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Supply response on the Hungarian pork meat sector

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ABSTRACT

Despite of the increasing production and consumption of white meats, pig breeding is still one of the most important animal husbandry sectors Worldwide and in the European Union as well. In Hungary over the past decades, the pig sector has undergone significant changes. The livestock has sharply decreased from more than 8.5 million in 1989 to 3.3 million in present. After the post 1989 increase of herd size bred in family farms, their share diminished, at present two-thirds of output is produced by corporate farms. It appears that small scale farming has major difficulties, they must consider all cost reducing alternatives to improve their competitiveness. With pressure on purchase prices from the downstream market levels, and considering that fodder represents about 50-60% within total production costs, in this paper we analyse the influence of these two factors upon pig breeding farmers' supply response. We employ Vector Error Correction Model specification, following the theoretical model of Hallam and Zanoli, 1993. Estimated long-run elasticities highlight farmers' reliance on live pigs for slaughter purchase price and soya fodder price.

Keywords: error correction model, supply response, pork sector, Hungary.

1. Introduction

Pig breeding was one of the most affected markets by the massive changes in the post 1989 Hungarian agricultural sector. The dismantling of socialist agricultural enterprises and cooperatives, and the shift towards private farming, had a major impact upon the pig stock that halved in just a couple of years. Newly emerged pig breeding family farms are fighting for survival, many being subsistence farms. The Hungarian meat industry is characterised by a distorted market structure, 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 size companies struggling with unused processing capacity. Jansik (2000) studying the foreign direct investment (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, having 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. The sales of meat industry report a slightly growing trend. The number of firms dropped by about one half, between 1996 and 2000, and then it started to grow again. The privatisation of the meat industry started late, in the mid 1990s, and was characterised by low FDI. In 2005, approximately 40 % of total capital was in foreign ownership. Thus, the concentration process was delayed; the five firm concentration ratios in the meat industry are still rather low with 30.6 % in 1992 and 44.1 % in 2003. The Hungarian pig meat sector has experienced numerous structural changes in the past 15 years. From 9.5 million head in September 1990, the pig stock decreased to 4.3 million by December 1994, and has fluctuated at 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 has not changed significantly since 2005. Many of these small-scale farms do not have commercial activity, i.e. they are subsistence farms. However, large proportions sell their products, forming a two-tier commercial and family pig meat production system.

The average herd size by farm type illustrates unambiguously the dual production structure in Hungarian pork sector. The average herd size in Hungary varies between 9-16 pigs. However these numbers hide the significant differences between various types of farms. Private farms on average hold 5 to 7 pigs, whilst the average herd size for economic organizations is 3.3 to 4.4 thousand pigs.

Considering the technology of pig fattening, there is a significant fluctuation concerning the most important fodders (soy, corn, wheat, barley). At present, soya is the most important fodder, despite the decreasing animal livestock Hungary is a net importer of soya meal which, approximately 600-700 thousand tonnes being imported every year.

The remainder of the study is organized as follows. The second section briefly reviews the existent supply response literature in Central and Eastern European (CEE) countries, followed by the empirical methodology in section 3. Variables are described in Section 4, while results are presented in section 5. The last section summarizes and offers some conclusions on the implications for the Hungarian pork meat producers.

2. Supply response analysis in CEE countries

There is already a great wealth of literature examining various aspects of the transition period from the transformation in the farm structure to competitiveness and efficiency analysis or vertical price transmission of various sectors. Research in the key determinants, and indeed the estimation of an appropriate agricultural supply response model for transition economies is however scarce. One reason is the limited data availability since only half-yearly pig stock data exists. Of the papers focusing on supply respons in CEE countries, Hallam (1998) analyses the supply response in some transition economies, namely Bulgaria, Romania and Slovenia. The author points out the problems of estimating econometric supply models due to the numerous structural breaks occurred during the transition period, and the lack of sufficiently long time series data. Mishev et al. (1998) estimates the price elasticities of supply for Bulgarian crop products, concluding higher own price elasticities than in developed economies, mostly determined by input shortages. Nyars and Vizvari (2005) apply linear and non-linear regression equations to estimate the supply response on the Hungarian pork market. The authors estimate that in good market conditions for pork producers (low input, high output prices), the Hungarian pork sector can produce 526,000 tons of live pigs for slaughter, whilst in unfavourable market environment (high input, low output prices) the capacity is reduced to 411,000 tons.

