S.E.		*p*-value	S.E.
CZ		25.420	CZ		15.448	CZ		13.381
DE	0.000	27.769	DK	0.000	9.934	SK	0.000	21.619
HU	0.000	20.106	DE	0.668	13.270	DE	0.000	19.723
AT	0.000	4.099	FR	0.000	11.891	IT	0.000	16.817
PL	0.000	17.299	NL	0.000	12.330	NL	0.000	14.708
SK	0.043	15.211	SK	0.082	15.506	FR	0.000	15.762
UK	0.000	9.464				RO	0.000	32.989

For the chicken meat market, there is no clear observable pattern at this level. The closest development of the price series in the Czech Republic is with the series in Slovakia and Hungary. While it is questionable if the development of the chicken meat prices in Germany is in relation with the Czech prices, we can more or less exclude Austria. The Czech Republic exhibits the second highest volatility (after Germany). The lowest volatility can be found in Austria and UK.

At the 5% level of significance we can rule out the equality of means when compared to the Czech Republic (see Table 1) of the chicken meat products for all of the aforementioned countries.

For the pork meat, Slovakia, Germany and Netherlands exhibit the closest development of the prices series in the Czech Republic. The largest price differential is found in the case of Denmark with consistently lower prices, on average being 85% of the Czech prices. This easily explains the leading position of Denmark as a source of imports of pork to the Czech Republic. It should also be noted that Denmark is one of the leading world exporters of pork meat and the largest exporter of pork in Europe, followed by Germany, incidentally also the largest pork meat producer and consumer

in Europe. Apparent from the visual depiction of the series is a short period of sudden increase in the pork price, beginning in the second quarter of the year 2008. This behavior was caused by the increasing price of corn which transmitted into the price of the feed for pigs. This ongoing cost increase made the business unprofitable for many farmers. Moreover, in the same time the demand of developing countries was rising. The price linkage, not necessarily limited to agricultural products, among countries might also have contributed.

At the 5% level of significance, we can rule out the equality of means (when compared to the Czech Republic, see Table 1) of the pork meat for Denmark, Netherlands (the first and the third largest import sources to the Czech Republic) and France. However, we can not reject the equality of means for Slovakia and Germany (with Germany being the second largest import source to the Czech Republic).

As for the beef meat market, in spite of considerable differences in the development of the time series, we can find the closest relation with the import sources, i.e. Slovakia and Germany. France also exhibits rather similar pattern as Germany. At the 5% level of significance, we reject the hypothesis of the equal means for all examined countries. While the p-value of the test was the highest for Slovakia, its time series is significantly more volatile than that of the Czech series, so there is very little in common. Regarding Germany, there is a considerable price differential, on average on the scale of about 12% of the Czech prices. Other countries do not exhibit any significant signs of common development.

To summarize, there is somewhat close visual pattern relating to the behavior of the prices in the Czech market in these cases:

(i) In the chicken meat market between the Czech Republic and the following countries: Hungary, Slovakia, and perhaps Germany. A relationship with the UK is unlikely. However, no signs for equality of means for any of the examined countries.

(ii) In the pork meat market between the Czech Republic and the following countries: Slovakia, Germany and Netherlands. Furthermore, we can not reject the equality of means for Slovakia and Germany.

(ii) In the beef meat market between the Czech Republic and the following countries: Slovakia and Germany. Due to its similarity to the German price series, France may also be considered.

Furthermore, for the meat market in the Czech Republic, there is only a very slight indication of a relationship between pork and beef, even though pork and chicken meat prices are closer in their means.

3.3 Stationarity tests

The stationarity tests results are provided in Tables 2 and 3. Please note the the null hypothesis of the ADF test is non-stationarity of the series, while the null of KPSS test is stationarity. The lag order was set by *test down* method, i.e. by starting with

high number of lags, and sequentially ruling out the last insignificant lag. While this procedure may reduce the power of the test, disallowing for high enough lag would lead to residual autocorrelation and inapplicability of the empirical distribution for the p-value estimates. The selection of the (lower) number of lags based e.g. on the information criteria would be applicable if there is a rather limited number of observations. However, in the case of high frequency data, this should not be an issue.

