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The Impact of Food Price Shock on Heterogenous Credit Constrained Firms

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The Impact of Food Price Shock on Heterogenous Credit Constrained Firms*

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Abstract

The paper analyses how rising agricultural prices affect heterogenous farm access to inputs and production under credit market imperfections in the transition economies. We estimate farm credit constraint equation using a unique farm level panel data and find that, on average, small individual farms (IF) are 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 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 transition and developing countries in general: not only the consumers but also producers, which on average are more credit constrained than farmers in developed countries, may lose their market shares and hence income in the long run.

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

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1 Introduction

Agricultural output prices have experienced high volatility in the recent years. According to *FAO* (2008), during 2006-2008 the aggregated food price index has increased by more than 40 percent. After the extraordinary price increase followed a decrease in the second half of 2008. However, on average the price levels remain above their long-term average before the price shock. Generally, such developments are not unusual for agricultural prices, which are rather sensitive to short run shocks in supply, e.g. due to changes in weather conditions, leading to large price volatility. However, compared to previous price fluctuations, the recent price shock is caused by structural changes, such as increasing input costs, the changes in the demand structure 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 rising food prices (*FAO* 2008).[1]

According to *IMF* (2008), *von Braun* (2008), *World Bank* (2008b), particularly consumers in the developing economies (DE) and transition economies (TE) might suffer from welfare losses due food price shocks, such as the one in 2007, because their food expenditure share is much higher compared to consumers in the industrialised (developed) countries.[2] In order to address the poverty issue of the growing agricultural prices and hence food expenditures of poor income levels, several DCs have already implemented policy measures targeted particularly at the most disadvantaged groups, such as poor consumers (*FAO* 2008).

On the supply side the distributional consequences of price shocks have been studied to a much lesser extent, although, changes in the 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 relatively more (substitution effect). More precisely, in response to changes in relative prices, farms increase their output scale and adjust output mix until the marginal profits of fixed factors are non-positive. Hence, if markets are perfect and nothing else changes, competition among existing farms and entrants drive profits to zero. If however markets are imperfect, then farm ability to adjust production scale and/or output

[1] Although the growth rate of food demand is likely to decrease as a consequence of food price increase.

[2] In the present study transition economies (TE) refer to the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia. The choice of these eight European transition economies is mainly data driven. However, the empirical results are general and apply similarly to developing economies. In contrast, developing economies (DE) refers to developing countries in general.

mix depends, among other factors, on the functioning of input and output markets. Indeed, according to previous literature (*Bhattacharyya et al* 1996, *Binswanger* and *Rosenzweig* 1986; *Subbotin* 2005), in TE and DE market imperfections constrain farm ability to adjust to price changes in input and output markets.

The above literature suggests that TE and DE farms face two broad types of market imperfections, which constrain their ability to adjust their production processes: 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 when lenders (banks) consider the observed food price increase as a transitory phenomenon. If factor market imperfections are higher in TE and DE than in developed countries, then input constrained producers in TE and DE might lose their relative output share. The latter constrain farm re-specialisation according to changes in the relative sectoral profitability. As a result, farms in TE and DE may benefit less than farms in developed market economies.

These insights suggest that raising global food prices might disadvantage not only consumers in TE and DE but, in relative terms, they may make worse off also credit-constrained agricultural producers, e.g. by reducing farm possibility to respond to price signals. To our knowledge, this adverse impact of raising output prices on farm production and income in TE and DE has not been studied in the literature explicitly. Hence, our study is among the first attempts to assess this impact in the context of TE.

In this paper we study how rising agricultural input and output prices affect farm access to inputs and hence production in the presence of credit market imperfections in transition economies.[3] Relying on a profit-maximisation model with heterogenous firms and drawing on a unique farm-level panel data for the transition economies we examine empirically how changes in the relative input and output prices affect corporate farms (CF) and individual farms (IF), which on average are more credit constrained. First, from the theoretical profit-maximisation model with heterogenous farms we derive testable hypothesis of the impact of agricultural price shocks on farmers. Second, we econometrically estimate the TE 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 examine the effects on 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 summarise the food and input price developments in TE and examine input and output price differences between different types of farms. Section 3 presents the underlying theoretical framework. In section 4 we empirically estimate the production and credit constraint equations, which provide us with the theoretical model's parameters. After introduc-

[3]According to the previous literature, there are important credit market imperfections in agricultural sector of the transition economies (e.g. *Bezemer* 2003).

ing the used farm level panel data, in section 4.2 we derive the empirically estimable equations. In section 4.3 we present the estimation results. Finally, in section 5 we perform simulations of the recent price increase in agricultural input and output markets. In particular, we simulate the food price and input price increase and examine their impact for CF and IF. Section 6 concludes and derives policy implications.

