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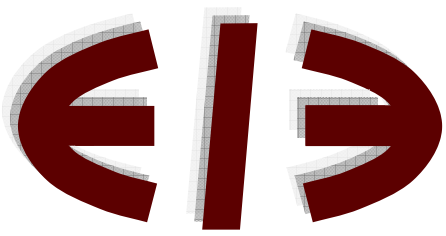
EERI Research Paper Series No 2/2008



EERI
Economics and Econometrics Research Institute
Avenue de Beaulieu
1160 Brussels
Belgium

Tel: +322 299 3523
Fax: +322 299 3523
www.eeri.eu

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The Impact of Food Price Shock on Heterogenous Credit Constrained Firms

Pavel Ciaian* d'Artis Kancs†

August 2008

Abstract

The paper analyses how the rising agricultural prices affect heterogenous farm access to inputs and production under credit market imperfections in the CEE transition countries. Using farm level panel data which contains 37416 observations, we estimate a farm credit constraint equation and find that small individual farms (IF) are on average more credit constrained than large corporate farms (CF). Using the estimated parameters we simulate the effect of the recent food price shock. Our results suggest that in the presence of credit market imperfections, the relatively less credit constrained CF benefit more from higher output prices than IF, as they are able to expand their production more flexibly. These findings have implications for the developing countries: not only consumers in the LDC may loose, but also producers, which on average are more credit constrained than farmers in developed countries, may loose their market shares and hence income in the log run.

Keywords: Credit constraint, food price shock, heterogeneous firms.
JEL classification: Q11, Q12, P23.

1 Introduction

Agricultural output prices have increased sharply in the recent years. According to *FAO* (2008), during 2006-2008 the aggregated food price index has increased by more than 40 percent. Generally, such developments are not unusual for agricultural prices, which are rather sensitive to short run shocks in supply, e.g due to changes

*Catholic University of Leuven, EERI and European Commission, Joint Research Centre. E-mail: pavel.ciaian@ec.europa.eu.

†Catholic University of Leuven and EERI. Correspondence address: Catholic University of Leuven, LICOS, Debériotstr. 34, B-3000 Leuven - Belgium, Tel: 32-16-326573 Fax: 32-16-326599 E-mail: dartis.kancs@econ.kuleuven.be, Web: www.econ.kuleuven.be/dartis.kancs.

in whether conditions, leading to large price volatility. However, compared to the previous price fluctuations, the recent price shock is caused by structural changes, such as increasing input costs, the changing structure of demand due to income and population growth, and the expansion of the bioenergy production, and therefore is expected to be persistent (*OECD* 2008). Hence, given that the current food price shock is also demand-driven, the observed increase in the world-wide demand for food might hold stand despite the raising food prices (though the growth rate of food demand might decrease as a consequence of food price increase) (*FAO* 2008).

Due to their wide-reaching consequences, the recent food price developments have sparked a controversial debate both at the political level as well as the scientific community. According to *IMF* (2008), *von Braun* (2008), *World Bank* (2008b), especially consumers in the developing countries (DC) and transition economies (TC) suffer from welfare losses due the recent food price shock, because their food expenditure share is much higher compared to consumers the industrialised (developed) countries (IC). In order to address the adverse impacts of the growing agricultural prices and hence food expenditures, several DCs have already implemented policy measures targeted particularly at the most disadvantaged groups, such as poor consumers (*FAO* 2008).

In contrast, the distributional consequences on the supply side have been studied to a much lesser extent, although, changes in relative input and output prices affect farmers too. According to *Binswanger* and *Rosenzweig* (1986), changes in agricultural prices induce two types of adjustments at farm level: profit maximising farms adjust their production scale and product mix. In the case of increasing food prices, farms increase their production (scale effect) and adjust their product structure toward those agricultural products, whose relative prices have increased (substitution effect). More precisely, in response to changes in the relative prices farms increase their output scale and adjust output mix until marginal profits of fixed factors are non-positive. Hence, if markets are perfect and nothing else changes, competition among existing farms and entrants drive again profits to zero. If however markets are imperfect, farm ability to adjust production scale and/or output mix depends, among other factors, on the functioning of input and output markets. Indeed, according to (e.g. *Bhattacharyya et al* 1996, *Binswanger* and *Rosenzweig* 1986; *Ciaian et al* 2008; *Subbotin*, 2005; *Swinnen* and *Gow*, 1999), in TC and DC market imperfections constrain farm ability to adjust to changes in relative prices.

The above literature suggests that TC and DC farms face two types of market imperfections, which constrain their ability to adjust production: factor input constraints (e.g. credit constraint) and transaction costs of farm re-specialisation. The former limit farm possibilities to expand their production scale. This is especially the case, if lenders consider the observed food price increase as a transitory phenomenon. If factor market imperfections are higher in TC and DC than in developed countries, then input constrained producers in TC and DC might loose their relative output share. The latter constrain farm re-specialisation according to changes in the relative sectoral profitability. As a result, in relative terms, raising food prices may reduce

farm profits and farmer income in TC and DC.

These findings suggest that raising global food prices might disadvantage not only consumers in TC and DC, but in relative terms, they may also disadvantage agricultural producers by reducing farm possibility to respond to price signals compared to farms in developed market economies. To our knowledge this adverse impact of raising output prices on farm production and income in TC and DC has not been studied in the literature before. Hence, our study is among the first attempts to assess this impact in the context of TC.

In this paper we analyse how rising agricultural input and output prices affect farm access to inputs and production in the presence of farm credit market imperfections in CEE.[1][2] Adopting a heterogenous firm model and drawing on a large farm-level panel data, which contains 37,416 observations for CEE, allows us to examine how changes in the relative input and output prices affect corporate farms (CF) and individual farms (IF), which on average are more credit constrained.[3] More precisely, we econometrically estimate the CEE farm access to short-run credit based on the FADN farm level data panel data. Using the estimated parameters we then simulate the recent agricultural input and output price increase and assess the effects farm access to inputs and production. Our empirical results support the theoretical hypothesis that asymmetries in credit market imperfections cause distributional consequences between different types of farms.

The rest of the paper is organised as follows. In section 2 we briefly introduce agricultural sector in CEE. We also summarise the recent price developments in the agricultural input and output markets. Section 3 presents the underlying theoretical framework. In section 4 we empirically estimate the production and credit constraint equations. Finally, in section 5 we perform simulations of the recent price increase in agricultural input and output markets. Section 6 concludes.

2 Agricultural sector in CEE

In this section we highlight the key distinguishing features of CEE agriculture, as they have implications for the theoretical framework. After introducing the data, in section 2.1 we highlight the dual farm structure, which is a particular feature of CEE. In section 2.2 we summarise the food and input price development in CEE.

[1] In the present study Central and Eastern Europe (CEE) refers to the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia.

[2] According to the previous literature, there are important credit market imperfection in agricultural sector of the CEE transition countries (e.g. *Swinnen* and *Gow*, 1999; *Bezemer*, 2003; *Latruffe*, 2005; *Petrick*, 2004; *World Bank*, 2001).

[3] In our study IF are repesentative for farms in TC and DC, and CF are representative for agricultural producers in developed countries.

2.1 Data

Our sample contains 37,416 observations for 2004 and 2005 for 8 CEE transition countries. The sample represents ca. 14% percent of the total farm population. In order to be able to disentangle the aggregate impacts of input and output price increase in agriculture, we estimate the access to short-run credit separately for IF and CF.

