Market power on the edge?
An analysis of the German and Hungarian hog markets

Marktmacht auf der Kippe?
Eine Analyse der deutschen und ungarischen Schweinemärkte

Lajos Zoltán Bakucs and Imre Fertő
Hungarian Academy of Science, Budapest, Hungary

Heinrich Hockmann and Oleksandr Perekhozhuk
Leibniz Institute of Agricultural Development in Central and Eastern Europe (IAMO), Halle (Saale), Germany

Abstract

A structural market model is estimated to analyse the impact of market power on resource allocation in the German and Hungarian pork markets. The regression analyses suggest that market power exists, although on a relatively low level. Moreover, the estimates show that processors might pursue Cournot strategies. In addition, we observe that the market power of processors in the German hog sector is decreasing, while in the Hungarian sector it is increasing. These results are consistent with the structural developments in pork production and pork processing.

Key words

market power; Germany; Hungary; pork chain

Zusammenfassung

Ein strukturelles Marktmodell wird geschätzt, um zu beurteilen, ob die Ausübung von Marktmacht die Ressourcenallokation auf den deutschen und ungarischen Schweinefleischmärkten verzerrt. Die Regressionsanalysen zeigen, dass zwar nicht von perfekten Märkten ausgegangen werden kann, die durch die Ausübung von Marktmacht bedingten Verzerrungen allerdings als gering anzusehen sind. Die Schätzungen implizieren, dass die Fleischverarbeiter sich konsistent mit der Verfolgung von Cournot-Strategien verhalten. Zusätzlich deuten die Schätzungen darauf hin, dass die Marktmacht der Verarbeiter im deutschen Schweinesektor abnehmend ist, während sie sich im ungarischen Sektor erhöht. Diese Resultate stimmen mit den strukturellen Entwicklungen in der Schweinefleischproduktion und in der Schweinefleischverarbeitung überein.

Schlüsselwörter

Marktmacht; Deutschland; Ungarn; Schweinefleischkette

1. Introduction

The last decades have been characterised by changing requirements on all food chains. Structural change in retailing, processing and farming, together with growing market saturation and increasing consumer concerns regarding product and process quality have strongly influenced not only organisational type and structure, but also the generation of profits along the food chain. Despite the growing emergence of vertically integrated structures, market allocation still plays a major role in the governance of product flows within food chains. Moreover, starting with agriculture, the number of firms in downstream sectors (processors, retailers) decreases. Because of the oligopsonsitic market structure on both the retail and processing levels, these sectors might be able to exploit their favourable position. Market power can be exerted by various means. The most obvious way for processors to exploit market power is to depress purchasing prices in upstream sectors below the level of a perfectly functioning market. Other uses of market power are to deter market entry or foster market exit. Generally, market power induces a biased allocation of resources within the value chain. Besides welfare losses associated with suboptimal resource allocation, market power will lead to a redistribution of factor incomes at the cost of both upstream and downstream sectors.

Empirical analysis initiated by the work of HARBERGER (1954) suggested that the impact of market power on overall economic performance is expected to be rather small. However, conclusions may be altered when looking at individual sectors. Since many agricultural products are supplied inelastically, the exertion of market power may have more severe consequences on allocation and factor remuneration in this sector than in others. Although the need to investigate the impact of market power is broadly acknowledged (MCCORRISTON, 2002), the relevance of this topic does not correspond to the number of studies. In fact, studies of market power in European food chains (especially for transition countries) are rather rare.

This paper contributes to the closure of this gap in literature. As such, its aim is to identify the magnitude of market power and to discuss possible consequences for development in the Hungarian and German pork chains, and on the hog market in particular. The chains exhibit some similar structural features. First, there is at least some indication of a dual structure in agriculture. In Hungary this development is a result of the transition process. In Germany, however, it is due to unification in 1990, when two rather different agricultural systems (family farming in the Western part and large-scale enterprises in the East) merged. Second, the pork chains in both countries are not subject to high foreign direct investment (FDI). This implies that development within the chains is not biased by the activities of large multinational enterprises, which could exploit significant market power, especially in a relatively small country as Hungary. Furthermore, taking Germany as a reference, we investigate whether there are some specific transition effects on the emergence of market power, i.e., whether the transition process in Hungary contained frictions that hindered the development of well functioning markets.

This paper is organised into five sections. The introduction is followed by a discussion of the relevance of investigating market power in food chains. In addition, a literature review is provided. Chapter 3 provides some basic facts about market and firm structures, as well as their development in the German and Hungarian pork chains. Section 3 presents our theoretical model and its empirical implementation. The results of the estimation are discussed in Section 4. A discussion of the implications, as well as limitations of the model is provided in Section 5.

