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Carsten Holst und Stephan von Cramon-Taubadel[1]

Department für Agrarökonomie und
Rurale Entwicklung
Georg-August-Universität Göttingen
D 37073 Göttingen
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[1] **Kontaktadresse**: Carsten Holst, Department für Agrarökonomie und Rurale Entwicklung, Platz der Göttinger Sieben 5, 37073 Göttingen, email: cholst@gwdg.de

Trade, Market Integration and Spatial Price Transmission on EU Pork Markets following Eastern Enlargement

Carsten Holst [*] ***and Stephan von Cramon-Taubadel***
Georg-August-University of Göttingen
Department of Agricultural Economics and Rural Development
Platz der Göttinger Sieben 5, D-37073 Göttingen, Germany
[*] *Corresponding author: cholst@gwdg.de*

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Abstract

The accession of ten countries to the EU in May 2004, and of Bulgaria and Romania in January 2007, eliminated barriers to trade between old and new, and among new member states. We analyse the effects of this accession on the integration of pork markets in the EU. Our results show that the speed of price transmission is positively related to the volume of pork trade between two countries. Our results also reveal that intra-regional price transmission between old or between new member states is more rapid than inter-regional price transmission between old and new member states, and that producer prices in the new member states adjust more rapidly to price changes in the old member states than vice versa. Price transmission is also more rapid between Euro-zone members and member states that share a common border. Finally, our results show that the strengths of these effects have changed in predictable ways in the years since accession took place, as a single, increasingly integrated European pork market has evolved.

1 Introduction

Pork is the most consumed and produced meat in many countries of the European Union (EU). The accession of ten countries[2] to the EU in May 2004, and of Bulgaria and Romania in January 2007, eliminated trade barriers between old and new, and among new member states. This has triggered many changes in production and trade flows. Since accession, pork production has fallen markedly in most of the new member states, for example by more than 50 percent in the Czech Republic and Slovakia. Over the same period, the new member states have increased imports of live slaughter pigs or carcasses, especially from Germany, the Netherlands and Denmark.

The Eastern enlargement of the EU and subsequent changes on pork markets in old and new member states provide a unique opportunity to study the impact of liberalisation and trade on price transmission. It is reasonable to expect that pork prices in the members of the EU will have become more responsive to one another as trade flows have increased. If so, this will be reflected in increasing speeds of pork price transmission among these countries. The aim of this paper is to test whether pork price transmission has indeed become more rapid due to increasing trade flows among the new and old member states of the EU following Eastern enlargement.

To this end we first estimate bilateral spatial price transmission models for producer pork prices in old and new EU member states. We then use panel methods to test whether the estimated speed of price transmission between two countries is affected by the volume of trade in slaughter pigs between these countries. To control for other factors that might influence the speed of price transmission, such as the ease of information flow and the existence of traditional trading networks, we also test whether price transmission is more rapid between countries that share a common border within the EU, and between Euro-zone members. In addition, we test whether price transmission is more rapid between old member states than between new member states, or between old and new member states. The methods that we use allow us to overcome a limitation that has constrained past attempts to directly link patterns of price transmission to trade flows, which is the fact that unlike price data, trade data are rarely available at the high (daily or weekly) frequencies that are generally required to adequately estimate price transmission processes.

[2] Cyprus, the Czech Republic, Estonia, Latvia, Lithuania, Hungary, Malta, Poland, Slovakia and Slovenia

The rest of this paper is structured as follows. A brief survey of the literature on price transmission on pork markets is provided in Section 2. Based on a review of key trends in EU pork production and in intra-EU slaughter pig trade following Eastern enlargement, we derive hypotheses about factors that affect the speed of price transmission on EU pork markets in Section 3. Sections 4 and 5 describe our empirical methods and results, respectively. Chapter 6 closes with a discussion of the results and concluding remarks.

2 Literature review: Price transmission on pork markets

Agricultural markets have been the focus of many price transmission studies. Studies of vertical price transmission focus on the transmission of price changes along the food value chain, while studies of horizontal or spatial price transmission analyses deal with the relationship between prices of homogeneous goods at different locations. Fackler and Goodwin (2001) survey the literature and the methods employed.

On pork markets, many studies analyse vertical price transmission, especially for the U.S. pork sector (i.e. Boyd and Brorsen, 1988; Schroeder, 1988; Goodwin and Harper, 2000; and Gervais, 2011). Vertical price transmission in the pork chain has also been studied for Slovenia (Bojnec, 2002), the Czech Republic (Čechura and Šobrová, 2008), Vietnam (Le Goulven, 2001), China (Xu et al., 2011), South Korea (Park et al., 2012) and Australia (Griffith and Piggott, 1994). Some studies have tested for evidence of asymmetric vertical pork price transmission. Most of these studies (von Cramon-Taubadel, 1998, for Germany; Miller and Hayenga, 2001, for the U.S.; Abdulai, 2002, for Switzerland) find that wholesale or retail prices respond more rapidly to increasing producer prices (which squeeze margins in the pork chain) than they do to falling producer prices (which stretch margins). Bakucs and Fertõ (2005), however, cannot confirm this using Hungarian price data.

Fewer studies consider spatial price transmission on pork markets. Vollrath and Hallahan (2006) study the spatial integration of meat and livestock (including pork) markets in the U.S. and Canada, while de Arêdes et al. (2012) and Chen et al. (2011) investigate regional pork producer prices in Brazil and China, respectively. On European pork markets, Sanjuán and Gil (2001) analyse price transmission between seven member states and confirm the high degree of pork market integration in the EU. Meyer (2004) applies a Threshold Vector Error Correction Model (TVECM) to analyse pork price transmission between Germany and the

Netherlands. He finds that price adjustment only takes place when price differences between these countries exceed trading costs. Serra et al. (2006) argue that parametric models such as the TVECM are often too restrictive for analysing price transmission. They compare the results of a threshold autoregressive model with a non-parametric approach based on local linear regression techniques to examine interactions between producer prices for pork in Germany, Denmark, France and Spain. In a similar vein, Emmanouilidis and Fousekis (2012) test whether pork markets in Denmark, France, Germany and Spain are integrated using an Exponential Smooth Transition Autoregressive (ESTAR) model. Fousekis (2007) uses multivariate cointegration techniques and price data from 14 member states to study EU pork (and poultry) market integration. Finally, Liu (2011) analyses how Finland's EU accession in 1995 has affected the adjustment of Finish meat prices to the price changes in Germany and Denmark.

The studies outlined above use a wide variety of econometric methods, member states and time periods. Despite this variety, all find more or less strong evidence of price transmission among EU pork markets. The assumption underlying these studies is that spatial price transmission is driven by trade flows that are triggered by opportunities for spatial arbitrage. Price transmission can be caused by factors other than trade flows, however. Stephens et al. (2012), for example, find that spatial price transmission between tomato markets in Zimbabwe is generally more rapid in periods without physical trade flows. They argue that even in the absence of physical trade, information flows can lead to co-movement of prices.