Contrary to the Nyars and Vizvari (2005), the aim of this paper is to estimate a parsimonious Vector Error Correction econometric model, using yearly data from the past 21 years. We follow the methodology outlined in Hallam and Zanoli, 1993, which prove the superiority of error correction specifications to the more common partial adjustment models with regard to agricultural supply response. Earlier studies (e.g. Ness and Colman, 1976, Holt and Johnson, 1988 or Hallam and Zanoli, 1993) demonstrated that the target breeding herd may be modelled as a linear function of own price (pig purchase price) and feed price. Also, the pig breeding technology excludes the possibility of significant cross-price elasticities with respect to other outputs.

3. Methodology

The the long-run supply function may be modelled as:

$$s_t = c + \beta_1 p^e + \beta_2 f^e \quad (1)$$

where s_t is the target breeding stock, p^e is the expected real purchase price, and f^e is the expected fodder price. There are several possibilities of defining farmers' price expectations, naive, rational or adaptive. Hallam and Zanoli 1993 shows that a VECM model can adequately describe real pig and feed prices through autoregressive lags. Thus, we wish to estimate the long and short –run pig supply elasticities with respect to pig purchase price and fodder price.

The empirical procedure is based on modern time series econometrics, namely Vector Error Correction model estimations. Series are first tested for unit roots, than cointegration, followed by the estimation of a Vector Error Correction Model simultaneously depicting both long and short run response of the breeding stock to changes in pork purchase and soya fodder prices.

3.1 Testing for Unit Roots

With time series data, one needs to pay a particular attention to the stationarity of the variables. In the presence of unit roots, classical ordinary least square (OLS) regression yields biased estimates, invalid tests, and ultimately, spurious regressions. Considering the first order autoregressive process, AR(1):

$y_t = \rho y_{t-1} + e_t$ where $t = \ldots,-1,0,1,2,\ldots,$ and e_t is white noise error stochastic term. (2)

The process is considered as stationary, if $|\rho| < 1$, thus testing for stationarity is equivalent with testing for unit roots ($\rho = 1$). (2) is rewritten to obtain

$$\Delta y_t = \delta y_{t-1} + e_t, \text{ where } \delta = 1 - \rho \quad (3)$$

and thus the test becomes:

null hypothesis $H_0 : \delta = 0$ against the alternative hypothesis $H_1 : \delta < 0$.

There are a large number of unit root testing procedures in the literature, see Maddala and Kim (1998) for a detailed discussion. Considering the notoriously low size and power properties of unit root tests, in this paper we employ three unit root tests that have alternative null hypotheses. The null hypothesis of the Augmented Dickey-Fuller, ADF (Dickey and Fuller, 1979) and Phillips-Perron, PP (Phillips and Perron, 1988) test is a unit root in the variable against the alternative of stationarity. The KPSS (Kwiatkowski et al., 1992) procedure tests the null of stationarity against the alternative of a unit root process.

3.2 Cointegration analysis and Vector Error Correction Modelling

Non stationary variables may be analyzed in a cointegration framework. We test for cointegration using Johansen's multivariate cointegration approach (Johansen, 1988). This procedure is a Maximum Likelihood (ML) approach in a multivariate autoregressive framework with enough lags introduced to have a well-behaved disturbance term. It is based on the estimation of a Vector Error Correction model (VEC) of the form:

$$\Delta \mathbf{Z}_t = \mathbf{\Gamma_1} \Delta Z_{t-1} + \ldots + \mathbf{\Gamma_{k-1}} \Delta Z_{t-k+1} + \mathbf{\Pi} Z_{t-k} + \mathbf{u_t} \quad (4)$$