2. The significance of market power

Generally, two approaches regarding the investigation of market power can be distinguished. The first is (vertical) price transmission analysis. Within this framework, the symmetry of joint movements of prices at different levels is tested. There are a great number of empirical studies dealing with marketing margin and asymmetry problems in livestock markets. VON CRAMON-TAUBADEL (1998) finds asymmetrical price transmission in the German pork market. DAWSON and TIFFIN (2000) identify a long-run price relationship between UK lamb farm-retail prices, and study the seasonal and structural break properties of the series, concluding that the direction of Granger causality is from retail to producer prices. Thus, lamb prices are set in the retail market. Threshold Autoregressive Models were developed by GOODWIN and HOLT (1999), GOODWIN and HARPER (2000) and BEN-KAABIA et al. (2002) in studies of the US beef sector, US pork sector and Spanish lamb sector, respectively. GOODWIN and HOLT (1999) found that farm markets do adjust to wholesale market shocks, whilst the effect of retail market shocks is largely confined to retail markets. In their pork market study, GOODWIN and HARPER (2000) found a unidirectional price information flow from farm to the wholesale and retail levels. Farm markets adjust to wholesale market shocks, but retail level shocks are not passed on to wholesale or farm levels. BEN-KAABIA et al. (2002) establish a symmetric price transmission, concluding a long-run perfect price transmission, where any supply or demand shocks are fully transmitted through the system. They also observe that an increased horizontal concentration allows retailers to exercise market power. BOJNEC (2002) found that both the Slovenian farm-gate beef and pork markets are weakly exogenous in the long run, with a mark-up long-run price strategy for beef and a competitive price strategy for the pork market. BAKUCS and FERTŐ (2005 and 2006) use VECM and cointegration with structural breaks models to study price transmission on the Hungarian pork and beef markets, and found competitive pricing and no evidence of price transmission asymmetries.

Most empirical results emphasise the presence of feedback among the different market levels, and support the imperfect price transmission between farm and retail markets in all meat categories studied. In short, most studies find asymmetrical price transmission in livestock markets, also establishing a mostly unidirectional price information flow from farm to wholesale and finally to retail levels. However, while symmetric movements suggest well-functioning markets, asymmetric movements can only be attributed to market imperfections when several restrictive assumptions are met. These comprise no delays in price adjustment, no demand or technological change, no outsourcing of functions, and no increase of other production costs at the retail and processor level etc. (MEYER and VON CRAMON-TAUBADEL, 2004).

The second approach was developed in the context of New Industrial Economics (BRESNAHAN, 1982 and 1989). Starting with APPELBAUM (1982), the investigation of market power focuses on the conduct of firms in an industry and attempts to identify market power by the estimation of structural market models. In this framework, conduct is usually described by a firm's conjectural variation, i.e., the expected reaction of competitors to an increase in output or demand. A few studies have been conducted regarding food processing. MUTH and WOHLGENANT (1999) analysed whether the US meat packaging industry possesses market power in the input or output markets. In both cases the hypothesis of market power had to be rejected. Similar results were derived by MORRISON PAUL (1999), who found significant market power in this industry, though at a relatively low level. Market power in US food retailing was analysed by PARK and WELIWITA (1999). According to their estimates, there is some evidence that together with the concentration process in retailing, there was an emergence of market power, though also at a low level. In his analysis of the German meat market, ANDERS (2005) reached the same conclusion. The findings in DOBSON et al. (2003) contradict sharply these conclusions. Their results suggest that the ongoing concentration processes allow retailers to dictate terms and conditions to processors.

Recent papers have attempted to establish the link between price transmission and market power. WELDEGEBRIEL (2004) evaluates the impact of oligopsony power on the degree of price transmission using a formal theoretical model. He shows that when taking the degree of price transmission in a perfectly competitive market as a benchmark, oligopoly and oligopsony power do not necessarily lead to imperfect price transmission, although they can. Indeed, they may counteract each other's impact on the degree of price transmission. The outcomes depend on the functional forms for retail demand and farm supply. LLOYD et al. (2006) show that if market power has an effect on the farm–retail margin, this determines the specification of the cointegrating relationship and thus provides a test of market power. Their results for the UK beef chain suggest that the importance of market power cannot be rejected.

3. Developments in the German and Hungarian pork chains

3.1 German pork chain

In order to facilitate a better understanding of the estimation results, it is essential to provide some background information regarding the structural development in pork production and processing. Figure 1 provides information about the number of slaughterhouses and meat processors, and the amount of meat produced. Meat production shows a slight but steady increase in the period under investigation. The same holds, though with fluctuations, for the number of meat processors. Since the data covers all firms with more than 20 employees, the increase is not an indication of market entry but of firm growth. Moreover, this also indicates that concentration processes have not yet started in the

338

German meat processing industry. The same holds for slaughterhouses. The number of these enterprises was relatively stable in the period under investigation. In addition, slaughtering is much more concentrated than processing. One slaughterhouse delivers to four processors, on average.

The fact that no market exit can be observed is rather astonishing. The restructuring of food chains in Eastern Germany resulted in the creation of high slaughtering and processing capacities. Together with the collapse of meat production, this resulted in high overcapacities and strong competition on the market for pigs and pork as well (WELLERT, 2000). Both the existence of overcapacities and strong competition would suggest accelerated concentration processes. Moreover, market exit may have taken place but could not be revealed by our data set. The reason is that the growth of small slaughterhouses and processing facilities has balanced out the exit of larger enterprises.