In this regard, Barrett (2001) stresses the distinction between market efficiency and market integration. Market efficiency, in the sense of whether prices adhere to spatial equilibrium conditions, can be measured using prices alone. But whether market efficiency is the result of market integration due to physical trade flows, or whether it is caused by other forces (e.g. information flows, or pan-territorial pricing by a state trading institution) can only be determined by analysing trade data as well.

Barrett's point is important, but in practice it is often difficult to distinguish between market efficiency and market integration because trade data are rarely available at the same frequency (often weekly or even daily) that underlies most empirical price transmission analysis. We wish to test whether changes in trade flows following the accession of countries in Eastern Europe have affected the speed of price transmission on EU pork markets. But we face a mismatch between the weekly price data available for estimating pork price transmission, and the highest frequency pork trade data available in the EU, which is monthly. We propose an empirical strategy for overcoming this challenge in section 4.

3 The evolution of pork production and trade in the EU, and implications for price transmission

3.1 The structure of pork production in the EU

Since the two Eastern enlargements of the EU (in May 2004 and January 2007), pork production has developed very differently in the old and the new member states. Table 1 illustrates this by showing how holdings of pigs for fattening in the EU changed between December 2003 and December 2012. Table 1 presents information on the EU as a whole, on the old (EU-15) and the new (EU-12) member states, as well as on the 15 individual member states (ten old – Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Portugal, Spain, and the United Kingdom; and five new – the Czech Republic, Hungary, Poland, Slovakia and Slovenia) that we study in our empirical analysis below.

Table 1 shows that the number of pigs for fattening in the EU-27 decreased by 6 percent between 2003 and 2012. However, this aggregate decrease was composed of a 36 percent contraction in the new member states (EU-12), and a 4 percent expansion in the old member states (EU-15). The contraction was largest in new members that are closest to the old members, for example exceeding 50 percent in the Czech Republic and Slovakia. In Romania, which is located on the Eastern periphery of the EU and which joined the EU later, the number of pigs for fattening fell by only 16 percent. In the old member states production grew especially in Germany, where it increased by almost one-fifth from 2003 to 2012. The Netherlands, Belgium, Italy and Spain also increased production, while the number of fattening pigs receded in other important pork producing countries such as France and Denmark.

The changes in production volumes presented in Table 1 reflect ongoing structural change. Agricultural production structures in the Central and Eastern European countries were distorted by decades of central planning and therefore often highly inefficient. Hence, agriculture in these countries underwent dramatic adjustments in the years following 1990 and prior to EU accession. While this process of transition from central planning was largely complete by the time of accession, structural change continued in response to increased exposure to competition with new partners in the EU. Structural change has also continued in response to ongoing technical change in pork production in the EU and worldwide.

As a result, many small producers in the new member states have ceased production since Eastern enlargement of the EU. Average herd sizes per farm in these countries have increased in the process but remain much smaller than in the old member states. Only in the Czech Republic do herd sizes approach the levels found in France, Germany and Spain, while pig farms in all other Eastern European countries remain comparatively small (Table 1).

Table 1 Changes in the total number of fattening pigs (> 50 kg) between 2003 and 2012, and the average number of all pigs per farm in 2010, in the EU and selected member states

	December 2003 (in 1,000)	December 2012 (in 1,000)	Change 2003-2012	Average number of all pigs per farm (2010)
Germany	10,427	12,459	+ 19 %	459
Netherlands	3,934	4,189	+ 6 %	1743
Belgium	2,807	2,933	+ 5 %	1092
Italy	4,875	5,075	+ 4 %	356
Spain	9,772	10,142	+ 4 %	354
Austria	1,254	1,208	– 4 %	85
France	5,821	5,570	– 4 %	569
Denmark	3,539	3,253	– 8 %	2598
Portugal	716	659	– 8 %	38
United Kingdom	1,704	1,557	– 9 %	445
Other countries of EU-15	2,179	2,018	– 7 %	
Poland	6,300	3,982	– 37 %	39
Slovenia	250	147	– 41 %	14
Hungary	2,308	1,305	– 43 %	18
Czech Republic	1,269	615	– 52 %	477
Slovakia	555	252	– 55 %	55
Other countries of EU-12	5,286*	3,916	– 26 %	
Aggregate EU-15	47,027	49,063	+ 4 %	
Aggregate EU-12	15,968*	10,216	– 36 %	
Aggregate EU-27	62,995*	59,279	– 6 %	

Source: Eurostat (2013a) and Eurostat (2013b).
* The number of fattening pigs is not available for Romania in 2003. This missing value is replaced by the corresponding number for 2004.

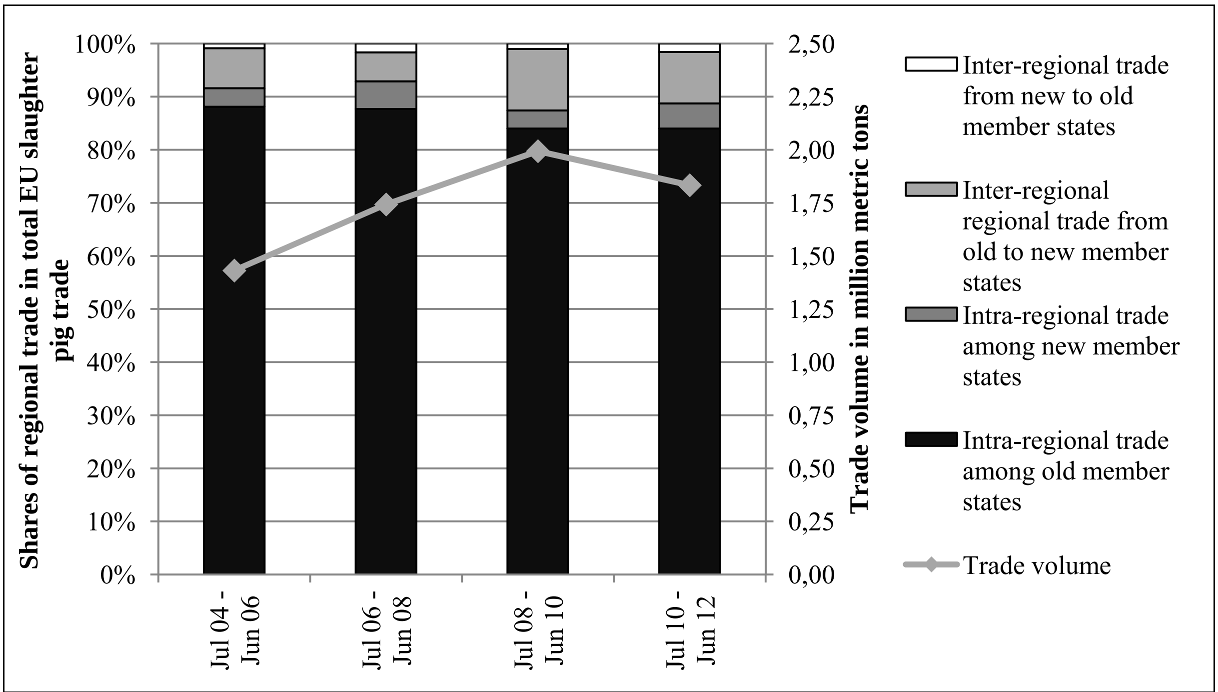
These differences in the structure of pork production are exemplified by comparing Poland and Germany. 93 percent of Polish pig producers held less than 100 pigs in 2010, and roughly 50 percent held less than 10 pigs. While only 0.7 percent of the Polish holdings exceed 500 pigs, these farms together account for nearly one third of Polish production (Skrzymowska, 2012). In Germany only 12.5 percent of the pig farms hold less than