2 Food price developments and firm heterogeneity

2.1 Price developments in TE

Following the world price developments, agricultural prices in TE 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 TE. This is contrary to the developments in the Western European countries where real prices declined. At the beginning of the 1990s output prices in TE were significantly lower than in the Western European countries. The economic transition and European integration processes during the last two decades led to a continuous convergence of the TE prices to the EU price level. The real prices, however, remained relatively stable for most of the agricultural products in TE, as the TE-EU price convergence just offset the upward pressure from inflation (see Figure 1).

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

Table 1 shows the change in real crop prices in 2007 relative to 2004 by crop and by country. Overall for the TE, 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 TE, while it increased at world level. Sugar price decline in TE 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 TE crop prices and the world prices is relatively strong, more than 70%.

Table 1 suggests a considerable variation in crop price changes between TE. A particularly low increase in food prices is observed for 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, the Table suggests that in Baltic countries (Estonia, Latvia and Lithuania) food price increase tends to be higher than in other TE.

The real animal prices increased less than the real crop prices in TE. Overall for

Table 1: Changes in real crop prices in TE (percentage change 2007 to 2004)

	Wheat	Barley	Maize	Rape	Sunflow	Sugar b.	Potatoes
Czech Republic	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
TE	59.4	48.9	51.4	20.4	42.2	-29.4	49.9

Source: Authors' calculations based on the Eurostat (2008) data. Notes: Prices for TE used to calculate changes are simple averages over the available TE prices.

the TE, the 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 2). Similar mixed picture is observed in development of world animal prices. The real 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).

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

2.2 Price differences between farm types

Farm ability to benefit from a food price increase depends on their ability to access markets and their negotiation power with traders and/or processors. Particularly, this may depend on the farm output level, which affects both the relative negotiation

Table 2: Changes in real animal prices in TE (percentage change 2007 to 2004)

	Cattle	Pig	Lambs	Chicken	Milk
Czech Republic	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
TE	22.2	-18.2	0.7	3.6	21.9

Source: Authors' calculations based on the Eurostat (2008) data. Notes: Prices for TE used to calculate changes are simple averages over the available TE prices.

power of the farm, and the transaction costs per unit traded. As a result, usually farms which trade larger quantities, i.e. large corporate farms, receive higher net price. Hence, one may expect that larger farms might benefit relatively more from the recent price increases.

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

According to Figure 4, the farm gate price for milk increases with 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 the farm size and 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 impact of changes in the relative prices depends, among other, on the structure of farm credit. If farm access to credit is mainly determined by availability of agricultural assets (e.g. land), then higher output prices affect farm credit 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 the total farm credit directly. However, in both cases the impact on farm input use depends on the input price developments. If input prices increase significantly, then the total farm input use may actually decrease even with better access to credit. Moreover, if the structure of credit differs between types of farms, then the rising input prices may also affect different types of 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 (*Ciaian* and *Swinnen* 2009, *Carter* and *Wiebe* 1990, *Feder* 1985). Hence, we assume that variable inputs (e.g. fertilisers, hired labour) 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 (*Ciaian* and *Kancs* 2009).[4] This requires pre-financing of variable inputs. This can be done either through internal finance (savings or cash flow) and/or through credits.

In line with the empirical evidence from TE and DE, we assume that there are two types of farms: corporate farms and individual farms. 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 farm subsidies.

To model the short-run imperfect credit market, we follow the approach of *Feder* (1985), *Carter* and *Wiebe* (1990), *Ciaian* and *Swinnen* (2009), *Briggeman*, *Towe* and *Morehart* (2008) by introducing a farm credit constraint. It is assumed that the maximum amount of credit, C, 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

[4] 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 transition economies 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 realised 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.

the loan), and government subsidies:[5]

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

where α_w, α_u, α_r, α_π and α_s are credit elasticities, B_c is a constant, W is non-agricultural assets, K_o is own non-land 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 farm 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:[6]