Figure 2 shows some indicators regarding pig production in Germany. Corresponding to the increase in meat production, the number of pigs is also slightly increasing. Contrary to the situation in the slaughtering and processing industries, structural change in agriculture is much more pronounced. Within one decade, the number of pig farms declined by more than 50% and, consequently, significant increases of herd sizes could be observed. This development in the farm sector may have changed the bargaining position of the farmers considerably and thus may have led to a redistribution of power among the partners. We will consider this possibility in the deduction of the empirical model.

3.2 Hungarian pork chain

The Hungarian meat industry is characterised by a distorted market structure, which is emphasised by the large number of small, not very cost efficient firms. The dramatic decrease of raw material production left many of the formerly efficient larger companies struggling with unused processing capacity.

JANSIK (2000), studying the FDI in Hungary, finds that industries characterised by a monopolistic market structure (sugar, vegetable oil, tobacco, soft drinks, starch) were privatised in the early 1990s and have over 70% foreign ownership of their capital. Meat processing is the largest food

industry, accounting for over 18% of the total Hungarian food processing output. Meat industry sales show a slightly growing trend (figure 3). The number of firms shows a J curve. This number dropped by about one-half between 1996 and 2000, and then started to grow again. The privati-

Figure 1. **Evolution of the number of meat processors, slaughterhouses and meat production in Germany**
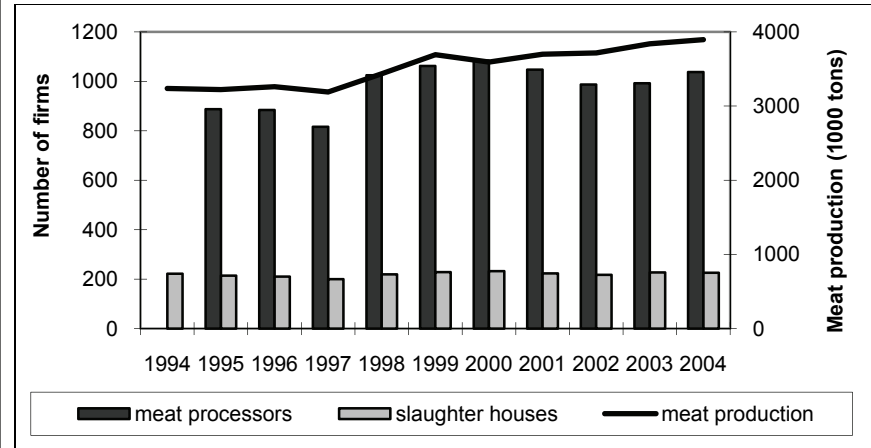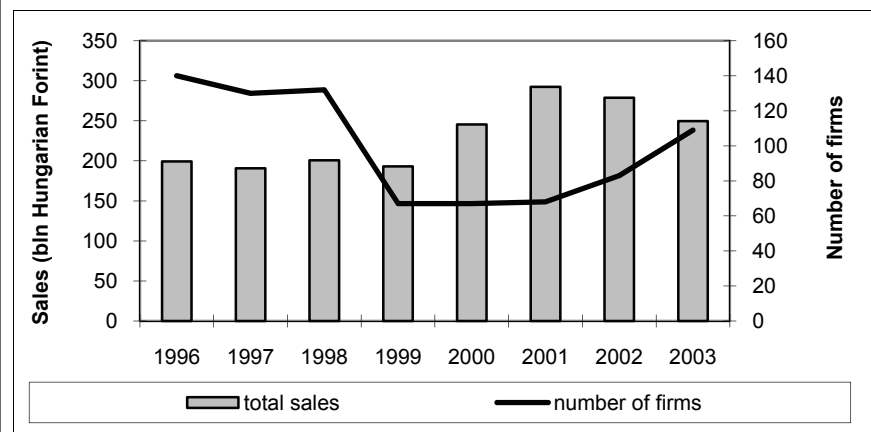

Source: ZMP (various issues)

Figure 2. **Evolution of the number of pig farms, average herd size, and total number of pigs in Germany**
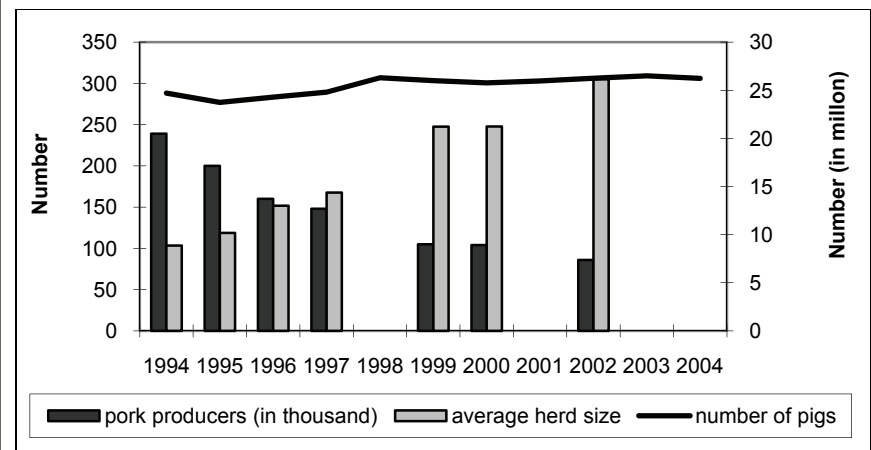
Source: ZMP (various issues)

Figure 3. **Evolution of total sales and number of firms in the meat industry sector in Hungary**

Source: HCSO (2007), AKI (various accesses)

sation of the meat industry started late, in the mid-1990s, and was characterised by low FDI. In 2005, approximately 40% of total capital was under foreign ownership. Thus, the concentration process was delayed; the share of the five largest firms was still rather low, with 30.6% in 1992 and 44.1% in 2003.