100 animals (accounting for around one percent of Germany's total pig stock), while nearly 87 percent of pork production is realised by farms with more than 500 pigs (AMI, 2011). In Denmark and the Netherlands, the average pork producer holds well over 1000 pigs.

3.2 *Slaughter pig trade in EU*

Figure 1 illustrates changes in the structure of intra-EU slaughter pig trade over four two-year sub-periods between 2004 and 2012. We consider monthly trade of live pure-bred swine (> 50 kg, excluding breeding stock) for the 15 member states listed above. Between 2004 and 2012, a total volume of roughly 7 million metric tons of live slaughter pigs (around 58 million pigs of 120 kg each) was traded among these 15 member states. After increasing from the first to the second and third sub-periods, this volume fell slightly from 2008/10 to 2010/12.

Figure 1 Shares of inter- and intra-regional trade between old and new EU member states* in total intra-EU slaughter pig trade (2004-2012)



Source: Own calculations based on Eurostat (2013c).

* The member states considered are: (old) Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Portugal, Spain and the United Kingdom; and (new) the Czech Republic, Hungary, Poland, Slovakia and Slovenia. Some missing values have been interpolated. Bilateral trade data are often inconsistent (A's reported exports to B differ from B's reported imports from A). We have averaged these flows to calculate the shares presented here.

Figure 1 shows that intra-regional trade among the old member states dominates intra-EU trade with a share of over 80 percent. Of this, German imports from the Netherlands account for nearly 37 percent of all the slaughter pigs traded among these 15 countries. The share of intra-regional trade among the new member states is comparatively small and is mostly due to Hungary's imports from Poland and the Czech Republic's exports to Slovakia. While inter-regional trade from the new to the old member states is negligible, exports of slaughter pigs from old to new member states are higher in the third and fourth sub-periods than in the first and second. Exports from Germany, Denmark and the Netherlands to Poland and Hungary are especially important.

As their pork production has fallen, and their imports from the old member states have increased, the new member states have become increasingly dependent on imported pigs. In Poland, for example, self-sufficiency in pork fell from 105 percent in 2004 to 86 percent in 2011 (ZMP, 2006; AMI, 2013) as production fell (see Table 1) and pork imports increased from 110 to 625 thousand tonnes (Skrzymowska, 2012).

3.3 Implications for pork market integration and price transmission

Together, these trends in EU pork production and trade in the years following Eastern enlargement have implications for the integration of pork markets and the nature of pork price transmission in the EU. We summarise these implications in the following six hypotheses about trade and other factors that affect the speed of price transmission in intra-EU pork trade:

- *Hypothesis 1: Larger volumes of slaughter pig trade between two countries are associated with higher speeds of pork price transmission between these countries*. All other things being equal, larger trade volumes imply more traders and more transactions leading to more transmission of price signals and more rapid correction of any violations of spatial equilibrium conditions.

To test this hypothesis we must control for other factors that might affect the speed of price transmission among EU pork markets. First, the effect of a given volume of trade to or from a country on domestic prices in that country will depend on the size of the country's domestic market. For example, 10,000 tons of pork trade can be expected to have a larger influence on prices in Slovenia than on prices in Germany. Hence, we employ a relative measure of trade defined as the ratio of trade volume to pork production in a country.

Second, trade and price transmission are affected by informal trade barriers such as the similarity of institutions across trade partners, information flows, trust and established trade relations (Huchet-Bourdon and Cheptea, 2011). To account for such factors we formulate and test five additional hypotheses:

- *Hypothesis 2: Price transmission is more rapid between countries that share a common border than between countries that do not*. We expect that price transmission will be more rapid the shorter the distance between the markets in question. Distance is not only correlated with the transport costs of trade, but is also a proxy for institutional similarity and established trade relations. However, since countries are not point markets, there is no unique measure of the distance between them. We use a shared border as a proxy for closeness.
- *Hypothesis 3*: *Price transmission is more rapid between Euro-zone countries.* The transaction costs of trade will be lower between countries that share a common currency due to reduced risk and costs of currency conversion.
- *Hypothesis 4: The speed of intra-regional price transmission in the EU is higher than the speed of inter-regional price transmission*. Many intra-regional trade relations among old or among new member states were established prior to Eastern enlargement. Hence, traders operating within one of these regions (e.g. between Poland and Hungary, or between Germany and Belgium) can draw on a longer tradition of contacts and trust than those engaged in inter-regional trade (e.g. between Germany and Hungary). As a consequence, transaction costs in intra-regional trade will thus tend to be lower, favouring more rapid transmission of prices.
- *Hypothesis 5a: The speed of inter-regional price adjustment has increased over time*. As a corollary to *Hypothesis 4*, we expect that any initial deficits in inter-regional trade relations and trust will have lessened over time since EU accession. Furthermore, pork production systems (pig breeds, feeds, slaughter weights and grading systems) have become increasingly similar across the EU over time. Together, these developments will have increased the speed of price transmission in inter-regional trade.
- *Hypothesis 5b: The speed of intra-regional price adjustment between old member states has fallen over time*. In the case of trade among old member states, we expect that much of the institutional convergence that underlies *Hypothesis 5a* (improvements in trade relations and harmonisation over time) will already have taken place prior to Eastern

enlargement. Moreover, some costs of pork trade have increased over time. For example, energy costs have risen, and animal welfare concerns have led to stricter regulation of live pig transport. On balance, price transmission between old member states may have become slower as a result.

- *Hypothesis 6: In inter-regional pork trade (e.g. Germany-Poland), pork prices in the new member state will respond more rapidly to shocks than prices in the old member state*. Pork markets in the new member states are generally smaller than those in the old member states (Table 1). In response to a deviation from the long-run relation between prices on markets of different size, the price on the smaller market (most often a new member state) will tend to react more strongly than the price on the larger market (most often an old member state).