2.2 Farm structure

Our study is motivated by the recent systemic change taking place in Central and Eastern Europe (CEE),[4] which offers a natural experiment for studying the impact of agricultural price shocks. During the Soviet period the CEE was a great example of a system-wide central planning with administratively dictated prices, which were decoupled prom production costs and consumer demand. Both input and output prices were very stable over time and, even in the few cases they did change, these changes were not transmitted to changed in producer incentives. In addition, the pattern of state-owned company specialisation was largely determined by central planners and not by inter-industry differences in the expected profits, as in developed market economies.

The centrally planned pattern of inter-regional and cross-country specialisation became unsustainable, when the systemic transition to the market economy started. Facing hard budget constraints the formerly state-subsidised companies became unprofitable under free market prices and had to be reorganised. Transition process in agriculture involved privatisation of agricultural recourses and farm restructuring. The predominant form of privatisation of agricultural land and other assets in CEE countries was restitution to former owners (*Swinnen* 1999; *Lerman* 2001).

The privatisation process was followed by farm restructuring. New private owners of farm assets and land were allowed to break away from the cooperative farms and to start individual farming. This led to the emergence of family farms (IF) that were significantly smaller in size than cooperatives, but comparable to their Western European and North American counterparts. However, not all cooperative farms were transformed into IF, as part of the former state-owned cooperatives were transformed into reorganised corporate farms (CF). More precisely, part of the 'old' socialist cooperatives were turned into cooperatives of new owners of agricultural assets (including land), joint-stock companies, limited-liability companies or partnerships (*Swinnen* 1999). As a result, a dual farm structure consisting of IF and CF emerged in CEE.

A striking feature of the CEE is that the dual farm structure is considerably more visible between regions and countries than within regions and countries. I.e. depending on whether the local/national government prioritised large or small scale

[4] In the present study CEE refers to Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia.

farming, in regions/countries emerged CF or IF (*Swinnen* 1999). As a result, today some regions and countries are dominated by large CF, whereas in other regions and countries small IF cultivate most of the land. These cross-country differences in the CEE farm organisation are summarised in Table 1, which reports the percentage shares of land cultivated by IF and their share in the total agricultural output. The last column of Table 1 reports the average farm size in ha.

Table 1: Farm organisation and size in CEE in 2004

	IF share land %	IF share output %	Average farm size ha
Czech R.	11.8	19.5	250.1
Estonia	63.5	48.9	119.6
Latvia	55.2	63.9	64.0
Lithuania	77.4	83.8	42.5
Hungary	36.2	47.5	53.2
Poland	94.5	96.2	15.8
Slovenia	99.9	99.9	12.7
Slovakia	10.8	13.6	535.5

Source: Authors' calculations based on the FADN (2008) data.

The figures reported in Table 1 suggest sizeable differences in farm organisation across the CEE transition economies.[5] According to columns 2 and 3, Slovenia and Poland have the highest share of IF in both land use and in agricultural output. In contrast, Slovakia and the Czech Republic have the lowest share of IF. Table 1 confirms the evidence documented in the previous literature that the share of IF is negatively and strongly correlated with the average farm land size (e.g. *Pollak* 1985; *Allen* and *Lueck* 1998). Countries with relatively high share of CF (low share of IF), e.g. the Czech Republic and Slovakia, have considerably larger farms than countries with high share of IF (e.g. Slovenia and Poland).

According to *Pollak* (1985) and *Allen* and *Lueck* (1998), one of the key distinctive differences in production technology between IF and CF is the relative labour and capital intensity. Indeed, several studies which have evaluated the production technology of individual farms and corporate farms have found significant differences in the relative labour/capital intensity (e.g. *Ciaian et al* 2008). On average, IF tend to use less capital compared to CF, whereas CF tend to use less labour compared to IF in producing the same product.

These farm-type differences in labour/capital intensity are largely determined by differences in the relative factor costs and factor productivity (*Pollak* 1985; *Allen*

[5] Although, not reporter here, the structural differences between different regions in countries are even more sizeable than between countries.

and *Lueck* 1998). In terms of labour, usually IF face lower labour costs. Given that farmer is the residual income claimant, IF do not suffer from the moral hazard problem, which is an important issue for CF (*Schmitt* 1991). This leads to higher labour productivity in IF compared to CF.

In terms of capital, usually IF face higher per-unit capital costs. Because of missing collateral, IF are more credit constrained than CF, and in the presence of fixed capital transaction costs, IF face higher per-unit capital costs than CF (*Ciaian* and *Swinnen* 2007). Moreover, capital productivity of IF is often lower compared to CF because of sub-optimal production scale and underemployment of farm equipment and machinery (*Pollak* 1985; *Allen* and *Lueck* 1998). Hence, large CF tend to have higher marginal productivity of capital than small IF.

According to *Ciaian et al* (2008), despite sizeable differences in technological advantages/disadvantages of producing a particular good in a particular region, farm organisation is rather persistent in CEE.[6] The sizeable differences in farm organisation are due to the fact that the adjustment in farm organisation is constrained by transaction costs, as the transition process did not succeed to eliminate all constrains hindering adjustments in farm organisation. For example, the new land owners face significant transaction costs if they want to withdraw their land from former cooperative farms and relocate it. The transaction costs of farm reorganisation include costs involved in bargaining with farm management, in obtaining information on land and tenure regulations, in implementing the delineation of the land and dealing with inheritance and co-owners etc. (*Prosterman* and *Rolfes* 2000; *Ciaian* and *Swinnen* 2006; Swain 1999; World Bank 1999).[7]

These findings suggest that the re-organisation of former centrally planned farms depends among other factors on political priorities of local and national government during the transition. Farm ability to reorganise production in turn depends on transaction costs and differences in profits between the two types of farms. In other

[6]In particular, according to the previous studies, IF seem to have comparative advantages in labour intensive agricultural activities, e.g. horticulture, whereas CF seem to have certain comparative advantages in capital intensive agricultural activities, e.g. grain and root crops.

[7]Credit market imperfection is not limited only to transition and developing countries. Various studies confirmed that farms are also credit constraint in developed countries. In an empirical study of French farmers, Blancard et al (2006) find that two-thirds of the farmers in their sample are credit constraint in the short run and all of them are credit constrained in the long run. Lee and Chambers (1986) and Färe, Grosskopf, and Lee (1990) find that at least part of the US farms in their study are credit constrained. Benjamin and Phimister (2002) find that differences in the structure of agricultural credit markets alter farm credit constraints. They find that in the case of the UK where non-specialized commercial banks dominate and with little government interventions, farms with less collateral were more credit constrained, while in France with dominant specialized agricultural cooperative bank and with extensive government interventions, farm credit is less dependent on collateral. Closer relationships between the cooperative bank and farms in France address better information asymmetry and reduce the reliance on collateral. In a recent study Briggeman Towe and Morehart (2008) find that the drop in the value of production due to the credit constraint in US, constitutes 3% and 13% of total value of production for farm and non-farm sole proprietorships, respectively.

words, historical institutions may help to explain why a particular type of farm organisation emerged in particular country/region, whereas transaction costs of farm re-organisation explain why the dual farm structure is persistent over time.

2.3 Price developments in agriculture

Following the world price developments, agricultural prices in CEE increased significantly during the last three years. Although, Figure 1 shows significant fluctuations of real crop prices between 1993 and 2007, in general the reported prices do not show a significant upward or downward trend until 2005. Up to 2005 real crop prices were relatively stable in CEE. This is contrary to the developments in the Western European countries where real prices declined. At the begging of 1990s output prices in CEE were significantly lower than in the Western European countries. With market reforms implemented during transition period in CEE in the 1990s and with the integration with EU markets in 2000s, this led to continuous convergence of CEE prices to the EU price level. The price convergence offset the inflation effect and real prices remaind relatively stable for most of the agricultural products in CEE (see Figure 1).