The Hungarian pork sector has experienced numerous structural changes in the past 15 years. From the 9.5 million head in September 1990, the pig stock decreased to 4.3 million by December 1994, and has fluctuated around 5 million head ever since. One important feature of the Hungarian pig sector is the large number of small-scale farms. Even before privatisation, small-scale farms accounted for 50% of the total pig stock, a figure that had not changed significantly by 2005. Many of these small-scale farms do not have commercial activity, i.e., they are subsistence farms. However, a large proportion does sell their products, which forms a two-tier commercial and family pork production system.

The average herd size by farm type illustrates unambiguously the dual production structure in the Hungarian pork sector. The average herd size in Hungary varied between 9-16 pigs, however, these numbers hide the significant differences between various farm types. Private farms on average hold 5 to 7 pigs, whilst the average herd size for economic organisations is 3.3 to 4.4 thousand pigs (see table 1).

Table 1.	Average herd size in Hungary		
Year	Private farms	Economic organisations	Total
1996	5.6	3 836	10.2
1997	5.0	4 177	9.3
1998	5.6	4 595	10.2
1999	5.9	4 484	10.7
2000	5.2	3 374	10.6
2001	6.3	3 891	12.7
2002	7.0	4 137	14.5
2003	5.2	3 903	11.3
2004	6.7	3 884	16.0

Source: HCSO (2007)

4. Theoretical background

4.1 Structural model of oligopsony market power

We follow the methodology developed by BRESNAHAN (1982) and MUTH and WOHLGENANT (1999) to test for oligopsony market power. The profits of a representative processor are:

$$(1) \quad \pi_i = p \, f(x_i, \mathbf{z}_i) - r_x \, x_i - \mathbf{r_z}' \mathbf{z}_i,$$

where x_i is the number of pigs slaughtered and $\mathbf{z}_i$ is a vector of demand shifters (usually other inputs). P and $\mathbf{r_z}$ represents prices of outputs and other inputs, respectively, while r_x is the price of pigs, which is given by the inverse pork supply function:

$$(2) \quad r_x = g(x, \mathbf{s}).$$

Here, $\mathbf{s}$ is a vector of supply shifters and x represents total hog supply. This setting implicitly assumes that slaughter-

houses and pork processors produce homogeneous goods and act as price-takers on the output market while they are able to influence prices on the procurement market.

The first order condition of profit maximisation is:

$$(3) \quad p \cdot \frac{\partial f(x_i, \mathbf{z})}{\partial x_i} - r_x - \frac{\partial g(x, \mathbf{s})}{\partial x} \frac{\partial x}{\partial x_i} x_i = 0,$$

where, $\dfrac{\partial x}{\partial x_i}$ represents the increase of farm supply (or total demand) induced by an increase of firm i's demand. In the case of a perfect market, this derivative is zero and we have a usual first-order condition for price-taking behaviour. In a monopsony or under Cournot competition, the parameter is equal to one.

The first order condition can be aggregated over all n firms in the industry. Defining this,

$$\frac{1}{n} \sum_{i=1}^{n} \frac{\partial f(x, \mathbf{z}_i)}{\partial x_i} = \frac{\partial f(x, \mathbf{z})}{\partial x}$$

(3) can be written as:

$$(4) \quad r_x \left(1 + \frac{\Theta}{\varepsilon_x}\right) = p \frac{\partial f(x, \mathbf{z})}{\partial x},$$

where $\varepsilon_x = \dfrac{\partial x}{\partial r_x} \dfrac{r}{x}$ denotes the price elasticity of pork supply

and $\Theta = \dfrac{1}{n} \sum_{i=1}^{n} \dfrac{\partial x}{\partial x_i} \dfrac{x_i}{x}$ is the average input conjectural elas-

ticity and captures the degree of market power (BRESNAHAN, 1989). The parameter range is $0 < \Theta < 1$, where $\Theta = 0$ corresponds to a perfectly competitive market, while $\Theta = 1$ characterises a monopsonistic market or perfect collusion. Cournot competition suggests $\Theta = \dfrac{1}{n}$.

5. Empirical analysis and interpretation

5.1 Econometric implementation

PERLOFF and SHEN (2001) demonstrated that linear structural market models produce completely unreliable estimates due to severe multicollinearity. The problem is mitigated partially by using flexible function forms (SEXTON and LAVOIE, 2001).