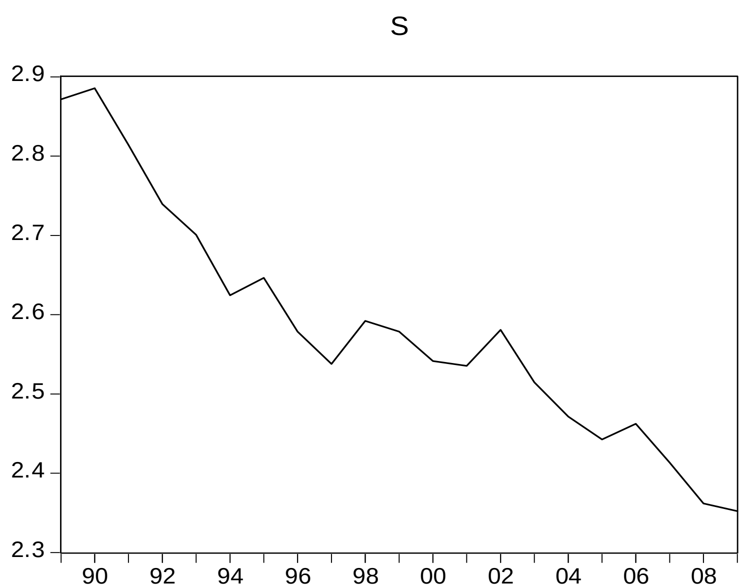
where $Z_t = [s_t, p_t, sf_t]'$ is a (3 x 1) vector containing the three I(1) variables, where s stands for Hungarian breeding stock (sow stock), p the log of pork producer purchase price and sf the price of fodder, t for time period, $\mathbf{\Gamma_1}, \ldots \mathbf{\Gamma_{k+1}}$ are vectors of the short run parameters, $\mathbf{\Pi}$ is matrix of the long-run parameters, and $\mathbf{u_t}$ is the white noise stochastic term. Monthly seasonal dummy variables may also be included.

$\mathbf{\Pi} = \boldsymbol{\alpha\beta}`$, where matrix $\boldsymbol{\alpha}$ represents the speed of adjustment to disequilibrium and $\boldsymbol{\beta}$ is a matrix which represents up to (n - 1) co integrating relationships between the non-stationary variables. There are five possible models in (4) depending on the deterministic specification. Following Harris and Sollis (2003) these 1 to 5 models are defined as: (M1) no intercept or trend is included; (M2) the intercept is restricted to the cointegration space; (M3) unrestricted intercept without trends; the intercept in the cointegration space is combined with the intercept in the short run model resulting in an overall intercept contained in the short-run model; (M4) if there exists an exogenous linear growth not accounted for by the model, the cointegration space includes time as a trend stationary variable; and (M5) allows for quadratic trends in Z_t.

4. Data

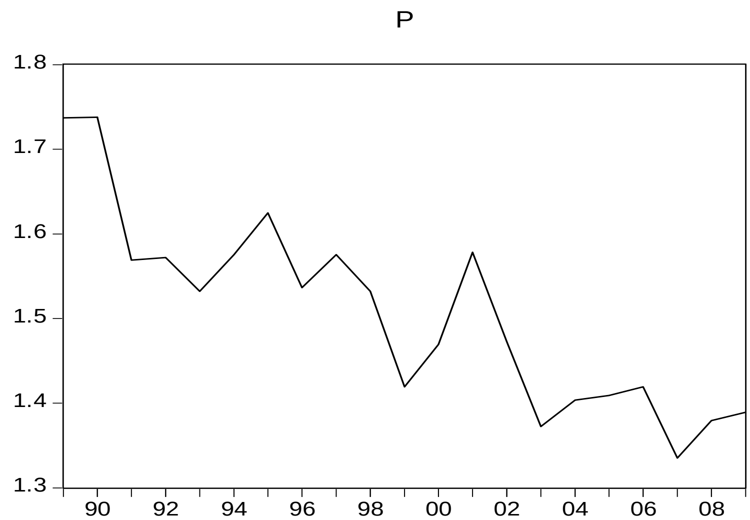
Annual data between 1981 and 2009 was provided by the Hungarian Central Statistical Agency (HCSA). The dataset consists of the sow stock, *s* (used as proxy for the breeding stock), annual average purchase price of live pigs for slaughter, *p*, and the price one of the most important fodder used in Hungarian pig breeding technology, soya fodder, *sf*. Price data was deflated to 1989 by the national Consumer Price Index. Figures 1, 2 and 3 present the log of the sow stock, pig purchase price and soya fodder price respectively. The first graph illustrates the dramatic fall in the Hungarian total stock and indeed breeding stock after the fall of the socialist regime, discussed in the market overview section of this paper. In real terms however, price data also appears to be downward trended.