Figure 1 around here

Figure 1 suggest that starting from 2006 and 2007 there was a significant jump in real crop prices with exception of sugar beet. According to FAO (2008) and World Bank (2008a), the agricultural output price increase is largely due to droughts throughout the region, stronger food demand in other parts of the world as a result of rising incomes, increasing population and expansion of bio-fuel production.

Table 2 shows the change in real crop prices in 2007 relative to 2004 by crop and by country. Overall for CEE, except for rape and sugar beet, the real prices of all key crops shown in table 1 increased by more than 40% in 2007 relative to 2004. For cereals and oilseeds this development was comparable with the development of world prices. Sugar beet price decreased in CEE, while it increased at world level. Sugar price decline in CEE was mainly due to the introduction of sugar reform under the CAP of EU, which cut sugar intervention price. Except for sugar, the correlation between CEE crop prices and the world prices is relatively strong, more than 70%.

There is observed some variation in crop price changes between CEE countries. Particularly low increase in prices is observed in the Czech Republic. The Czech Republic experienced the lowest price decrease for sugar and the lowest price increases for the rest of crops. On the other hand, it appears that in Baltic countries (Estonia, Latvia and Lithuania) price increase tends to be higher than in other CEE countries.

The real animal prices increased less than the real crop prices in CEE. Overall for CEE cattle and milk prices increased by around 22% in 2007 relative to 2004. Lamb and chicken price remained almost unchanged, while pig price declined (Table 3). Similar mixed picture is observed in development of world animal prices. The real

Table 2: Changes in real crop prices in CEE (percentage change 2007 to 2004)

	Wheat	Barley	Maize	Rape	Sunflow	Sugar beet	Potatoes
Czech R.	26.4	15.9	19.6	5.4	9.1	-17.6	-0.2
Estonia	53.5	39.7	n.a.	35.1	n.a.	n.a.	n.a.
Latvia	73.3	69.3	n.a.	25.9	n.a.	-29.0	59.7
Lithuania	67.3	72.3	42.8	29.5	n.a.	-25.1	109.0
Hungary	75.2	48.3	82.9	6.3	43.3	-31.9	62.2
Poland	68.1	47.1	67.4	24.1	n.a.	-35.1	37.9
Slovenia	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Slovakia	60.1	56.6	77.2	13.0	84.8	-31.4	52.0
CEE	59.4	48.9	51.4	20.4	42.2	-29.4	49.9

Source: Authors' calculations based on the Eurostat (2008) data. Note: Prices for CEE used to calculate changes are calculated as simple average over available CEE countries.

world prices for beef, pig and poultry declined in 2007 relative to 2004 while prices of dairy products expanded by more than 40%.

Comparing Figures 1 and 2 it appears that the real agricultural input prices face a less dramatic development compared to the agricultural output price developments. Since 1996 real input prices of some inputs increased (e.g. motor fuels, electricity), while real prices of some inputs decreased (e.g. herbicides) (Figure 2).

Figure 2 around here

During the last few years the development of the key input prices reverted from declining or stable development to increasing trend. This is particularly the case for fuel, fertilizers, and electricity. Overall for CEE, the real prices of these inputs increased by around 20%, 18% and 7%, respectively, in 2007 relative to 2004. However, except for fuel, this input price increase is weaker than in the case of output prices.

There is strong variation in input price changes among CEE countries in recent years. Only the increase in fuel price appears to be the most consistent among all CEE countries except for Hungary. The rest of inputs show high variation in price changes between countries. Baltic countries seem to have experienced a stronger input price shock than the rest of the CEE.

Whether farms can benefit from price increases depends on their ability to access markets and their negotiation power with traders and/or processors. Particularly, this may depend on the quantity the farm produces, which may affect the negotiation power of the farmer and the transaction costs per unit traded. Therefore, usually farms which trade larger quantities, i.e. large corporate farms, receive higher net

Table 3: Changes in real animal prices in CEE (percentage change 2007 to 2004)

	Cattle	Pig	Lambs	Chicken	Milk
Czech R.	43.1	-2.7	12.4	n.a.	n.a.
Estonia	n.a.	n.a.	n.a.	n.a.	2.7
Latvia	22.8	-4.2	n.a.	n.a.	n.a.
Lithuania	27.7	-7.1	-15.1	n.a.	62.5
Hungary	n.a.	-49.1	-4.6	1.5	8.4
Poland	28.3	n.a.	n.a.	n.a.	37.6
Slovenia	n.a.	n.a.	n.a.	n.a.	n.a.
Slovakia	19.4	-1.0	8.6	5.7	14.8
CEE	22.2	-18.2	0.7	3.6	21.9

Source: Authors' calculations based on the Eurostat (2008) data. Note: Prices for CEE used to calculate changes are calculated as simple average over available CEE countries.

price. Hence, one may expect that larger farms might benefit more from the recent price increases.

Figures 3 and 4 show average farm gate cereal and milk prices, respectively, by farms size for the period 2004-2006. In almost all CEE countries for which the data were available, farm gate cereal prices increase with the farm size (Figure 3). Larger farms receive higher price than smaller farms. Only in the Czech Republic the smallest farms in the country received the same price as the largest farms. For the rest of farms in the Czech Republic the cereal price increases with the farm size.

Figures 3 and 4 around here

According to Figure 4, in the case of milk, the farm gate price increases with the farms size in those countries where IF are dominant in land use, i.e. Estonia, Lithuania and Poland. In those countries, where CF are dominant, the Czech Republic and Slovakia, the data does not suggest a clear correlation between farm size and the milk price. On the other hand, in Hungary where the share of IF and CF is almost equal, the correlation is reverse. Small farms tend to receive higher price than large farms. This could be due to quality differences. For IF it may be difficult to invest in new technology required to increase the quality of milk due to more difficult access to credit. Hence in countries with dominant IF only larger IF can afford to invest and deliver higher quality milk and hence receive higher price (Dries and Swinnen, 2004).

3 Theoretical framework

The structure of farm credit determines how rising prices affect input use and hence production. If farm access to credit is determined by availability of agricultural assets (e.g. land) then the direct impact of higher output prices on farm access to credit is small. Farm access to credit may be affected only indirectly, through higher prices of agricultural assets induced by higher agricultural profitability. This may induce banks to provide more credits because the collateral value of agricultural assets increases. If instead banks give credit based on farm profits, then higher agricultural prices may increase total farm credit directly. However, in both cases whether farms' input use increases depends on the input price developments. If input prices increase significantly then total farm input use may actually decrease even with better access to credit. Moreover, if the structure of credit differs between farms, the rising input prices may affect farms differently.

In this study we model short-run credit constraints of farms, which arise due to time gap between agricultural production and payments throughout the season. In general variable inputs are paid at the beginning of season, whereas the revenue from the sale of production is collected after the harvest at the end of season. Hence, we assume that variable inputs (e.g. fertilisers, hired labor) have to be paid at the beginning of the season, while payments to fixed inputs (land and fixed capital) occur at the end of the season, after harvest.[8] This requires pre-financing of variable inputs. This can be done through internal finance (savings or cash flow) and/or through credits.

Empirical findings from section 2 suggest that farm organisation is heterogenous and rigid in the CEE transition countries. Hence, different types of farms need to be modelled explicitly, if we want to look beyond the aggregate sectoral results. Therefore, in line with the empirical evidence from CEE, we assume that there are two types of farms, f: corporate farms, cf, and individual farms, if. Both types of farms produce agricultural goods combining land, A, variable capital, V, and fixed capital, K, according to a Cobb-Douglas production function $Q = BA^{\beta_a}V^{\beta_v}K^{\beta_k}$ with $Q_{ii} < 0$, $Q_{ij} > 0$, for i, j. Production parameters β_i are farm-type specific, B is a constant. The end of the season farm profits are defined as follows:

$$\Pi = pQ - w_a A - w_k K - v_v (1 + r) V + S \tag{1}$$

where p is the output price, w_i is the per unit input price with $i = A, V, K$. Interest rate of capital is r with $w_v = v_v (1 + r)$, and S denotes total farm subsidies.