Taking this into account, we used a translog function to specify pork supply g:

$$(5) \quad \begin{aligned} \ln x &= \alpha_0 + \alpha_x \ln w_x + \frac{1}{2}\alpha_{xx}\left(\ln w_x\right)^2 \\ &+ \alpha_s' \ln \mathbf{s} + \frac{1}{2}\ln \mathbf{s}' \mathbf{A}_{ss} \ln \mathbf{s} + \ln \mathbf{s}' \mathbf{a}_{sw} \ln w_x \end{aligned}$$

Substituting the supply elasticity,

$$(6) \quad \varepsilon_x = \frac{\partial \ln x}{\partial \ln w_x} = \alpha_x + \alpha_{xx} \ln w_x + \ln \mathbf{s}' \mathbf{a}_{sw}$$

into the optimality condition (4) provides:

340

$$(7) \quad r_x \left(1 + \frac{\Theta}{\alpha_x + \alpha_{xx} \, ln \, w_x + ln \, \mathbf{s}' \mathbf{a}_{sw}} \right) = p \frac{\partial f(x, \mathbf{z})}{\partial w} \; .$$

The marginal product $\partial f(x, \mathbf{z})/\partial x$ was derived from a translog specification of the production function:

$$(8) \quad \begin{aligned} \ln y &= \beta_0 + \beta_x \ln x + \frac{1}{2} b_{xx} (\ln x)^2 \\ &+ \boldsymbol{\beta}_z ' \ln \mathbf{z} + \frac{1}{2} \ln \mathbf{z}' \mathbf{B}_{zz} \ln \mathbf{z} + \ln \mathbf{z}' \mathbf{b}_{zx} \ln x \end{aligned}$$

The marginal product is obtained as:

$$(9) \quad \frac{\partial y}{\partial x} = \frac{\partial \ln y}{\partial \ln x} \frac{y}{x} = \left(\beta_x + b_{xx} \ln x + \ln \mathbf{z}' \mathbf{b}_{zx} \right) \frac{y}{x} \; .$$

Substituting (9) into (7) and rearranging terms provides the derived demand equation:

$$(10) \quad \begin{aligned} r_x &= p \frac{y}{x} \left(\beta_x + b_{xx} \ln x + \ln \mathbf{z}' \mathbf{b}_{zx} \right) * \\ &\left(1 + \frac{\Theta}{\alpha_x + \alpha_{xx} \ln w_x + \ln \mathbf{s}' \mathbf{a}_{sw}} \right)^{-1} . \end{aligned}$$

In addition, we accounted for possible changes in the exertion of market power by assuming:

$$(11) \quad \Theta = \Theta_0 + \Theta_t \, t \; ,$$

where t represents time.

The parameters can be obtained by simultaneously estimating the supply equation (5) and derived demand (10). However, with the translog specification, meat production enters into derived demand. Moreover, this variable is not exogenous but depends on the supply function (5). In order to account for this endogeneity, we extend the conventional estimation procedure by considering the supply function (5), the production function (8) and the derived demand function (10) simultaneously. Unfortunately, this procedure only proved to be reliable for Germany. Severe data problems hindered a consistent interpretation of the estimated parameter in the Hungarian case. Thus, for Hungary we estimated the reduced system consisting of (5) and (10) only. In order to account for the endogeneity problem, we instrumented production and used the estimated values in (10). Because of the nonlinear relationships in the parameters, we estimated the model within a nonlinear Three-Stage-Least-Squares (NL3SLS) framework. This allowed us to consider a flexible variance covariance structure of the stochastic influences of the individual equations (GREENE, 2003).

5.2 Specification of the supply and production function

In order to guarantee a sufficient number of degrees of freedom, we used monthly data. Periods under consideration are January 1995 to December 2004 for Germany, and January 1993 to December 2003 for Hungary. In our empirical analysis we assumed that no external trade of pigs exists. Although there is some import and export of live animals, this represents only a marginal share of the total hog supply. Moreover, the availability of data causes a difference in the variables chosen for estimation between Germany and Hungary.

Since slaughterhouses and meat processors produce pork and beef, we approximated output by an index of real returns (y). Product prices are given by an index on whole-sale meat prices. The industry production function was assumed to depend on labour input (a), pork and cattle slaughtering (x and w, respectively), and power consumption (v) as an indicator for variable inputs. Due to the lack of data, for Hungary no indicator of variable inputs in slaughtering and processing was available. In addition, capital input was not considered for both countries. However, since Hungary and Germany possess relatively high overcapacities in slaughtering, the expected production elasticity of capital would be zero. From this point of view, the omission of capital does not represent a severe problem for estimation.

The specification of the hog supply function causes a specific problem. Because of fixed production processes, the pig supply on a specific date is basically determined by the number of piglets taken into stock approximately six month before. The investment decision is a function of expected costs and benefits. We assumed that these considerations find their expression in pork inventories (q). From this discussion it follows that actual prices will only have little impact on actual supply. Depending on the output and input prices, farmers may accelerate or decelerate hog finishing to some extent. We considered actual prices of hogs (r), piglets (s) and feed stuff (f) as variables in the supply function. All prices have been deflated by the Consumer Price Index. Because of the requirement of theoretical consistency, we impose the restriction that the supply function is linearly homogeneous of a degree of zero in prices.