Table 2. ADF non-stationarity test

	Chicken			Pork			Beef	
	lag order	p-value		lag order	p-value		lag order	p-value
CZ	6	0.60	CZ	12	0.00	CZ	0	0.50
DE	9	0.35	DK	16	0.00	SK	10	0.53
HU	1	0.55	DE	10	0.00	DE	5	0.32
AT	10	0.48	FR	12	0.00	FR	9	0.00
PL	2	0.05	NL	13	0.00	IT	6	0.11
SK	5	0.23	SK	11	0.00	NL	9	0.29
UK	9	0.28				RO	10	0.91

Table 3. KPSS stationarity test (5% critical value = 0.463)

	Chicken			Pork			Beef	
	lag order	KPSS test		lag order	KPSS test		lag order	KPSS test
CZ	6	1.6272	CZ	12	0.1544	CZ	4	2.6170
DE	9	2.1543	DK	16	0.0760	SK	10	1.4469
HU	1	3.3180	DE	10	0.1133	DE	5	0.5464
AT	10	1.5998	FR	12	0.1564	FR	9	0.1886
PL	2	1.5714	NL	13	0.0869	IT	6	0.5296
SK	5	0.7412	SK	11	0.2455	NL	9	0.3224
UK	9	0.9775				RO	10	n.s.

In the chicken meat market, based on the ADF tests, we do not reject the null hypothesis of the non-stationarity in all countries but Poland. Based on the KPSS test, we reject the null hypothesis of stationarity and conclude for the non-stationarity in all countries. The first differences of the series are stationary in all cases. The time series are therefore integrated of order 1.

In the pork meat market, both ADF and KPSS tests indicate the stationarity of the series for all the examined countries.

In the beef meat, the results of ADF and KPSS tests do not provide as clear answer as in the previous cases. ADF test allows the rejection of the the unit root hypothesis only for France. On the other hand, the KPSS test doesn't reject stationarity moreover for Netherlands. Taking into the consideration that the type I error is less probable

than type II error, we are inclined not to reject the presence of a unit root in the case of Netherlands.

Based on the aforementioned results, we can conclude:

(i) In the chicken meat market, all examined countries exhibit non-stationary behavior, integrated of order 1.

(ii) In the pork meat market, all examined countries exhibit stationary behavior.

(iii) In the beef meat market, apart from France and Netherlands, all other examined countries exhibit non-stationary behavior.

For the general meat market, based on the stationarity tests, we can formulate this partial conclusion. Since the time series for the pork, unlike those for chicken and beef, are stationary, there co-exist at least two relevant markets on the general meat market.

3.4 Cointegration and Granger causality tests

In this part, we proceed to test the cointegration regressions. Since we are interested in the relationships of examined countries with relevance to the Czech Republic, we examine the binary relationships by testing the stationarity of the residual from the cointegration relationship (Engle and Granger 1987). Summary of these regressions are provided in the Tables 4 and 5. Note the Granger causality is examined by testing whether all the lagged variables corresponding to a given country in the VAR model are jointly zero (i.e. performing the F-test). However, in the case of general meat market, it makes sense to establish the testing by Johansen procedure (Johansen 1991), which allows to identify a number of cointegration relations. Based on the visual assessment of the series, we employ the so-called unrestricted constant specification, which allows for the linear trend in the data and a presence of a constant (but not the time trend) in the cointegration relationship.

For the chicken meat market, none of the cointegration regressions exhibits the stationarity of the residuals. Therefore we find no evidence for the cointegration relationship between the Czech Republic and any of the aforementioned countries. At the 5% level of significance there is no evidence of Granger causality of the prices of chicken meat in the Czech Republic affecting the prices in other countries or vice versa. There are only weak signs of causality (level of significance $> 10\%$) of the Austrian and Hungarian prices on the Czech chicken meat market.

For the pork meat market, we are dealing with the stationary prices. Therefore, the cointegration tests are not feasible. The Granger causality however exhibit several relationships. The proposed sign of of mutual influence as an evidence for a relevant market can be found in the case of Germany and the Czech Republic and Slovakia and the Czech Republic. Furthermore there are signs of one-way causality in case of France and somewhat surprisingly Netherlands. With a large portion of imports coming from Netherlands, it appears the Czech market price can be considered important for the suppliers. However, this direction of causality is probably heavily influenced by the cointegration of Czech prices with German prices. We can recall the Germany is one

Table 4. Cointegration tests (p-values)

Chicken		Pork		Beef	
DE	0.683	DK	N/A	SK	0.423
HU	0.496	DE	N/A	DE	0.049
AT	0.414	FR	N/A	FR	n.s.
PL	0.423	NL	N/A	IT	0.153
SK	0.288	SK	N/A	NL	0.840
UK	0.413			RO	0.891

Table 5. Granger causality tests (p-value of F-test)