[8] Although there are no systematic data on this, our inquiries indicate that these assumptions are consistent with reality. When land rents are paid in kind or through sharecropping this obviously implies that they are paid after the harvest. However, in CEE transition countries and developing countries also cash payments tend to be paid at the end of the year/season. Regarding the fixed inputs: if they are owned by the farmer then the returns from them are realized at the end of the season. If farmer uses long-run credit to finance them we assume that the credit is paid at the end of the season which allows farmer to pay the credit from the revenues from selling the harvest.

To model the short-run imperfect credit market, we follow the approach of *Feder* (1985), *Carter* and *Wiebe* (1990), *Ciaian* and *Swinnen* (2009), and *Briggeman*, *Towe* and *Morehart* (2008) by introducing a farm credit constraint. It is assumed that the maximum amount of credit that a farm can borrow for purchasing variable inputs, $w_v V$, depends on five factors: non-agricultural (fixed) assets, non-land agricultural assets, agricultural land, the farms' gross profits (which determine its ability to repay the loan), and government subsidies:

$$w_v V = B_c W^{\alpha_w} \left[K_o R_k\left(w_k\right)\right]^{\alpha_u} \left[A_o R_a\left(w_a\right)\right]^{\alpha_r} \left(\pi_g A^{\beta_a} K^{\beta_k}\right)^{\alpha_\pi} S^{\alpha_s} \tag{2}$$

where α_w, α_u, α_r, α_π and α_s are credit elasticities, B_c is constant, $K_o R_k\left(w_k\right)$ is market value of own non-agricultural assets, A_o is own land, R_a and R_k are land and fixed capital sales prices, which depend on land rent, w_a, and capital rental price, w_k. Term $\pi_g A^{\beta_a} K^{\beta_k}$ captures the gross average profitability of the agricultural sector and depends on the size of farm (on land use and fixed capital). π_g is aggregate gross profitability parameter per unit of combined fixed inputs (land and fixed capital) defined as follows:[9]

$$\pi_g = \frac{pBA_g^{\beta_a} V_g^{\beta_v} K_g^{\beta_k} - w_a A_g - w_k K_g}{A_g^{\beta_a} K_g^{\beta_k}}$$

where A_g, V_g and K_g are aggregate quantities of land, variable and fixed capital inputs.

Farms maximize their profits (1) subject to credit constraint (2). In the presence of a binding credit constraint, the optimal level of land and capital demand by farm is as follows:

$$A = \left[\left(\beta_a + \beta_v \alpha_\pi \beta_a\right) pQ - \alpha_\pi \beta_A C\right] \frac{1}{w_a} \tag{3}$$

$$K = \left[\left(\beta_k + \beta_v \alpha_\pi \beta_k\right) pQ - \alpha_\pi \beta_k C\right] \frac{1}{w_k} \tag{4}$$

According to equations (3) and (4), farm demand for land, A, and fixed capital, K, depends on farm output, Q, output price, p, land rent, w_a, and capital rental price, w_k, as well as parameters of the model.

4 Empirical implementation

In this section we estimate the theoretical model's parameters. First, we briefly introduce the data we use. In section 4.2 we derive the empirically estimable equations.

[9] The assumption that banks cannot observe profitability at the farm level but only at the aggregate agricultural sector level is consistent with the literature on credit rationing (e.g. Stiglitz and Weiss, 1981; Carter, 1988; Bester, 1985; Boot, Thakor and Udell, 1991; Boucher, Carter, and Guirkinger, 2005).

Finally, in section 4.3 we present the estimation results.

4.1 Data

The empirical analysis is based on the Farm Accountancy Data Network (FADN), which is a harmonised farm-level survey data of the European Union. The annual sample of FADN covers approximately 80000 holdings. In 2004 they represented a population of about 5000000 farms in the 25 Member States, covering approximately 90% of the total utilised agricultural area (UAA) and accounting for more than 90% of the total agricultural production of the EU. The information collected, for each sample farm, concerns approximately 1000 variables.

In the present study we make use of a panel data for 8 CEE economies covering 66 FADN regions and two years - 2004 and 2005. The unbalanced panel contains 37416 observations: 34851 for IF and 2565 for CF. In the sample 827 CF farms and 10012 IF are represented in both years. Although, the CF amount only to 6.86% of the total number of farms in our sample, they cultivate almost half of the total UAA in CEE.

In order to distinguish between the IF and CF, we follow the FADN definition, which is captured in the variable A18 - organisational form. All variables are weighted by the number of farms they represent. Hence, by multiplying the each farm in the sample by the number of presented farms in the population we are able to exactly much the aggregate data for agricultural accounts in CEE. The economic variables we use in our study are summarised in the Appendix.

4.2 Empirical specification

The starting point of the empirical specification is equation (2). Defining credit constraint as $C = w_v V$ and land and fixed capital sales prices as $R_a = w_a^{\eta_a}$ and $R = w_k^{\eta_k}$ yields:

$$C = B_c W^{\alpha_w} \left[K_o w_a^{\eta_a}\right]^{\alpha_u} \left[A_o w_k^{\eta_k}\right]^{\alpha_r} \left(\pi_g A^{\beta_a} K^{\beta_k}\right)^{\alpha_\pi} S^{\alpha_s} \tag{5}$$

where η_i $(i = K, A)$ is the sales price elasticity with respect to the rental price.

In order to capture the heterogeneity in institutional, socio-economic, climatic and geographic environment between different regions in CEE, we introduce fixed effects, ν, on the right hand side of equation (5). Substituting equations equations (3) and (4) and into equation (5) and applying a logarithmic transformation yields

$$\begin{aligned} \ln C \;=\; & \gamma_0 \ln B_c + \gamma_1 \ln W + \gamma_2 \ln K^o + \gamma_3 \ln w_k + \gamma_4 \ln A^o + \gamma_5 \ln w_a \\ & + \gamma_6 \ln S + \gamma_7 \ln w_a A + \gamma_8 \ln w_k K + \gamma_9 \ln \pi_g + \nu + \epsilon \end{aligned} \tag{6}$$

where $\gamma_1 = \alpha_w$, $\gamma_2 = \alpha_u$, $\gamma_3 = (\alpha_u \eta_k - \alpha_\pi \beta_k)$, $\gamma_4 = \alpha_r$, $\gamma_5 = (\alpha_r \eta_a - \alpha_\pi \beta_a)$, $\gamma_6 = \alpha_s$, $\gamma_7 = \alpha_\pi \beta_a$, $\gamma_8 = \alpha_\pi \beta_k$ and $\gamma_9 = \alpha_\pi$ are the parameters to be estimated,

ν is a time invariant constant term capturing region specific fixed effects and ϵ is a random prediction error.

In addition to the farm credit constraint, we also need to estimate the production function. Applying a logarithmic transformation to the Cobb-Douglas production function yields a linearly estimable production equation:

$$\ln Q = \delta_0 \ln B + \delta_1 \ln A + \delta_2 \ln V + \delta_3 \ln K + \nu + \epsilon \tag{7}$$

where, as above, ν is a time invariant constant term capturing region specific fixed effects and ϵ is a random prediction error and $\delta_1 = \beta_a$, $\delta_2 = \beta_v$ and $\delta_3 = \beta_k$ are the coefficients to be estimated.