However, the availability of data causes the definition of variables for the hog supply and industry production to differ between the two countries. Moreover, since some variables are reported in annual frequency only, these had to be interpolated to monthly frequency. The variables, as well as some descriptive statistics, are presented in tables 2 and 3 for Germany and Hungary, respectively. In addition, in order to account for the effects of technological change we included a time trend (t) in the set of shifter variables for both the hog supply and meat production.

5.3 Estimation results

The derived demand function is highly nonlinear in the parameters. This suggests that the estimation results may depend to a large extent on the starting values of the parameters. In order to provide such appropriate values, we estimated the production and supply function first by OLS and used the parameter values for nonlinear estimation. Even with this procedure, the estimates of market power depend to a large extent on their starting values of the variables capturing market power. We selected among the different options with regard to the values we received for the supply and demand elasticities: the production elasticities should be positive. Moreover, the pork and beef numbers were expected to represent the significance of these inputs in the production process. Besides having the correct sign (positive in hog prices and negative in input prices) the supply elasticities should be consistent with the rather inelastic reaction explained above. Best results were obtained using $\Theta_0 = 1$ (perfect collusion) and $\Theta_t = 0$ (constant market power) as starting values.

Table 2. Variables and some descriptive statistics, Germany

	Symbol		Mean	Standard Deviation	Minimum	Maximum
Market results	x	Hog slaughtering (index)	88.9	13.1	64.3	107.4
	r	Hog prices (€/100 kg)	145.3	25.3	86.9	219.6
Supply shifters (**s**)	s	Piglet prices (€/head)	0.91	0.2	0.6	1.4
	f	Price of compound feed (€/ton)	183.4	12.4	161.5	204.0
	q	Pig inventories (thousand head)	25 482	944.1	23 722	26 500
Demand shifters (**z**)	a	Labour input (million hours)	95.1	4.6	86.1	108.8
	w	Cattle slaughtering (thousand head)	374.1	50.1	203.7	511.4
	v	Power consumption (million kilowatt hours)	42 247	3 684.2	33 459	53 815
	y	Revenues (index)	97.1	12.0	68.0	135.1
	p	Index of pork wholesale price	109.0	7.4	90.0	127.4

Source: ZMP (various issues), EUROSTAT (various accesses), own calculations

Table 3. Hungarian variables and some descriptive statistics

	Symbol		Mean	Standard Deviation	Minimum	Maximum
Market results	x	Hog slaughtering (thousand head)*	536 190	42 232	457 740	61 489
	r	Hog prices (HUF/kg)	193.1	77.8	71.4	367.0
Supply shifters (**s**)	s	Piglet prices (HUF/kg)	262.2	128.9	86.5	566.3
	f	Price of compound feed (HUF/kg)	7.4	2.1	3.8	15.3
	q	Pig inventories (thousand head)*	5 294.3	466.9	4 340.4	6 770.3
Demand shifters (**z**)	a	Labour input (persons)*	22 995	3 647.8	18 999	30 339
	v	Cattle slaughtering (thousand head)*	21 919	6 550	13 733	37 000
	y	Revenues of the meat industry (million HUF)	347.6	46.4	270.7	458.3
	p	Wholesale prices (index)	202.8	32.7	130.9	271.8

Note: * Transformed from annual to monthly data by interpolation.

Source: HCSO (2007), AKI (various accesses), own calculations

Since the NL3SLS procedure is an instrumental variable estimator, R^2 has no sound statistical interpretation. Thus, this indicator is neither used for model selection, nor is it reported in the tables. The Durban Watson coefficient can only be consistently interpreted when the equation contains a constant. This holds for the production function and the supply function. The values of this indicator in the different estimates suggest that autocorrelation might be a severe problem in some equations. However, estimations with autocorrelation failed because of non-positive definite variance covariance matrices. Moreover, since autocorrelation effects the efficiency but produces no bias of the estimates, we argue that autocorrelation is a minor problem as long as the significance of the parameters is satisfactory.

All variables were normalised by their geometric mean. Because of this, the parameter estimates for the supply and production function can directly be discussed in terms of elasticities.

The NL3SLS results for the German hog market are presented in table 4. The production elasticities for hog and beef slaughtering are approximately 0.32 and 0.25, respectively. In the period under investigation, the relation between hog and cattle slaughtering is about 3:1 (3 m tons of pork and 1 m tons of beef). Thus, the estimated production elasticity of beef appears relatively high. However, given that we used real returns as an output index and that beef prices are relatively high compared to pork prices, the esti-

mates appear reasonable. An estimate of $b_{xx} = 12.308$ suggests that the production function is convex in hog demand $(\beta_{xx} + \beta_x^2 - \beta_x > 0)$. Although the value appears to be unreasonably high, the general conclusion is consistent with the overcapacities in the German meat industry. An increase in slaughtering would allow a more efficient use of resources and thus would increase output more than proportionally. This conclusion is also confirmed when looking at a (local) proportional variation of all inputs. Summarising the production elasticities provides a value of about 1.1, i.e., increasing economies of scale. The results also show the existence of technological change. Converting the estimate from monthly to annual data suggests that the productivity of factor use increases by approximately 2% per year.