4 Methods

To test these hypotheses we follow a two-step approach. In the first step we use weekly producer price data from 15 European countries to estimate price transmission models for 105 pairs of countries[3] in four two-year sub-periods since Eastern enlargement (July 2004 – June 2006, July 2006 – June 2008, July 2008 – June 2010 and July 2010 – June 2012). The countries we consider are ten old member states (Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Portugal, Spain, and the United Kingdom), and five new member states (the Czech Republic, Hungary, Poland, Slovakia and Slovenia). These countries account for 96 (62) percent of total pork production in the old (new) member states, and are thus sufficiently representative of the EU as a whole.[4] From each of these price transmission models we extract two measures of the speed of price transmission for the country pair and sub-period in question. The result is a balanced panel of 210 estimates of the speed of price transmission observed over four consecutive sub-periods.

In the second step we use this panel to test whether the speed of price transmission between two countries is affected by the volume of trade between these countries. To control for other factors that might affect the speed of price transmission we include variables such as whether

[3] $105 = (15^2-15)/2$ is the number of possible combinations of the 15 member states we study.

[4] These 15 countries are the member states highlighted in Table 1 above. In 2012, Bulgaria and Romania together accounted for roughly 30 percent of pork production in the new member states. Since they acceded to the EU in 2007, however, the price and trade data that we require is not available over the entire 2004-2012 period for Bulgaria and Romania.

the countries in question share a common border or a common currency (the Euro), and whether trade between them is intra-regional (either old-old or new-new) or inter-regional (old-new or new-old).

4.1 Estimating the speed of price transmission

To estimate the speed of price transmission between two countries we use an approach based on Engle and Granger (1987). Two price series p_t^A and p_t^B from countries A and B respectively are cointegrated if each is a non-stationary process (integrated of order 1 or I(1)) and if the residuals ε_t of the long-run relationship between these prices

(1) $$p_t^A = \beta_0 + \beta_1 p_t^B + \varepsilon_t$$

are stationary (integrated of order 0 or I(0)). According to the Law of One Price (LOP) the prices of a homogeneous product at two locations should differ by no more than the costs of trading that product from one location to the other; in other words these two prices should co-move in the long run, separated by the relevant costs of trade. We therefore impose the restriction $\beta_1 = 1$ in equation (1). In addition, we include a linear time trend to account for possible changes in the trading costs between two countries over time. The resulting specification of the long-run relationship is:

(2) $$p_t^A - p_t^B = \beta_0^* + \sum_{p=0}^{3} \beta_p^* \, time_{p,t} + \varepsilon_t^*.$$

To test whether individual pork price series p_t^A and p_t^B are I(1) we use the ADF (Dickey and Fuller, 1979) and KPSS (Kwiatkowski et al., 1992) tests. To test for cointegration between p_t^A and p_t^B we apply the ADF and KPSS tests to the residuals from equation (2), and confirm the results with the Johansen (1992) trace test.

Once we have established that p_t^A and p_t^B are indeed cointegrated, we use the estimated residuals $\hat{\varepsilon}_t^*$ from equation (2) to estimate a vector error correction model (VECM) for these two prices. This VECM takes the following general form:

(3) $$\Delta p_t^A = \gamma_0 + \sum_{i=0}^{2} \gamma_i^B \, \Delta p_{t-i}^B + \sum_{i=1}^{2} \gamma_i^A \, \Delta p_{t-1}^A + \sum_{p=0}^{3} \alpha_p^{A_B} \, \hat{\varepsilon}_{t-1}^* + \nu_t^A$$

$$\Delta p_t^B = \delta_0 + \sum_{i=0}^{2} \delta_i^A \, \Delta p_{t-i}^A + \sum_{i=1}^{2} \delta_i^B \, \Delta p_{t-1}^B + \sum_{p=0}^{3} \alpha_p^{B_A} \, \hat{\varepsilon}_{t-1}^* + \nu_t^B.$$

The difference between equation (3) and the standard VECM specification is that we allow the so-called adjustment parameters, $\alpha_p^{A_B}$ and $\alpha_p^{B_A}$, to vary across the four sub-periods (which are indexed by $p = 0, 1, 2, 3$). This modification is analogous to the method employed by Amikuzuno and von Cramon-Taubadel (2012) to model seasonal variation in price transmission. Our results indicate that it suffices to include up to two lags of the lagged price changes on the right-hand-side of equation (3).

The adjustment parameters $\alpha_p^{A_B}$ and $\alpha_p^{B_A}$ measure the speed with which price transmission takes place. Hence, they are the parameters of interest in the second stage of our analysis. Error correction, and thus cointegration between p_t^A and p_t^B, requires that $\alpha_p^{A_B} < 0$ and $\alpha_p^{B_A} > 0$. For example, if p_t^A is too high with respect to p_t^B then $\hat{\varepsilon}_t^*$ in equation (2) will be positive. In this case, $\alpha_p^{A_B} < 0$ and $\alpha_p^{B_A} > 0$ in equation (3) ensure that p^A falls and p^B increases in the next period, thus guiding these prices towards the long-run relationship in equation (2). In the context of price transmission we expect that $0 < (-\alpha_p^{A_B} + \alpha_p^{B_A}) \leq 1$.[5] If $(-\alpha_p^{A_B} + \alpha_p^{B_A}) = 1$, then changes in p_t^A and p_t^B will completely correct any deviation from the long-run relationship within one period. Hence, the closer $(-\alpha_p^{A_B} + \alpha_p^{B_A})$ is to 1, the more rapid the transmission between p_t^A and p_t^B. Of course, "rapid" in this context is relative to the frequency of the data being analysed: $(-\alpha_p^{A_B} + \alpha_p^{B_A}) = 0.5$ for weekly data indicates more rapid price transmission than $(-\alpha_p^{A_B} + \alpha_p^{B_A}) = 0.75$ for monthly data. If $\alpha_p^{A_B}$ and $\alpha_p^{B_A}$ are of the same magnitude, then p_t^A and p_t^B adjust equally to deviations from their long-run relationship. Otherwise, the relative magnitudes of $\alpha_p^{A_B}$ and $\alpha_p^{B_A}$ indicate which of the two prices reacts more strongly to a deviation. If market A is much larger than market B, for example, then we expect p_t^B to react more strongly than p_t^A, and therefore $\alpha_p^{B_A}$ to be larger (in magnitude) than $\alpha_p^{A_B}$.