Equations (6) and (7) can be estimated in several ways. The appropriate estimation method depends upon the structure of the error terms, ϵ, and the correlation between the observed determinants of credit constraint and the different components of the error term. In order to determine the most appropriate estimation technique, we perform extensive specification tests of equations (6) and (7). The sepcification test results do not yield a definite answer regarding the preffered specification. Therefore, we estimate equations (6) and (7) with fixed effects (FE) and with random effects (RE). Theoretically, the FE model is always consistent in the absence of endogeneity or errors in variables. On the other hand, the RE model is only consistent if the individual effects are uncorrelated with all other explanatory variables. In that case, RE estimators have the advantage to be more efficient than FE estimators. If these conditions do not hold, only the FE approach is consistent since it cleans out all the time-invariant effects.

In addition, we estimate several alternative specifications. For example, given that variable inputs, V, enter the right hand side of equation (6) and the left hand side of equation (7), they may be endogenous. In order to allow for the possibility that equations (6) and (7) contain endogenous variables among the explanatory variables, we also estimate the 3SLS, which is a combination of 2SLS and SUR.

4.3 Estimation results

We estimate equations (6) and (7) for the CEE transition countries separately for CF and IF. All variables required to estimate equations (6) and (7) are extracted from the FADN (2008) and *Eurostat* (2008). The FADN panel data contain 37416 observations for years 2004 and 2005. However, the panel is not balanced - there are 21678 groups implying than on average there are 1.65 observations per group (1.55 for CF and 1.73 for IF).

In this section we report the panel data estimates of equations (6) and (7), wto of which (fixed-effects (within) and random-effects GLS) we discuss in more detail. In addition, we also report the the three-stage least-squares estimates. In order to obtain estimates, which are consistent with the underlying theoretical model, we impose

parameter restrictions. More precisely, we impose three parameter restrictions, when estimating equations (6) and (7): $\beta_a + \beta_v + \beta_k = 1$, $\gamma_7 = \delta_1\gamma_9$ and $\gamma_8 = \delta_3\gamma_9$.

The estimation results for fixed effects and random effects are reported in Tables 4 - 5. All estimates reported in Tables 4 and 5 are significant either at 95 or at 99% confidence level. The rather high significance of the estimated variables might be explained among other factors by the large sample size. Moreover, all coefficients are positive, hence they have the expected signs. These results are in line with the underlyng model discussed in section 3 and with previous studies (e.g. *Bhattacharyya et* al 1996; *Binswanger* and *Rosenzweig* 1986).

The upper part of Tables 4 and 5 report the production function, $\ln Q$, estimates. All three inputs (land, materials and capital) have positive and significant coefficients. In both specification and for both types of farms variable material inputs have the highest elasticity, which is in line with literature. The magnitude of the estimated input coefficients is similar between FE and RE specifications. Though not reported here, the coefficient δ_1 (land) becomes negative, when not controlling for differences in land quality. Therefore, in all estimations we include regional fixed effects.

The lower part of Tables 4 and 5 report the credit constraint, $\ln C$, estimates. Again, all variables have positive and statistically significant coefficients. However, the credit constraint estimates have a considerably larger variation in their magnitude. For CF we estimate the largest elasticities for non-agricultural assets, γ_1, own fixed capital, γ_2, capital rental rate, γ_3, own agricultural land, γ_4, and gross profitability of the sector, γ_9. All coefficients for these variables have a magnitude in a range of 0.25-0.35. These results are in line with the underlying theory of rural credit markets, which suggest that own land and fixed capital are regarded by banks as the most secure collateral. In contrast, according to our estimates the total value of land and capital assets (own and rented) have the lowest elasticities. Again, these results are in line with our expectations, as banks are hardly willing to accept rented land and capital as a collateral.

The estimation results for IF are different from the CF estimates. In particular, for the determinants of credit constraints we estimated different coefficients. For the IF we estimate the largest coefficients for own fixed capital, γ_2, capital rental rate, γ_3, own agricultural land, γ_4, and gross profitability of the sector, γ_9. The significance of non-agricultural assets, γ_1, seem to be considerably lower for IF. This might be due to the fact that for banks it is more difficult and more costly to evaluate and monitor heterogenous and small and non-agricultural assets of IF. As for CF, our estimates suggest that the total value of land and capital assets (own and rented) have the lowest elasticities in the farm credit constraint function.

Table 6 reports the 3SLS estimation results. The 3SLS estimation results are rather similar to those reported in Tables 4 - 5 . All estimates reported in Table 6 are significant either at 95 or 99% confidence level. All coefficients have positive signs, which is in line with the theoretical model and previous studies. According to the estimation results reported in Table 6, most of the coefficients are larger for

Table 4: Fixed effects panel data estimates

		CF		IF	
		coeff	std err	coeff	std err
$\ln Q$	δ_1	0.126^{**}	(0.092)	0.102^{**}	(0.084)
	δ_2	0.665^{***}	(0.011)	0.695^{***}	(0.003)
	δ_3	0.208^{***}	(0.037)	0.203^{***}	(0.022)
	R^2	0.589		0.573	
	N	2565		34851	
$\ln C$	γ_1	0.290^{***}	(0.057)	0.149^{***}	(0.002)
	γ_2	0.295^{***}	(0.026)	0.278^{***}	(0.003)
	γ_3	0.246^{***}	(0.075)	0.344^{***}	(0.007)
	γ_4	0.275^{***}	(0.046)	0.251^{***}	(0.006)
	γ_5	0.155^{***}	(0.008)	0.149^{***}	(0.010)
	γ_6	0.208^{***}	(0.096)	0.124^{***}	(0.018)
	γ_7	0.108^{***}	(0.106)	0.106^{***}	(0.011)
	γ_8	0.060^{***}	(0.012)	0.058^{***}	(0.006)
	γ_9	0.349^{***}	(0.074)	0.358^{***}	(0.012)
	R^2	0.440		0.465	
	N	2565		34851	

Source: Authors' estimations of equations (6) and (7) based on the FADN and Eurostat (2008) data. Standard errors in parentheses. Though not reported, all regressions include a constant, FADN-region and time fixed effects. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

CF compared to IF. This result is in line with the underlying theoretical framework, which suggests that IF are more credit constrained than CF.

The estimated coefficients allow as to calculate the structural parameters, which are required for empirical implementation of the underlying theoretical model presented in section 3. Given that all three specifications yield estimates in the same order of magnitude, theoretically, we could use coefficients for backing out the structural parameters from any of the three specifications. However, given that in addition to the standard panel data issues, the 3SLS addresses also the potential endogeneity of explanatory variables, it is our proffered specification for calculating the structural parameters.