The productivity growth in the hog supply is twice as large as that in the meat industry. At first glance, an impact of approximately 4% in pig production may appear too high. However, the data discussed in table 2 reveal the rapid structural change in German pork production, which is expected to have significantly contributed to productivity growth. The supply elasticities have the correct sign and correspond to the expectation of inelastic reactions. No parameter estimates for feed stuff are reported. The reason is that this input was selected for imposing the homogeneity restriction of the supply function. Given the other supply elasticities, the price elasticity of feed stuff would be at about -.018. The Durbin Watson coefficient is rather low

for the hog supply function. However, since most coefficients are highly significant, autocorrelation does not appear to be a problem.

The parameters entering the derived demand function are marked by dark cells in table 4. The estimates show that market power cannot be neglected on the German hog market. In addition, the results suggest that the meat industry has lost bargaining power in the period under investigation ($\Theta_t < 0$). This result is consistent with the large structural change in German pig production insofar as the decrease of the number of processors and the increase of average herd have improved the market position of individual farmers.

Table 4.   NL3SLS parameter estimates for Germany

Production Function		Derived demand	Supply Function	
β_0	-0.0184*		0.0062	α_0
β_t	0.0015***		0.0032***	α_t
β_{tt}	0.0001***		-0.0002***	α_{tt}
β_x	0.3237***	▓	0.0697***	α_r
β_a	0.2936**		-0.0511*	α_s
β_w	0.2483***		2.2572***	α_q
β_v	0.1926***	▓	0.0037**	α_{rt}
β_{xt}	-0.0397***	▓	-0.0062***	α_{st}
β_{at}	-0.0005		0.0903**	α_{qt}
β_{wt}	0.0004	▓	-0.1758***	α_{rr}
β_{vt}	0.0011		0.3849***	α_{ss}
β_{xx}	12.3080***	▓	45.5490	α_{qq}
β_{aa}	1.6625	▓	0.1138**	α_{rs}
β_{ww}	0.8363**		2.4116**	α_{rq}
β_{vv}	-4.4308***		5.7578***	α_{sq}
β_{xa}	0.3935	▓		
β_{xw}	-0.0830			
β_{xv}	0.1528			
β_{aw}	-1.5022			
β_{av}	2.4564			
β_{ww}	-0.0802			
Θ_0		0.0724**		Θ_0
Θ_t		-0.0048***		Θ_t
DW	1.7089	1.4351	0.3159	DW

Source: own calculations

The estimation results of the model for Hungary are presented in table 5. As mentioned above, we were not able to consider the endogeneity of the production function separately, but had to instrument this variable in the NL3SLS approach. Because of this, only those parameters of the production function that enter derived demand were estimated and reported. In general, the meat industry production function for Hungary has similar characteristics to the production function for the German case: Convexity in hog supply suggests the existence of increasing economies of scale and a relatively high production elasticity of hog slaughtering. Compared to Germany, the production elasticity in Hungary is considerably higher. This is consistent with the rather low importance of cattle production in Hungarian agriculture. In the period under investigation, the ratio of pork and beef production was about 6:1. This illustrates that beef contributed only marginally to the output of

Table 5.   3 SLS parameter estimates for Hungary

Derived demand		Supply function	
β_x	0.7214***	0.0163*	α_0
β_{xt}	-0.0198***	-0.0008***	α_t
β_{xx}	0.9826	-0.0001	α_{tt}
β_{xa}	-1.3150	0.0994**	α_r
β_{xv}	-1.4102**	-0.0703**	α_s
		0.5162***	α_q
		-0.0019**	α_{rt}
		0.0023***	α_{st}
		-0.0007	α_{qt}
		-0.0325	α_{rr}
		-0.1396**	α_{ss}
		-2.1437*	α_{qq}
		0.0179	α_{rs}
		0.7202**	α_{rq}
		-1.0375***	α_{sq}
Θ_0	0.0284*		Θ_0
Θ_t	0.0008*		Θ_t
DW	2.1540	0.1577	DW

Source: own estimations

the meat industry, and in turn justifies the relatively high production elasticity for pork.

Unlike Germany, the estimates provide no indication of technological change in pig production in Hungary. One reason may be the dominance of small-scale producers who could not benefit from new animal breeds, and improvement of production technologies etc. The estimates do not provide comprehensive information about the impact of technical change in meat production, since the corresponding parameters (β_t and β_{tt}) were not estimated. However, the estimate for β_{xt} suggests that technological change is present and has, like in Germany, pig-saving characteristics. This kind of technological change is due to new processing techniques that allow the improved extraction of valuable parts from the carcasses. The DW for hog supply is rather low, however, like in Germany, this does not appear to be a serious problem given the significance of the individual parameters in the hog supply function.

The Hungarian pig market is also characterised by market power, however, to a lower extent than the market in Germany. One reason for this result may be the dual structure of pig production in Hungary. The small pig producers market their animals not necessarily to meat processors, but directly to local markets. The choice between the two channels is affected by the relative prices farmers receive on the different markets. This reduces the meat industry's possibilities to exert market power and to redirect rents from farmers to processors. However, there is evidence that the position of meat processors, although marginally, has improved in recent years ($\Theta_t > 0$). This result is consistent with the structural change, i.e., the increase of concentration in the Hungarian meat industry.