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

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

According to equation (2), the farm access to credit depends on four components: non-agricultural assets, W^{α_w}, non-land own agricultural assets, $[K_o R_k(w_k)]^{\alpha_u}$, own agricultural land, $[A_o R_a(w_a)]^{\alpha_r}$, farms' gross profits, $\left[\pi_g A^{\beta_a} K^{\beta_k}\right]^{\alpha_\pi}$, and government subsidies S^{α_s}. The elasticities α_w, α_u, α_r, α_π, and α_s determine the relative importance of each component. Farms maximise their profits (1) subject to credit constraint (2). In the presence of a binding credit constraint, the equilibrium conditions for land, capital demand by farm and variable capital are:

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

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

$$V = \frac{C}{w_v} \tag{5}$$

The equilibrium input demand and output supply depend on output price, input prices and farm access to credit: $X = X(y, C)$, for $X = A, K, V, Q$; $y = p, w_a, w_k, w_v$. The impact of agricultural prices on farm input demand and output supply can be decomposed in two components as follows:

[5] This type of modelling farm credit (*Feder* 1985; *Carter* and *Wiebe* 1990; *Ciaian* and *Swinnen* 2009; *Briggeman*, *Towe* and *Morehart* 2008) implicitly implies that farms are not constrained for long-run credit.

[6] 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).

$$\frac{dX}{\partial y}=\frac{\partial X(y,C)}{\partial y}+\frac{\partial X(y,C)}{\partial C}\frac{\partial C}{\partial y} \tag{6}$$

The first term on the right hand side in equation (6) is the direct channel through which prices impact on farm inputs and output. The direct channel measures farm adjustments in inputs demand and output supply to price changes for a given level of farm credit, C. Agricultural prices affect profitability of agricultural production. Farm inputs increase with own input price and output price and decrease with prices of rented inputs. Output increases with output price and decreases with input prices. The second term on the right hand side of equation (6) is the indirect channel through which prices impact on farm inputs and output, according to which prices affect farm input use and output supply by changing the level of farm credit. From equation (2) it can be derived the effect of prices on farm credit, $\frac{\partial C}{\partial y}$:

$$\begin{aligned}\frac{\partial C}{\partial y} &= \alpha_u C\frac{K_o}{K_oR_k(w_k)}\frac{\partial R_k(w_k)}{\partial w_k}\frac{\partial w_k}{\partial y} \\ &+\alpha_r C\frac{A_o}{A_oR_a(w_a)}\frac{\partial R_a(w_a)}{\partial w_a}\frac{\partial w_a}{\partial y} \\ &+\alpha_\pi\frac{C}{\pi_g A^{\beta_a}K^{\beta_k}}\frac{\partial\left(\pi_g A^{\beta_a}K^{\beta_k}\right)}{\partial y}\end{aligned} \tag{7}$$

Prices affect credit through changing the collateral value of agricultural assets and agricultural profitability. More precisely, the effect depends on the extent to which non-land agricultural asset price, $\frac{\partial R_k(w_k)}{\partial w_k}\frac{\partial w_k}{\partial y}$, agricultural land price, $\frac{\partial R_a(w_a)}{\partial w_a}\frac{\partial w_a}{\partial y}$, and farm gross profits, $\frac{\partial\left(\pi_g A^{\beta_a}K^{\beta_k}\right)}{\partial y}$, are affected by prices changes.[7][8] Second, the importance of each component (α_u, α_r and α_π, respectively) in determining the farm access to credit determines the overall impact of prices on credit. For example, if output price increases values of agricultural assets, then farms can obtain more credit as their collateral value is boosted. Then higher credit changes output, land and fixed capital through the increase of variable input use.

In summary, the impact of price shock on each farm type (IF or CF) depends on the structural characteristics of both direct and indirect channels affecting input use and output supply. Particularly, the differences in farm access to credit and the relative importance of each agricultural component in the credit constraint (non-land

[7]Note that important is how the lenders perceive the impact of prices on asset prices and gross profits. If lenders base their decisions on past values of profits or on asset values that have not yet incorporated the impact of prices, then, the farm credit will be not affected by agricultural price changes. In this case $\frac{\partial R_k(w_k)}{\partial w_k}\frac{\partial w_k}{\partial y}=\frac{\partial R_a(w_a)}{\partial w_a}\frac{\partial w_a}{\partial y}=\frac{\partial\left(\pi_g A^{\beta_a}K^{\beta_k}\right)}{\partial y}=0$.