Table 5: Random effects panel data estimates

		CF		IF	
		coeff	std err	coeff	std err
$\ln Q$	δ_1	0.124^{**}	(0.072)	0.113^{**}	(0.054)
	δ_2	0.658^{***}	(0.009)	0.690^{***}	(0.003)
	δ_3	0.219^{***}	(0.006)	0.197^{***}	(0.008)
	R^2	0.582		0.569	
	N	2565		34851	
$\ln C$	γ_1	0.248^{***}	(0.053)	0.153^{***}	(0.002)
	γ_2	0.272^{***}	(0.024)	0.263^{***}	(0.003)
	γ_3	0.270^{***}	(0.083)	0.370^{***}	(0.006)
	γ_4	0.283^{***}	(0.041)	0.251^{***}	(0.006)
	γ_5	0.160^{***}	(0.008)	0.153^{***}	(0.009)
	γ_6	0.218^{***}	(0.105)	0.123^{***}	(0.018)
	γ_7	0.111^{***}	(0.093)	0.098^{***}	(0.011)
	γ_8	0.056^{***}	(0.012)	0.056^{***}	(0.006)
	γ_9	0.330^{**}	(0.096)	0.333^{***}	(0.013)
	R^2	0.421		0.436	
	N	2565		34851	

Source: Authors' estimations of equations (6) and (7) based on the FADN and Eurostat (2008) data. Standard errors in parentheses. Though not reported, all regressions include a constant, FADN-region, and time fixed effects. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

5 Decomposing the impact of agricultural price shock by farm type

In this section we simulate the food price and input price increase for CF and IF. For the simulation purposes we apply the theoretical model presented in section 3 and the parameters estimated in section 4. First, we solve the model for the base run (section 5.1). Next, we exogenously change input and output prices (which each single farm perceive as given) and solve the model again. Comparing the simulation results with the baseline we are able to assess the assess the impact of price increase in agriculture. In addition, we decompose the impact by farm type. Finally, in section 5.3 we perform sensitivity analyses and check the robustness of our results.

Table 6: Three-stage least-squares panel data estimates

		CF		IF	
		coeff	std err	coeff	std err
$\ln Q$	δ_1	0.1396**	(0.0623)	0.1258**	(0.1040)
	δ_2	0.6245***	(0.0105)	0.6747***	(0.0035)
	δ_3	0.2359***	(0.0068)	0.1994***	(0.0018)
	R^2	0.597		0.552	
	N	2565		34851	
$\ln C$	γ_1	0.2641***	(0.0476)	0.1582***	(0.0025)
	γ_2	0.3154***	(0.0229)	0.2608***	(0.0027)
	γ_3	0.2583***	(0.0830)	0.3441***	(0.0064)
	γ_4	0.2525***	(0.0445)	0.2458***	(0.0057)
	γ_5	0.1455***	(0.0098)	0.1529***	(0.0097)
	γ_6	0.2093***	(0.0968)	0.1266***	(0.0181)
	γ_7	0.1271***	(0.0990)	0.0989***	(0.0107)
	γ_8	0.0670***	(0.0105)	0.0572***	(0.0056)
	γ_9	0.3680***	(0.1944)	0.3098***	(0.0117)
	R^2	0.401		0.461	
	N	2565		34851	

Source: Authors' estimations of equations (6) and (7) based on the FADN and Eurostat (2008) data. Standard errors in parentheses. Though not reported, all regressions include a constant, FADN-region, and time fixed effects. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

5.1 Base run

First, we apply the theoretical model presented in section 3 and the estimated parameters from section 4, and solve the model for the base year. The obtained basee run results suggest that even though the model parameters have been estimated econometrically based on historical data, the observed base year data cannot be replicated exactly by the model (although the deviation is rather small - less than 4.3%). The reasons for these small deviations are, for example, estimation error, measurement error, or disequilibrium in the base year data. Note that, in the model we assume market equilibrium.

In order to fit the model exactly to the base year data, we calibrate the model to 2004 data aggregated for all eight CEE transition countries. The 2004 baseline data are reported in Table 7. Overall for CEE, most of land is used by IF (74% of total land) in 2004. The share of IF on total output is slightly lower than in the case of land use. On aggregate CF use more variable and fixed capital per hectare than IF by

Table 7: Baseline data for CEE, 2004

	Unit	IF	CF	Total
Output	Share, %	72	28	100
Total utilized area	Share, %	74	26	100
Total capital	EUR/ha	803	943	839
Own fixed capital	EUR/ha	115	45	96
Own land	Share, %	63	6	48
Subsidies	EUR/ha	164.25	166.87	165

Source: Authors' calculations based on the FADN and Eurostat (2008) data.

around 140 EUR. However, IF own more fixed capital and own more land they use. Land owned by CF is very small, only around 6% of total used. IF own 63% of used land. Subsidies do not differ significantly between farms as the biggest proportion of subsidies include per hectare payments which are not linked to productivity but only to land use.

An important factor which will determine the impact of agricultural prices changes on farm production and input use are elasticities of credit constraint (equation (2)). The estimated elasticities are reported in Table 8. All parameters are farm-type specific, but not country-specific, as in the estimations we pooled the FADN data for all CEE countries together. The elasticities for almost all components of the credit constraint have higher elasticity for CF than for IF. The only exception is price of capital. These differences in elasticities between farms indicate that credit of CF will be more responsive to changes of factors determining farm credit and hence more responsive to changes of input and output prices.

Table 8: Elasticities of farm credit constraint

	Parameter	IF	CF
Non-agricultural assets	α_w	0.16	0.26
Own non-land agricultural assets	α_u	0.26	0.32
Price of capital	$\alpha_u\eta_k - \alpha_\pi\beta_k$	0.41	0.35
Own land	α_r	0.25	0.25
Land rent	$\alpha_r\eta_a - \alpha_\pi\beta_a$	0.19	0.20
Profits	α_π	0.31	0.37
Subsidies	α_s	0.13	0.21

Source: Authors' calculations based on estimates reported in Table 6.

5.2 Simulation results

In this section we simulate price increase on agricultural input and output markets. More precisely, we design the following four scenarios:[10] (i) scenario 1: output price increase by 40%; (ii) scenario 2: input price increase (variable and fixed capital) by 40%; (iii) scenario 3: output price and input (variable and fixed capital) price increase by 40%; and (iv) scenario 4: output price increase by 40% and input price increase by 20%.

Table 9 reports simulation results for the four scenarios considered. The results are in percentage changes relative to the baseline data (2004). The results of scenario 1 show that output price increase by 40% leads to substantial increase in production and input use. This is due to two effects: direct and indirect. First, higher output prices directly increase profitability of agricultural activities which stimulates input use (fixed capital and land) leading to higher output. Second, output and input use is affected indirectly through credit constraint. Higher profits and higher values of land prices alleviate farm credit constraint. Farms are able to obtain more credit and can buy more variable capital thus further increasing output and input use.

Table 9: Simulation results for CEE (percentage change relative to baseline)

	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Output price	0	40	0	40	40
Variable capital price	0	0	40	40	20
Fixed capital price	0	0	40	40	20
IF					
Output	0	51	-37	-4	18
Land	0	-3	3	0	-1
Variable input	0	47	-36	-5	16
Fixed capital	0	121	-58	-4	41
CF					
Output	0	67	-44	-4	24
Land	0	8	-8	0	4
Variable capital	0	59	-41	-5	20
Fixed capital	0	145	-63	-4	48

Source: Authors' calculations. See section 3 for model's assumptions.

However, the results reported in Table 9 suggest important differences between IF and CF. The increase in output and input use is stronger for CF than for IF.

[10] We assume that the economy is small and open, which implies that the variable and fixed capital price and the output price are fixed and hence affected only by external factors. We also assume total land availability fixed.

This is mainly due to the differences in credit constraints between IF and CF. The credit constraint elasticity with respect to profits is higher for CF (0.37) than for IF (0.31) (Table 8). As profits increase with output price increase, CF are able to secure more additional credit than IF leading also to stronger increase in output and input use. In the same time, with higher farm profitability also land values increase. This allows farms to obtain more credit because the collateral value of land increases. Since IF own more land in relative terms than CF they can obtain more additional credit. However, this does not offset the effect of higher profits on credit. One reason is also because the elasticity of credit constraint with respect to own land and land price is almost equal for both IF and CF (see Table 8). Hence, overall the effect of price increase by 40% has stronger effect on credit for CF than for IF. Overall, the difference in output and input increase between CF and IF is more than 10%. The exception is land use. With fixed total land supply the IF renting declines by 3% (Table 9).