5.4 The interpretation of Θ

The estimates suggest that market power exists on the both the Hungarian and German hog markets. We derived

this result within a conjectural variation framework. Correspondingly, the parameter can only be interpreted consistently within this setting. As an alternative to the conduct performance approach used in this paper, the existence of market power may be analysed in a collusion framework. Using a dynamic oligopoly model with collusion, CORTS (1999) shows that within such a setting, the conjectural variation approach systematically underestimates the impact of market power on market allocation when supply shocks are not permanent. With regard to pork production, this may be a relevant problem since hog supply generally shows a cyclical pattern, known as the hog cycle. Thus, because supply changes are temporary, underestimation of market power may be a severe problem.

Although farmers are confronted by relatively few slaughterhouses and meat processors, according to our results the latter are only able to benefit slightly from their favourable industry structure. One reason might be the overcapacities in the industry, which lead to intense competition among processors on the hog market and restrict the incentives to collude. Given these facts, the poor evidence for market power from the structural model is coherent with the situation in the industry. This interpretation is supported by a variation of the econometric model. In table 3 we present the minimal value of the objective function of the NL3SLS procedure using different values of market power (0 for perfect competition, 1 for perfect collusion, and 1/n for Cournot competition). Determining the coefficients of market power within the estimation provides a lower value of the objective function and thus provides a better approximation to the existent data. This conclusion also holds for perfect competition.

However, given the number of firms in the meat industry (about 220 in Germany and about 100 in Hungary, on average), table 6 also indicates that Cournot competition does not appear to be a reasonable approximation of the situation on the pig market. This result imposes a further problem since the conjectural variation equilibrium may suffer from theoretical ambiguity. In order to overcome this problem, BRESNAHAN (1981) proposes restricting attention to consistent conjectures. However, analyses by DAUGHETY (1985) and LINDH (1992) suggest that the Cournot conjectures are the only consistent equilibrium strategies.

The extent of estimated market power is larger for both countries than the values that result from Cournot conjectures. From our point of view, this cannot be regarded as an indication for the theoretical inconsistency of our estimates. The reason is that it might be misleading to consider all domestic processors as potential market partners for a farmer. Transport costs and EU regulations regarding the

transport of live animals provide natural and institutional restrictions to market entry. Consequently, the number of meat processors a farmer may deal with is significantly smaller than the number of processors within the country. Assuming that the Cournot conjectures are present, our results suggest that on average German farmers may negotiate with 15 processors, while Hungarian farmers may choose among 35 firms. Given the number of slaughterhouses and processors in Germany and Hungary, as well as the size of the countries, these figures appear to be reasonable. Thus, the estimates of market power provide some indication that the firms in the meat industry behave consistently with Cournot conjectures regarding the procurement market.

6. Conclusions

This study investigated the existence of market power in the Hungarian and German pork chains, respectively. A structural market model was derived and estimated. The analysis was restricted to the demand and supply of pigs, and thus to the first stage of the pork chain. In both countries the hypothesis of market power could not be rejected. However, the degree of market power was relatively low in both countries. Consistent with the structural adjustment in the processing stages and farming, we found that market power was slightly increasing in Hungary but decreasing in Germany.

However, because of data availability, this empirical investigation was only able to detect average market power. This does not imply that market power is an irrelevant phenomenon on the markets under investigation. Due to their market shares in specific regions, some slaughterhouses might be able to exhibit significant market power. Considering the overall industry however, this might be balanced by the behaviour of other firms. Given the institutional restriction regarding hog transport, the national market might not be fully integrated. Indeed, we found that the degree of market power is higher than it would be suggested by Cournot competition in a fully integrated domestic market. In addition, our results appear to be consistent with Cournot behaviour in the regional markets. However, the detection of individual monopsony power requires firm-specific data, or at least regional data so that corresponding differences can be accounted for. Unfortunately, this information is not available.

The implied result that processors compete on quantities is surprising given the low use of overall capacities in meat processing. In addition, it can be debated whether examining monopsony power was the correct approach. At least for Germany, there is an indication for significant competition among slaughterhouses and meat processors. Moreover, a rapid concentration process in German pork production could be observed. This improved the bargaining position of pork producers and thus may have put them into a position in which farmers are able to exploit market power. The same could also be true for the Hungarian pork chain, since there are some large (and partially unused) production facilities. This suggests a modification to the model insofar as market power in the producer model has to be estimated.

Table 6.	Values of the objective function under different assumption of market power			
Function value/ number of observations	Perfect competition	Cournot	$\hat{\Theta}_0 + \hat{\Theta}_t t$ [*)]	Perfect collusion
Germany	2.340	2.311	1.996	2.578
Hungary	1.4044	0.8062	0.6961	0.9794

Note: * Estimated with the endogenously determined values for market power plugged in.

Source: own calculations

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Contact author:
PROF. DR. HEINRICH HOCKMANN
Leibniz Institute of Agricultural Development in Central and Eastern Europe (IAMO)
Theodor-Lieser-Str. 2, 06120 Halle (Saale), Germany
phone: +(49)-345-29 28 225, fax: +(49)-345-29 28 299
e-mail: hockmann@iamo.de