Figure 1 The log of Hungarian sow stock



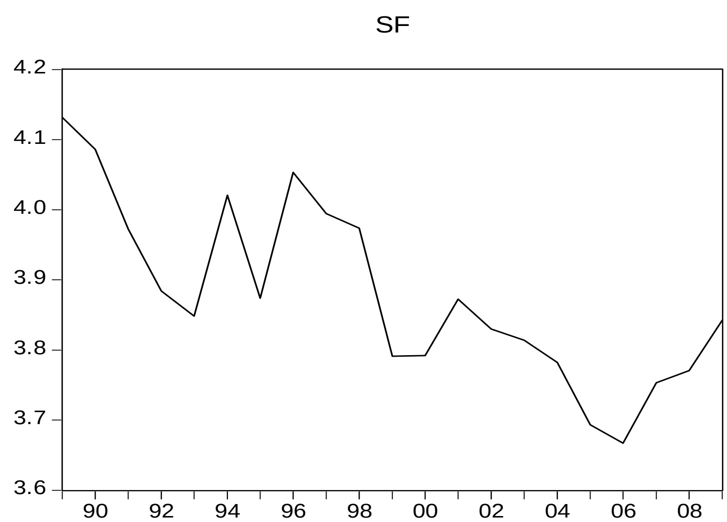
Note: Own calculations, data provided by HSCA.

Figure 2 The log of pork producer purchase price



Note: Own calculations, data provided by HSCA.

Figure 3 The log of soya fodder price



Note: Own calculations, data provided by HSCA.

Table 1 presents the descriptive statistics of the 3 time series.

Table 1 Descriptive statistics of variables

Variable	No. of Obs.	Mean	Std. Dev.	Min	Max
s	21	2.583	0.148	2.352	2.885
p	21	1.506	0.115	1.335	1.737
sf	21	3.878	0.125	3.667	4.131

Note: Own calculations, data provided by HSCA.

5. Results

To determine the properties of the time series data, a battery of unit root tests were applied. The null hypothesis of ADF and PP tests is unit root, against the alternative hypothesis of stationary series. The null hypothesis of the KPSS test however is stationary series against the alternative hypothesis of unit root in the series. Table 2 presents unit root test results in the sow stock, pig purchase price and soya fodder price series. The upper panel of table 2 presents test statistics (with 5% critical values below each statistic in brackets) where the test regression contains an intercept only. Results obtained by test regressions with intercept and trend as deterministic specifications are presented in a similar fashion in the lower panel of table 2.

Table 2 Unit root tests

Test statistic (5% crit. value)	s	p	sf
	with intercept only		
ADF	-0.462	1.673	-2.454
	(-3.144)	(-3.119)	(-3.02)
PP	-1.804	-2.096	-2.433
	(-3.02)	(-3.02)	(-3.02)
KPSS‡	0.616**	0.63**	0.546**
	(0.463)	(0.463)	(0.463)
	with intercept and trend		
ADF	-4.251**	-1.356	-1.084
	(-3.791)	(-3.875)	(-3.875)
PP	-2.06	-6.899***	-2.946
	(-3.658)	(-3.658)	(-3.658)
KPSS‡	0.132	0.322***	0.074
	(0.146)	(0.146)	(0.146)

Note: ***significant at 1%, **significant at 5%, *significant at 10%
‡the null hypothesis of the KPSS test is that variable is stationary

Mixed results were obtained. With intercept only, PP and ADF tests cannot reject the unit root null hypothesis, whilst the KPSS test significantly rejects the stationarity null hypothesis. Figures 1, 2 and 3 however suggest that data might be trended but with intercept and trend specification the picture is less clear. For the sow stock variable, ADF and KPSS tests suggest that data is stationary, whilst the PP test does not reject the unit root null. For the purchase price series, PP test rejects the unit root null, but ADF and

KPSS tests suggest the data contain unit root. Similarly, for the soya fodder price, KPSS suggest data is stationary, however ADF and PP tests conclude that data is not stationary. Considering the notoriously low power and size properties of unit root tests, we carefully conclude that all three time series are not stationary, i.e. integrated of order one, I(1).

Non-stationary data must be cointegrated in order to estimate any long-run relationship between variables. A number of different deterministic specifications were sequentially tested for co integration. Test results for models M2 and M3 (see the methodology section) are presented in table 3.