If the prices for both variable and fixed capital increase by 40% (scenario 2 in Table 9), then the effect is reverse to the result obtained with output price increase in scenario 1. This is because now higher input prices reduce profits and land values leading to lower farm credit. Again, the effect is stronger for CF than for IF, but now the output and input use decline, except for IF land renting. In general, the impact is smaller than in scenario 1. By assumption, fixed capital price increases by 40%. This increases collateral value of non-land agricultural assets and augments farm credit. Hence, more credit reduces the negative effect of lower profits and lower land assets resulted from higher input prices.

With output and input price rise by the same rate (40% in scenario 3 in Table 9) the impact on output and inputs is relatively small. This is because output price effect (e.g. scenario 1) offsets the input price effect (e.g. scenario 2). If output price increases by more than input prices (scenario 4 in Table 9) then the effect is similar to scenario 1. However, the effect is smaller than in scenario 1 because input price increase has offsetting effect. Again, CF are more affected than IF. Output and input use increases stronger for CF than for IF. In the same time, IF land renting declines.

5.3 Robustness and sensitivity analyses

In order to assess the robustness of the presented results, we perform extensive sensitivity analysis. In this section we summarise they key results of the sensitivity analyses. First, the sensitivity analyses indicate that the results presented in this paper are rather sensitive to two factors: (i) the nature of price change and (ii) the elasticities of farm credit constraint. The impact of prices on output and input markets depends whether output prices change, input prices change, or whether both prices change simultaneously.

On the other hand, elasticities of farm credit constraint determine how each farm reacts to price changes. If the elasticities are larger for factors, which can be affected

directly or indirectly by price changes (e.g. farm profits, prices of agricultural asset), then farms are more sensitive to price changes. This is because rising prices change both farm marginal conditions as well as amount of farm credit. Otherwise the effect of price changes seems to be rather small. For example, if credit is determined only by non-agricultural assets, then farm reaction to price changes is limited particularly to output price rise. In this case, rising prices affect only farm marginal conditions while the amount of credit is unaltered. In the same time, with rising prices, any difference between farms in the elasticities of credit constraint leads to structural changes and reallocation of recourses between farms.

When controlling for land quality (using 66 regional dummies), the estimated parameters tended to be robust to various constraints on parameters. Particularly, the direction of change in output and input use tends to be consistent over alternative estimates of production function and credit constraint function. In the same time, a large number of observations allow to obtain statistically significant parameters, which are required for obtaining robust simulation results.

6 Conclusions

This paper shows that in the presence of credit imperfections, rising agricultural prices have important impact on output and input markets in the CEE transition countries. We find that higher output prices increase profitability and lead to higher input use and production. This is the 'direct channel'. These results are familiar from the previous literature. In addition, we find that higher output prices affect farm credit through higher profitability and higher collateral value of agricultural assets. This is the 'indirect channel' affecting input use and farm output.

Decomposing the aggregate impact of price increase in agriculture by farm type we found significant differences between IF and CF because of differences in the relative importance of different determinants of their access to credit. CF are able to obtain more credit based on profitability hence benefiting more from output price rise. Higher land ownership by IF does not offset this effect. Rising input prices have a similar effect as in the case of output prices but with the reverse sign and may or may not offsets the output price effect. This depends on the relative output and input price increase. Again, the effects are different between CF and IF, which are more credit constrained.

Based on these findings we may conclude that our empirical results support our theoretical hypothesis that asymmetries in credit market imperfections affect heterogenous farms differently. These results may have strong implications for agricultural producers in developing countries and transition countries in general, if they are more credit constrained than farmers in developed market economies. In such a case our results would imply that, in relative terms, raising food prices might reduce farm profits and farmer income in TC and DC. Hence, not only consumers but also agricultural producers in DC and TC would loose from the increasing food prices. This

in turn may require the developed countries to reconsider their bio-energy support and other policies, which are co-responsible for the recent food price shocks.

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7 Appendix

7.1 Figures

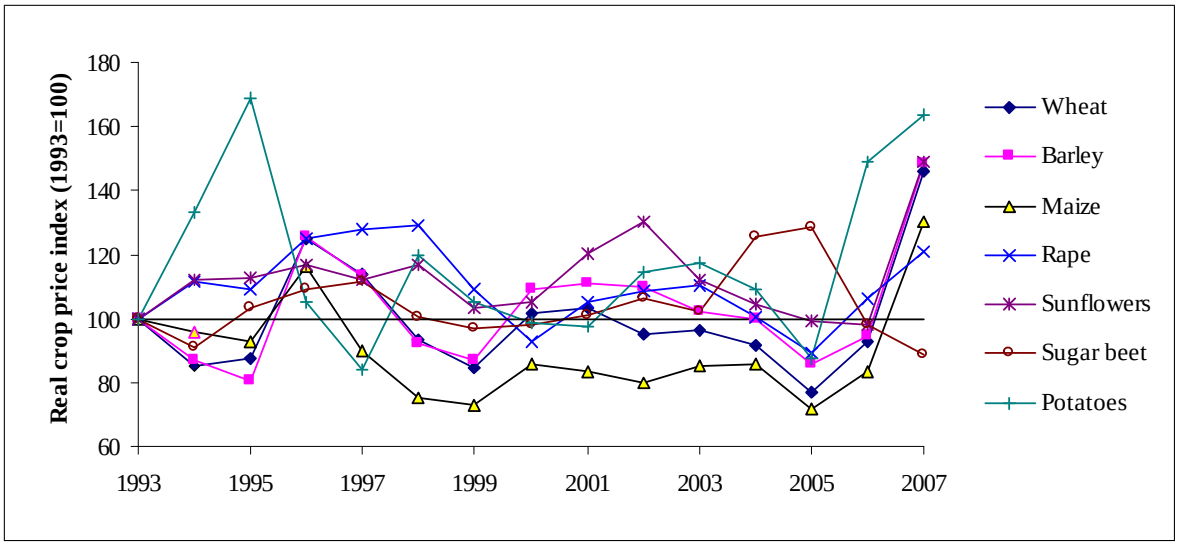

Figure 1: Development of real average crop prices in CEE (1993=100). Source: Authors' calculations based on the Eurostat (2008) data.