4.2 *Panel regression to explain the speed of price transmission*

The result of the first stage of our analysis is a panel of 210 adjustment coefficients (α_p^A and α_p^B for each of 105 possible pairs of the 15 countries we study) estimated in each of four two-year sub-periods. In the second stage of our analysis we test the six hypotheses presented above by estimating the following panel regression:

(4) $$\alpha_p^{AB} = c + \vartheta_1 lnV_p^{AB} + \vartheta_2 D^{AB} + \vartheta_3 pD^{AB} + \vartheta_4 E^{AB} + \sum_{i=1}^{4} \vartheta_{i+4} R^{AB} + \sum_{i=1}^{4} \vartheta_{i+8}\, pR^{AB} + u_p^{AB}$$

In equation (4) α_p^{AB} is the estimated adjustment parameter for country A in the VECM with country B in sub-period p. V_p^{AB} is the ratio of the bilateral trade in slaughter pigs between A

[5] This is more restrictive than the general condition for cointegration – see Zivot and Wang (2003) and the discussion in Greb et al. (2013) for details.

and B in sub-period p to the average number of slaughter pigs held in country A in sub-period p. D^{AB} and E^{AB} are time-invariant dummy variables that equal 1 if countries A and B share a common border or are both members of the Euro-zone, respectively. We include an interaction term between the common border dummy and the sub-period (pD^{AB}) to test whether border effects have become stronger or weaker over time. Finally, the R^{AB} are dummy variables that distinguish between intra- and inter-regional trade. R^{AB} has four possible expressions: $R_{Intra}^{Old_{Old}}$ and $R_{Intra}^{New_{New}}$ account for cases in which countries A and B are both old or both new member states (intra-regional price transmission); in cases of inter-regional price transmission $R_{Inter}^{New_{Old}}$ and $R_{Inter}^{Old_{New}}$ account for price reactions in new and old member states, respectively. To avoid multicollinearity we omit the last of these four categories. We interact these dummy variables with the sub-period (pR^{AB}) to allow for changes in the strength of intra- and inter-regional trade effects on the speed of price transmission over time.

5 Results

5.1 Preliminary analysis - Time series properties and cointegration

The national average slaughter pig prices that we analyse are reported weekly by the European Commission (2013) in Euro/100 kg grade E carcass weight (see Appendix Figure 1). For the levels of the price the ADF test (Dicker and Fuller, 1979) cannot reject the null hypothesis of a unit root, while the KPSS test (Kwiatkowski et al., 1992) rejects stationarity significantly (Table 2). The opposite results hold for the first differences of the prices. We conclude that the slaughter pig prices are all I(1).

To test for cointegration we next estimate the long-run relationship (equation 2) for each of the 105 possible pairs of slaughter pig prices. According to the ADF and KPSS tests, the residuals of these regressions are all stationary. Furthermore, Johansen's trace test (with constant and trend included, lag order determined according to the Hannan-Quinn criterion) indicates that the null hypothesis of no cointegration can be rejected at the 1 percent level of significance for 103 of the 105 price pairs. The two exceptions are the price pairs Poland-Slovenia and Denmark-Poland, for which the null hypothesis of no cointegration can be rejected at the 2 percent and 10 percent levels, respectively.[6] Altogether, these results confirm that slaughter pig prices in the 15 EU member states that we study are pair-wise cointegrated.

Table 2 Results of the ADF-Test and the KPSS-Test for pork prices in EU member states

	levels of price series			first differences of price series		
	no. of lags♦	ADF-Test	KPSS-Test	no. of lags♦	ADF-Test	KPSS-Test
Austria	2	-0.13	0.56**	1	-13.98***	0.05
Belgium	2	-0.17	0.55**	1	-14.23***	0.05
Denmark	1	+0.45	5.26***	1	-17.21***	0.15
France	1	-0.09	1.49***	0	-15.46***	0.09
Germany	2	-0.13	0.69**	1	-14.12***	0.04
Italy	1	-0.18	2.76***	0	-13.66***	0.04
Netherlands	2	-0.17	0.98***	1	-13.93***	0.04
Portugal	2	-0.32	1.05***	1	-7.85***	0.11
Spain	5	-0.04	0.72***	4	-8.46***	0.08
United Kingdom	3	+0.15	4.63***	2	-7.66***	0.14
Poland	2	+0.14	2.66***	1	-13.72***	0.08
Hungary	1	-0.06	2.20***	0	-14.74***	0.06
Czech Republic	2	-0.26	1.56***	1	-9.23***	0.04
Slovakia	4	+0.06	1.50***	3	-9.13***	0.07
Slovenia	1	+0.11	1.05***	0	-13.66***	0.05

Source: Own estimates; significance levels: 5% (**), 1% (***).
♦ Number of lags selected according to the Hannan-Quinn-Criterion (Hannan and Quinn, 1979) by the time series software JMulTi (Lütkepohl and Krätzig, 2004).

5.2 *Step 1 – Vector error correction models and the speed of price transmission*

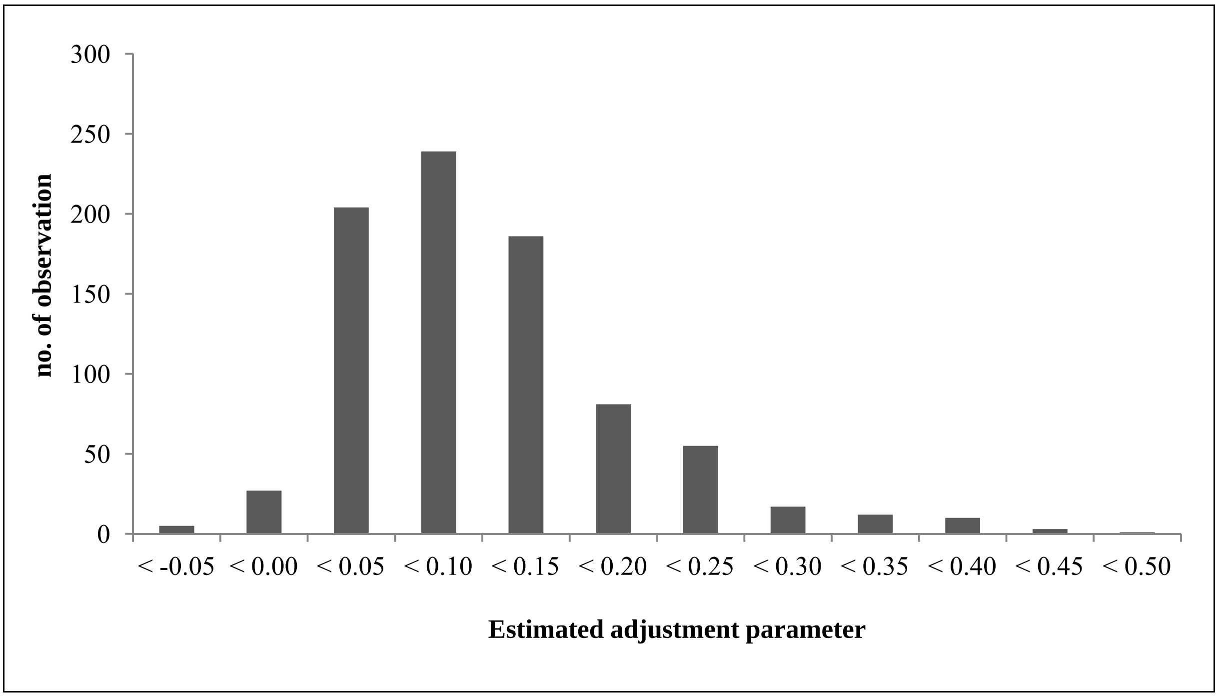
We first estimate the VECM in equation (3) for all 105 pairs of slaughter pig prices. The result is a panel of 840 estimates of adjustment parameters; two estimated parameters ($\alpha_p^{A_B}$ and $\alpha_p^{B_A}$) for each of 105 pairs in each of four sub-periods. Figure 2 presents the distribution of these estimated adjustment parameters. In Figure 2, estimated adjustment parameters that have the expected sign (recall that cointegration requires $\alpha_p^{A_B} < 0$ and $\alpha_p^{B_A} > 0$) are depicted as positive values; those that have the unexpected sign ($\alpha_p^{A_B} > 0$ or $\alpha_p^{B_A} < 0$) are depicted as negative values. Figure 2 shows that the estimated adjustment parameters have the expected signs in 808 of 840 cases. Correspondingly, 32 estimated parameters have unexpected signs that are incompatible with cointegration between the prices in question. However, none