Table 3 Johansen cointegration tests

Number of CI vectors	P-value (intercept only)	P-value (intercept and trend
0	0.029	0.007
1	0.478	0.086
2	0.382	0.376

Note: 3 lags in first differences was selected by AIC criteria

The null hypothesis of no cointegration between the 3 variables is rejected for both specifications. With trend included in the cointegration space, even the one cointegrating vector null hypothesis may be rejected in favour of 2 vectors at 10% level of significance. Based on the results from table 3, we consider the sow stock, pork purchase price and soya fodder variables co integrated with 1 cointegration vector. The long run relationship between these variables, basically the supply response function is:

$$s = 2.758p - 1.391sf + 3.794 \qquad (5)$$

Since data is in logs, coefficients represent long-run elasticities of the sow stock (breeding herd) with respect to the pork purchase price and soya fodder. Thus 1% increase in expected pig purchase prices induces an increase of 2.75% of the breeding stock, whilst the 1% increase in the expected fodder price decreases the breeding stock by 1.39%. The estimated VECM model of the pork supply response is presented in table 4 with some diagnostics and coefficients of determination in the lower panel. The upper panel contains the long-run supply response (with t statistics in brackets) identical to equation 4. The middle panel presents the short-run dynamics of the VECM also meant to model the rational expectations hypothesis of the pig breeding farmer through the autoregressive lags of variables. The first raw of the middle panel contains the coefficients of the error correction term, (**α** in equation 3, see methodology section) and their corresponding t statistics. These coefficients measure the speed of adjustment towards the long-run equilibrium, i.e. how fast the system returns to its long-run equilibrium path should an exogenous shock occur. The coefficients of adjustment are highly significant in the own price and fodder price equations, but surprisingly only marginally significant (at 10%) for the breeding stock equation. A non-significant coefficient would mean that the short-run equation does not adjust to deviations from the long-run equilibrium, i.e. it is weakly exogenous on long run.

The model appears to be well specified, the null hypothesis of no first and second order autocorrelation in the residuals cannot be rejected at 5% level of significance. The residuals are normally distributed, whilst the coefficients of determination are ranging between 38 and 66% acceptable for this kind of analysis.

Table 4 Supply response Vector Error Correction Model

Variable	Cointegration equation		
s_{t-1}	1.000		
p_{t-1}	-2.758 (-14.259)		
sf_{t-1}	1.391 (8.906)		
C	-3.794 (-10.882)		
short run dynamics			
	Δs_t	Δp_t	Δsf_t
error correction	0.271 (1.809)	0.478 (2.090)	-1.065 (-2.364)
Δs_{t-1}	-0.162 (-0.707)	-1.014 (2.887)	-0.004 (-0.006)
Δs_{t-2}	0.475 (2.838)	0.920 (3.597)	0.296 (0.587)
Δp_{t-1}	1.017 (3.215)	1.224 (2.531)	-1.438 (1.508)
Δp_{t-2}	0.257 (1.239)	0.461 (1.456)	-0.712 (1.140)
Δsf_{t-1}	-0.142 (-1.001)	-0.418 (1.923)	0.271 (0.632)
Δsf_{t-2}	0.052 (0.717)	-0.200 (1.792)	0.106 (0.483)
diagnostics‡			
LM test AR(1)	0.106		
LM test AR(2)	0.124		
Jarque-Bera	0.706	0.921	0.148
R^2	0.601	0.659	0.386

‡ p values (significance) are presented

6. Conclusions

The Hungarian pig sector, production as well as processing, has undergone extraordinary changes during the past two decades. The increasing competition and the continuous changes in the structure of farming and industry revealed several problems within the pig branch. In this paper we showed that there is a long run cointegrating relationship between the size of breeding stock, pork purchase price and soya fodder price. The analysis revealed the relatively high importance of expected pig purchase prices and the price of the most important input, the price of soya fodder in the production decisions of farmers. Estimated long-run elasticities of the sow stock with regards to the pork purchase price and soy fodder are quite high, 1 % increase in expected pig purchase prices induces a 2.75 % increase of the breeding stock, whilst a 1 % increase in the expected soy price decreases the breeding stock by 1.39 %.

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