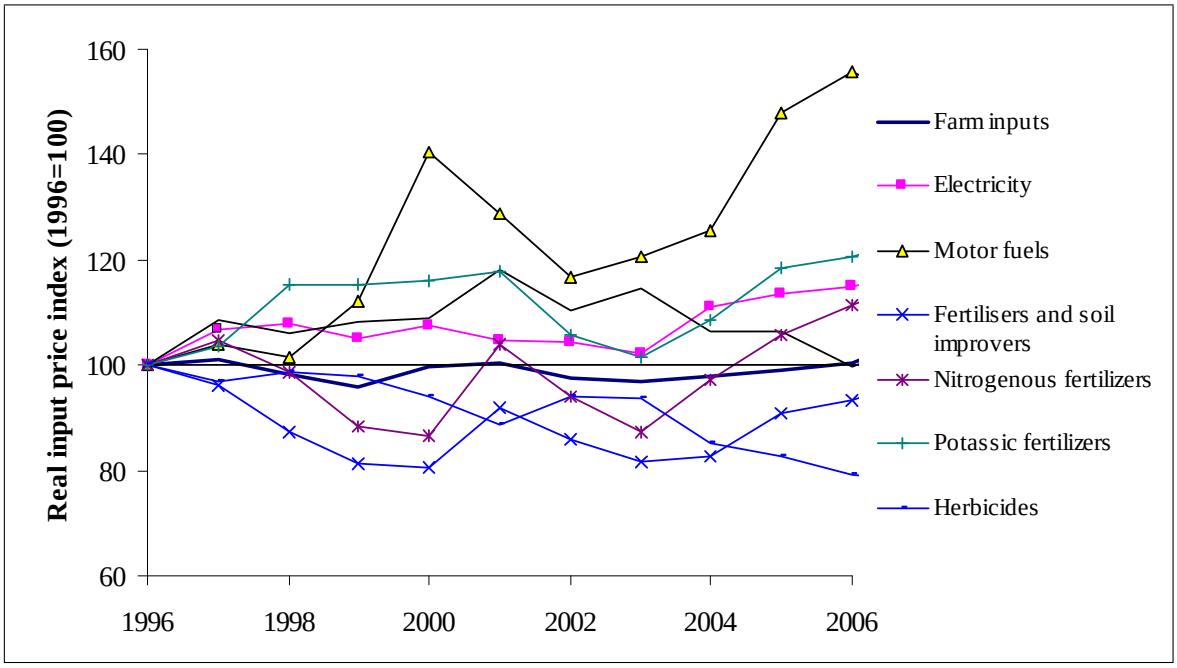

Figure 2: Development of real average input prices in CEE (1996=100). Source: Authors' calculations based on the Eurostat (2008) data.

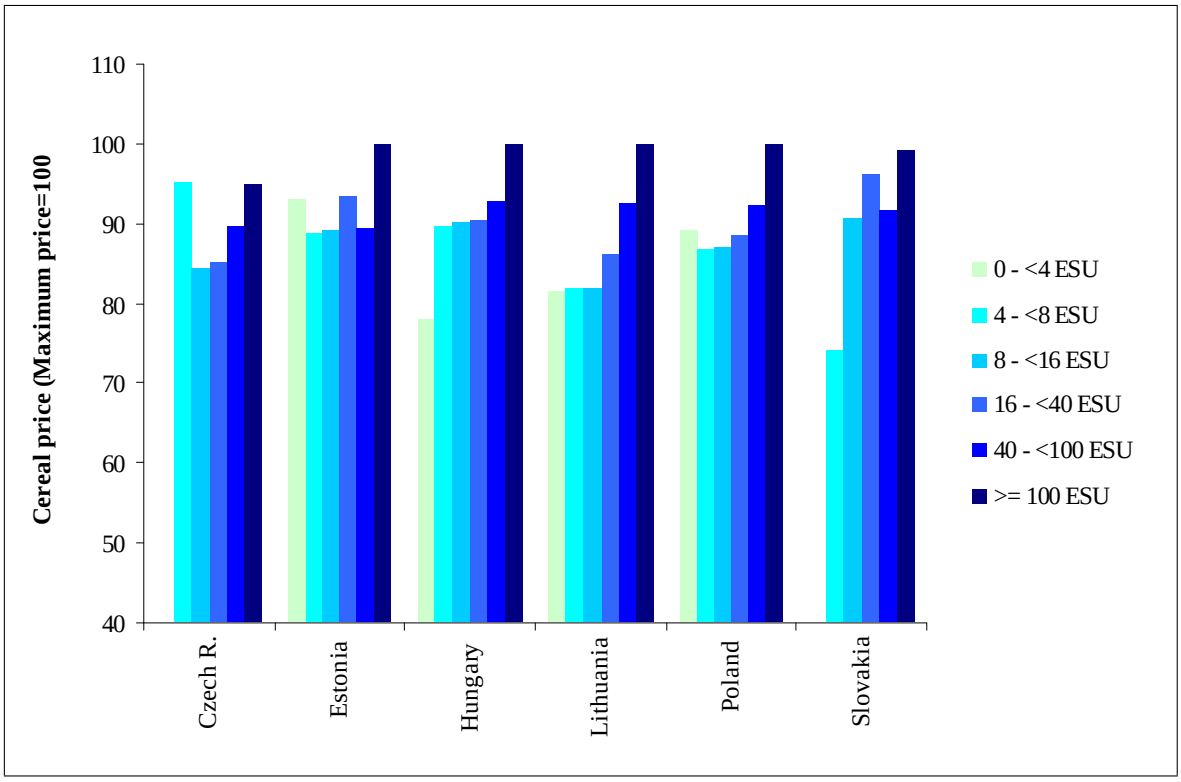

Figure 3: Nominal farm gate cereal prices by farm size in CEE (average prices for 2004-2006)

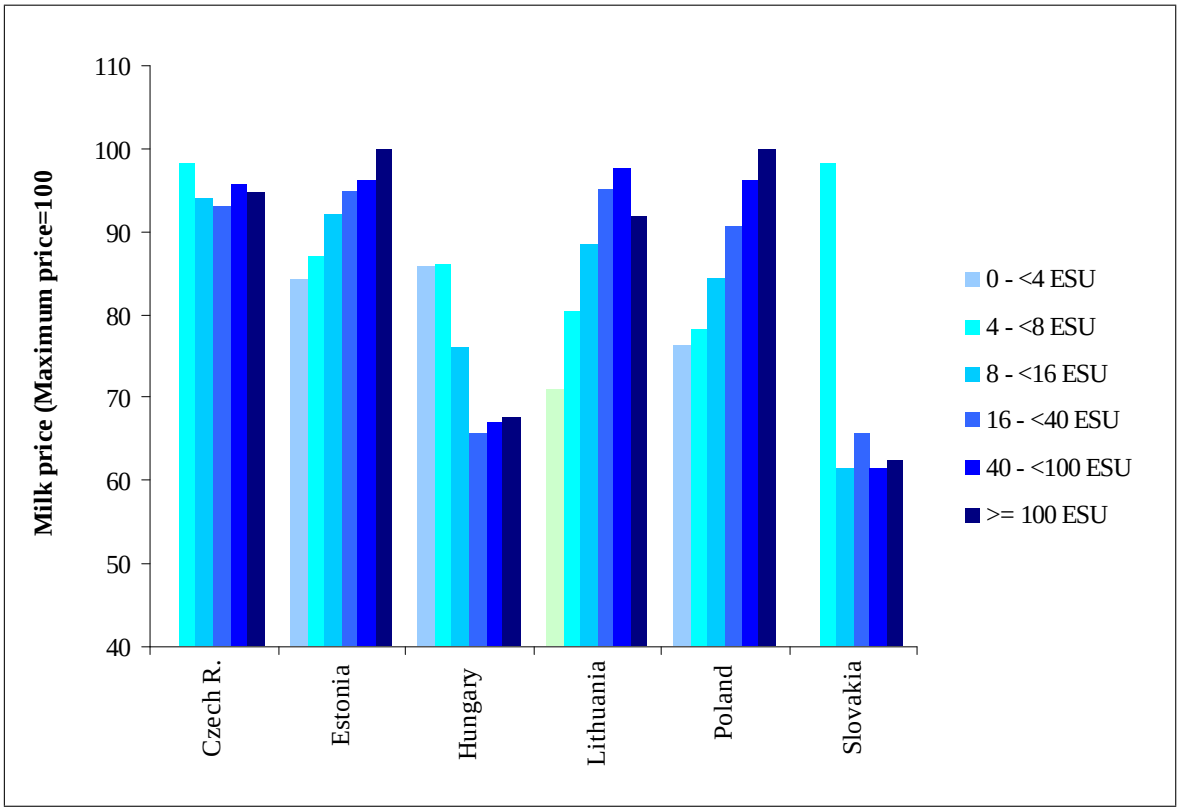

Figure 4: Nominal farm gate milk prices by farm size in CEE (average prices for 2004-2006)