[6] Results are available from the authors.

of these 32 estimates differs significantly from zero. Furthermore, in all 32 cases the other estimated adjustment parameter for the price pair in question has the expected sign and is larger in magnitude, thus ensuring that the condition for cointegration $(0 < (-\alpha_p^{A_B} + \alpha_p^{B_A}) \leq 1)$ is satisfied. These results confirm the finding of cointegration between all possible price pairs reported above.

The estimated adjustment parameters can be interpreted as follows: $\alpha_p^{B_A}$ = 0.15, for example, means that if prices in countries B and A deviate from their long-run equilibrium in week $t-1$, prices in country B will change in week t in a manner that corrects 15 percent of this deviation. Most of the estimated adjustment parameters depicted in Figure 2 are in a range between 0.00 and 0.15, and the median estimate is 0.086. However, the speed of price adjustment is considerably higher for some intra-regional relationships between old member states of the EU, especially Belgium, France, Germany and the Netherlands. For example, in the first sub-period (July 2004 – June 2006) the estimated adjustment parameters indicate that 90 percent of any deviation from the long-run equilibrium between Germany (Ger) and the Netherlands (NL) are corrected within one week: $\alpha_p^{Ger_{NL}}$ = 0.453 and $\alpha_p^{NL_{Ger}}$ = 0.447.

Figure 2 Histogram of the estimated speeds of price adjustment*



Source: Own presentation based on VECM results.
* Estimated adjustment parameters that have the expected sign are depicted as positive values; those that have the unexpected sign are depicted as negative values

5.3 *Step 2 – Explaining the speed of price transmission*

In the second step of our analysis we estimate the panel regression model in equation (4). The generalised least squares estimates are presented in Table 3. Breusch-Pagan test results indicate that we should use panel methods rather than pooled ordinary least squares, and the Hausman test provides evidence in favour of random over fixed effects (e.g. Verbeek, 2008; Breusch and Pagan, 1980; and Hausman, 1978).

Table 3 Results of the panel model with random effects (dep. var.: speed of price adjustment)

Symbol	Variable	Coefficient	Std. dev.	p-value	Sign.
c	Constant	0.041	0.009	<0.001	***
V_p^{AB}	*ln*(bilateral trade volume between A and B / number of pigs in A)*	0.018	0.004	<0.001	***
D^{AB}	Dummy(Common border)	0.036	0.012	0.004	***
pD^{AB}	Sub-period*Common border	-0.005	0.004	0.222	
E^{AB}	Dummy(Common currency)	0.013	0.008	0.104	
$R_{Intra}^{Old_{Old}}$	Dummy(Intra-regional trade among old member states)	0.060	0.013	<0.001	***
$pR_{Intra}^{Old_{Old}}$	Sub-period*Intra-regional trade among old member states	-0.011	0.003	<0.001	***
$R_{Intra}^{New_{New}}$	Dummy(Intra-regional trade among new member states)	0.076	0.018	<0.001	***
$pR_{Intra}^{New_{New}}$	Sub-period*Intra-regional trade among new member states	0.001	0.005	0.913	
$R_{Inter}^{Old_{New}}$	Dummy(Inter-regional trade, adjustment in old member states)	-	-	-	-
$pR_{Inter}^{Old_{New}}$	Sub-period*Inter-regional trade, adjustment in old members	0.007	0.003	0.035	**
$R_{Inter}^{New_{Old}}$	Dummy(Inter-regional trade, adjustment in new member states)	0.046	0.013	<0.001	***
$pR_{Inter}^{New_{Old}}$	Sub-period*Inter-regional trade, adjustment in new members	0.013	0.003	<0.001	***
	R^2	0.245			
	Breusch-Pagan-Test	$\chi^2(1) = 285.3$ ($p<0.001$)			
	Hausman-Test	$\chi^2(7) = 10.8$ ($p=0.149$)			

Source: Own calculations; significance levels: 5% (**), 1% (***).
* Bilateral trade volume in tons/year averaged over the two-year sub-period, divided by the average number of pigs of over 50kg weight in 1000 head in the two December animal censuses in that sub-period.

We interpret the results in Table 3 with respect to the 6 hypotheses derived above as follows:

Hypothesis 1: The positive and significant coefficient for the variable V_p^{AB} confirms that the speed of price transmission between two countries increases with the ratio of their bilateral trade to their respective production volumes. Taking the Netherlands and Slovakia in the 2010-2012 sub-period as an example, the large share of Slovakian pork imports from the Netherlands in total Slovakian pork production increases the adjustment parameter for

Slovakian prices in the VECM with Dutch prices by roughly 0.054 over what it would be if there were no trade between these countries. Hence, increases in intra-EU pork trade following Eastern Enlargement have increased the speed of price transmission and the efficiency of EU pork markets.

Note that in over 70 percent of the country pairs that we study, bilateral pork trade flows are zero or very small. For example, there is very little pork trade between Spain and Poland. Nevertheless, as presented above, we find evidence of cointegration for all country pairs, including pairs such as Spain and Poland. While the speed of price transmission does increase with the volume of trade between two countries, physical trade is obviously not a necessary condition for price transmission. This corroborates the results in Stephens et al. (2012) and suggests that other factors such as information flows and shared trade links with third countries (both Spain and Poland do trade pork with Germany, for example) can lead to price transmission.

Hypothesis 2: The speed of price transmission between two countries is higher if they share a common border. The estimated coefficient for the dummy variable D^{AB} is positive and significant, and equals 0.036 in the first sub-period (July 2004 – June 2006). Thus, if two EU member states share a common border, deviations from their joint long-run pork price relationship will be corrected by 3.6 percent more per week than if they did not share a common border. The negative coefficient (-0.005) for the interaction between this dummy and the sub-period index (pD^{AB}) suggests that the importance of geographic proximity has declined in the years following Eastern enlargement, however this effect is small and statistically insignificant.

Hypothesis 3: The speed of price transmission is more rapid between Euro-zone countries. However, this coefficient (0.013, which indicates that deviations from the long-run price relationship between two countries are corrected by 1.3 percent per week more if both countries are Euro-zone members) is not quite significant at conventional levels (p=0.104).