Causality $X \rightarrow$ CZ		Causality CZ $\rightarrow X$	
X	p-value	X	p-value
	Chicken		
CZ	0.000	CZ	0.000
DE	0.227	DE	0.168
HU	0.101	HU	0.242
SK	0.334	SK	0.289
AT	0.106	AT	0.657
PL	0.634	PL	0.763
	Pork		
CZ	0.000	CZ	0.000
DK	0.605	DK	0.851
DE	0.015	DE	0.024
FR	0.017	FR	0.417
NL	0.463	NL	0.055
SK	0.046	SK	0.002
	Beef		
CZ	0.567	CZ	0.567
SK	0.200	SK	0.452
DE	0.343	DE	0.294
FRA	0.900	FRA	0.705
IT	0.782	IT	0.704
NL	0.942	NL	0.031

of the major players in the pork market, both in production and consumption. It is therefore likely the swift adjustments of Czech prices to German prices can produce the apparent causal link from Czech (i.e. the same as German) to the prices in the Netherlands.

For the beef meat market, we have, somewhat surprisingly, found a cointegration relationship with Germany. Even though we have identified a significant cross-price

Table 6. Johansen tests (p-value)

Rank	Trace test	Lmax test
0	0.011	0.006
1	0.416	0.459
2	0.272	0.272

differential with consistently higher price in Germany, the tests suggest that both series have common long-run equilibrium development. Given the fact the Germany is the second largest producer of beef in Europe, this might be caused by the inability to differentiate the quality of beef, that is more differentiated with several beef cuts than e.g. with pork cuts. The customers in the Czech republic might therefore be willing to opt for lower priced beef cuts. On the other hand, no cointegration relationship was found with our leading trading partner Slovakia or with other examined countries. Even though the estimated VAR model with price differences doesn't show any evidence for a mutual casual relation in price development, we should note that in such case we in fact examine the second order dependencies (to avoid the estimation bias), which are more demanding than the ordinary first order linear dependencies.

As we mentioned before, the largest possible relevant market might include Czech beef and chicken meat and German beef meat. The results of the Johansen test are displayed in Table 6. Both tests suggest there exists only one cointegration relation, so there are two independent stochastic trends among the tested time series. As one of the cointegration relation was already identified in the beef market, we can conclude that the chicken meat market is not cointegrated with the beef meat market. This result is indirectly supported by the Granger causality tests (see Table 5). The mutual casual dependencies were found only between the Czech and the German beef meat prices.

The results of cointegration regressions and Granger causality tests:

(i) In the chicken meat market, there is no evidence for the cointegration relationship between the Czech Republic and any of the examined countries. Also, no evidence of Granger causality of the Czech prices on any of the examined countries or vice versa.

(ii) In the pork meat market, the stationary series rule out the possibility of cointegration. However, there is an evidence of bi-directional causality between the Czech Republic and both Germany and Slovakia.

(iii) In the beef meat market, we have identified a cointegration relationship with Germany. We have not found any evidence for the cointegration or the Granger causality with any other examined countries.

For the general meat market, we have only confirmed the cointegration relationship of Czech and German beef meat. We have found no evidence for a cointegration or a casual dependency with the chicken meat prices.

4. Conclusion

The objective of this article is to provide an empirical example of the application of the econometric methods for the geographic and product market delineation for various meat products in the case of the Czech Republic.

The data with relatively high frequency are used to examine the existence of mutual relationships in the behavior of the prices. Annual trade balances are employed to ensure there is a non-negligible amount of arbitrage among the examined countries. The methods employed ranged from visual assessment, simple correlation analysis and tests of the law of one price to the more complex cointegration analysis and Granger causality tests.

Based on the results of the previous chapters, we can conclude the following:

(i) In the chicken meat market, the evidence suggests the relevant market is only the Czech Republic.

(ii) In the pork meat market, the relevant market is the Czech Republic and Germany and Slovakia. For the Germany and Slovakia, we do not reject the equality of price means and we also find bi-directional causality with the Czech prices.

(iii) In the beef meat market, the relevant market is the Czech Republic and Germany, with the evidence of a cointegration relationship.

For the general meat market, we have come to the conclusion that the examined types of goods (meats) are not close enough substitutes to form a larger relevant market. For the competition agency, we would therefore recommend to operate with these three areas for the meat market: (i) the Czech chicken meat market, (i) pork meat market in the Czech Republic, Slovakia and Germany, and (iii) beef meat market in the Czech Republic and Germany.

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