Turning to the effects of intra- and inter-regional trade, recall that we exclude the dummy $R_{Inter}^{Old_{New}}$, which corresponds to price adjustment in an old member state in the case of inter-regional trade with a new member state ($\alpha_p^{Old_{New}}$). Hence, the estimated coefficients of the remaining three dummy variables, which are all positive and significant, indicate that all other types of price adjustment ($\alpha_p^{New_{Old}}$ in the case of inter-regional trade, and both $\alpha_p^{Old_{Old}}$ and $\alpha_p^{New_{New}}$ in the case of intra-regional trade) are more rapid than $\alpha_p^{Old_{New}}$.

Hypothesis 4: Both dummy variables for intra-regional trade (between old member states and between new member states) are positive and significant. In the case of intra-regional trade between old member states, the estimated coefficient equals 0.060; in the case of intra-regional trade between new member states the estimated coefficient equals 0.076. In the case of inter-regional trade, the corresponding coefficients equal 0.046 (for price adjustment in the new member state) and zero (the omitted dummy category for price adjustment in the old member state). Together, these results confirm that pork prices are transmitted more rapidly between old or between new member states than they are transmitted between old and new member states.

Hypothesis 5a: The speed of inter-regional price transmission has increased over time as the new member states have become increasingly integrated into the EU pork market. The coefficient on the interaction term $pR_{Inter}^{New_{Old}}$ indicates that the speed of inter-regional price transmission from old to new member states has increased by 0.013 per sub-period, or by almost 4 percent over the entire study period. Moreover, the estimated coefficient for the interaction term $pR_{Inter}^{Old_{New}}$ (0.007) is also positive and significant. This indicates that in the years following Eastern enlargement of the EU pork prices in the old member states have become more sensitive to price signals on pork markets in the new member states.

Hypothesis 5b: The speed of intra-regional price adjustment between old member states has fallen over time. The negative and significant estimated coefficient on the interaction term $pR_{Intra}^{Old_{Old}}$ (-0.011) might reflect increasing costs of pork trade, for example due to stricter regulation of live animal transport. In the case of intra-regional trade between the new member states the coefficient for the corresponding interaction term ($pR_{Intra}^{New_{New}}$) is positive but insignificant (0.001). This might be interpreted as evidence that increases in the costs of pork trade over time (which would reduce the speed of price transmission) have been compensated in the new member states by the positive effects of improvements in trade infrastructure and the development of trade networks and trust.

Hypothesis 6: Prices in new member states react significantly and increasingly rapidly to deviations from their long-run relations with prices in old member states, but prices in old member states remain comparatively insensitive to such deviations, despite the increases noted above (the estimated coefficient of 0.007 for the interaction term $pR_{Inter}^{Old_{New}}$). This can be attributed to the fact that pork markets in the new member states are generally smaller than those in the old member states.

6 Conclusions

Eastern enlargement of the EU has lead to increasing integration of pork markets in the old and new member states. Our empirical results confirm that the speed of price transmission between any two pork markets in the EU increases with the volume of trade in slaughter pigs between these markets. However, we also find evidence of price transmission between countries that do not trade pork with one another. Hence, we confirm that physical trade is not a necessary condition for price transmission. Our results also indicate that price transmission is more rapid between countries that share a common border or a common currency (the Euro). In addition, the speed of pork price transmission is higher in intra-regional trade (between old or between new member states) than in inter-regional trade. In inter-regional trade between new and old member states, producer prices for slaughter pigs in the new member states adjust more rapidly than prices in the old member states.

It therefore appears that over time pork markets in the new member states have become increasingly integrated into the much larger and established pork trade network in the old member states. Increased integration with pork markets in the old member states has increased competition and forced many small-scale producers in the new member states to exit pig production. This structural change will probably continue in the coming years. Whether pork trade flows from old to new member states will continue to increase, as they have since Eastern enlargement of the EU, depends on if and when investments in more competitive large-scale production units in the new member states begin to outweigh the continued decline in small-scale production.

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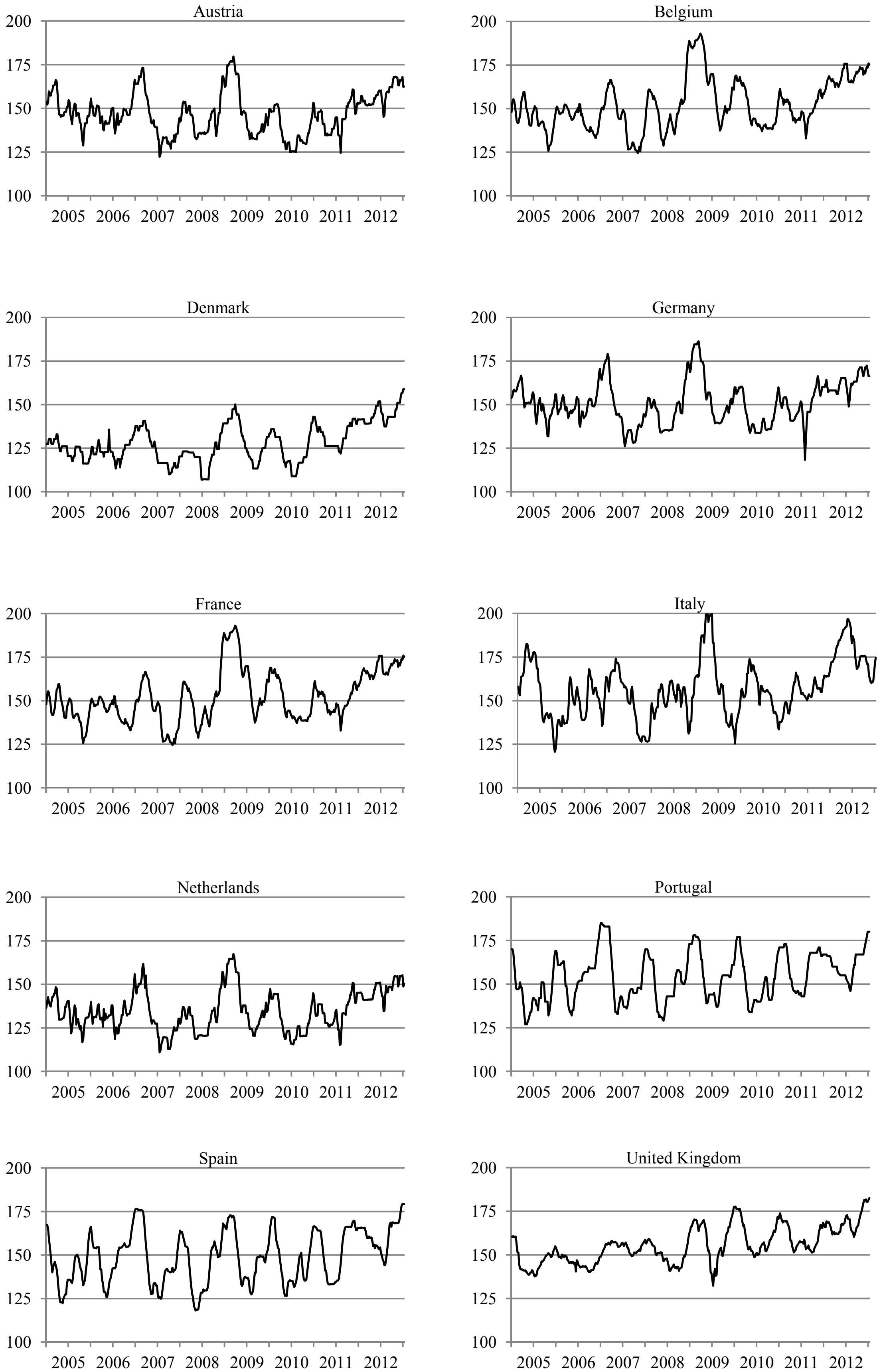
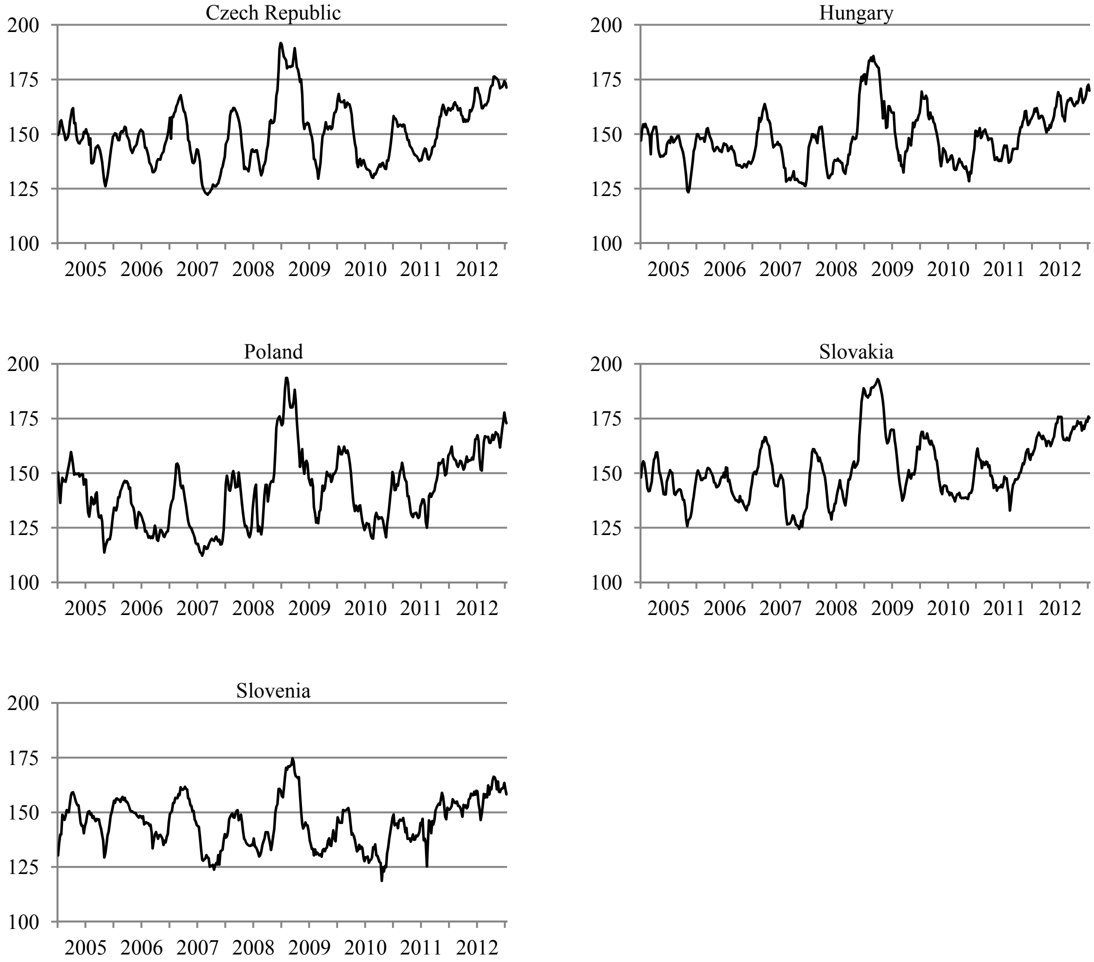
Appendix Figure 1 Producer prices for pork in different member states of the EU, in €/100 kg carcass weight (pig carcass grade E)





Source: European Commission (2013)

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	2013	
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Die Wurzeln der **Fakultät für Agrarwissenschaften** reichen in das 19. Jahrhundert zurück. Mit Ausgang des Wintersemesters 1951/52 wurde sie als siebente Fakultät an der Georgia-Augusta-Universität durch Ausgliederung bereits existierender landwirtschaftlicher Disziplinen aus der Mathematisch-Naturwissenschaftlichen Fakultät etabliert.

1969/70 wurde durch Zusammenschluss mehrerer bis dahin selbständiger Institute das **Institut für Agrarökonomie** gegründet. Im Jahr 2006 wurden das Institut für Agrarökonomie und das Institut für Rurale Entwicklung zum heutigen **Department für Agrarökonomie und Rurale Entwicklung** zusammengeführt.

Das Department für Agrarökonomie und Rurale Entwicklung besteht aus insgesamt neun Lehrstühlen zu den folgenden Themenschwerpunkten:

- Agrarpolitik
- Betriebswirtschaftslehre des Agribusiness
- Internationale Agrarökonomie
- Landwirtschaftliche Betriebslehre
- Landwirtschaftliche Marktlehre
- Marketing für Lebensmittel und Agrarprodukte
- Soziologie Ländlicher Räume
- Umwelt- und Ressourcenökonomik
- Welternährung und rurale Entwicklung

In der Lehre ist das Department für Agrarökonomie und Rurale Entwicklung führend für die Studienrichtung Wirtschafts- und Sozialwissenschaften des Landbaus sowie maßgeblich eingebunden in die Studienrichtungen Agribusiness und Ressourcenmanagement. Das Forschungsspektrum des Departments ist breit gefächert. Schwerpunkte liegen sowohl in der Grundlagenforschung als auch in angewandten Forschungsbereichen. Das Department bildet heute eine schlagkräftige Einheit mit international beachteten Forschungsleistungen.

Georg-August-Universität Göttingen
Department für Agrarökonomie und Rurale Entwicklung
Platz der Göttinger Sieben 5
37073 Göttingen
Tel. 0551-39-4819
Fax. 0551-39-12398
Mail: biblio1@gwdg.de
Homepage : http://www.uni-goettingen.de/de/18500.html