[8]Note that the component non-agricultural assets drops out because it is not affected by agricultural prices, $\frac{\partial W}{\partial y}=0$.

agricultural asset price, α_u, agricultural land price, α_r, farm gross profits, α_π) will lead to different responses between different types of farms.

First, all parameters determining farm access to credit may be expected to be higher for CF than for IF, because the per unit transaction costs of borrowing are smaller for CF than for IF. Hence, banks may be willing to offer more credit to CF than to IF for the same level of own assets, own land or gross profitability. As a result, CF are expected to be more responsive to price changes than IF.

The credit dependence on profits is expected to be bigger for CF than for IF. This is because if CF are perceived by banks less risky than IF. Hence, the CF credit is expected to be more dependent on profits than credit received by IF. For example, *Bezemer* (2003) finds that in the Czech Republic long-established large CF have better access to credit than small IF. *Petrick* and *Latruffe* (2003) find for Poland that among others the probability of borrowing increases with having permanent book-keeping, which is the case of CF. Book-keeping allows better monitoring of farm activities by bank. In general, IF do not keep books in TE. This may indicate that farm output and input use response to agricultural price change through the profit component of the credit constraint will be stronger for CF than for IF.

On the other hand, access to credit of more risky IF may more strongly depend on collateral value of agricultural assets (particularly on own land) than for CF. Studies have shown that with the presence of costly contract enforcement and ex-post asymmetric information collateral it is more effective and more likely to be used in the case risky investments (*Bester* 1985; *Ghosh*, *Mookherjee* and *Ray* 2000). This may imply larger effect of prices on IF output and input use if agricultural prices are strongly correlated with prices of agricultural assets.

4 Empirical implementation

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 TE 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 one quarter of the total UAA in TE. Given that the panel is not balanced - there are 21678 farm groups - on average there are 1.65 observations per group (1.55 for CF and 1.73 for IF).

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 TE. The economic variables we use in our study are summarised in the Appendix.

4.2 Empirical specification

The starting point for deriving an empirically estimable model 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 $R = w_k^{\eta_k}$, respectively, yields:

$$C = B_c W^{\alpha_w} \left[K_o w_a^{\eta_a}\right]^{\alpha_u} \left[A_o w_k^{\eta_k}\right]^{\alpha_r} \left(\pi_g A^{\beta_a} K^{\beta_k}\right)^{\alpha_\pi} S^{\alpha_s} \tag{8}$$

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 TE, we introduce fixed effects, ν, on the right hand side of equation (8). Substituting equations (3) and (4) into equation (8) and applying a logarithmic transformation yields:

$$\begin{aligned} \ln C &= \gamma_0 \ln B_c + \gamma_1 \ln W + \gamma_2 \ln K_o + \gamma_3 \ln w_k + \gamma_4 \ln A_o + \gamma_5 \ln w_a \\ &\quad + \gamma_6 \ln S + \gamma_7 \ln w_a A + \gamma_8 \ln w_k K + \gamma_9 \ln \pi_g + \nu + \epsilon \end{aligned} \tag{9}$$

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 farm production equation:

$$\ln Q = \beta_0 \ln B + \beta_a \ln A + \beta_a \ln V + \beta_k \ln K + \nu + \epsilon \tag{10}$$

where, as above, ν is a time invariant constant term capturing region specific fixed effects and ϵ is a random prediction error and β_a, β_v and β_k are the coefficients to be estimated.

Equations (9) and (10) 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. 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 order to determine the most appropriate estimation technique, we perform extensive specification tests to equations (9) and (10). The *Hausman-Wu* specification test results do not yield a definite answer regarding the preferred specification. Therefore, we estimate equations (9) and (10) both with fixed effects (FE) and with random effects (RE) estimators.

According to (*Briggeman*, *Towe* and *Morehart* 2008), the estimation of equations (9) and (10) may be subject to endogeneity issues. For example, given that variable inputs, V, enter the left hand side of equation (9) and the right hand side of equation (10), they may be endogenous. In order to allow for the possibility that equations (9) and (10) 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 (9) and (10) for the transition economies separately for CF and IF. All variables required to estimate equations (9) and (10) are extracted from the FADN (2008) and *Eurostat* (2008). 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 (9) and (10): $\beta_a + \beta_v + \beta_k = 1$, $\gamma_7 = \delta_1\gamma_9$ and $\gamma_8 = \delta_3\gamma_9$.

The estimation results for fixed effects and random effects model are reported in Tables 3 - 4. All estimates reported in Tables 3 and 4 are significant either at 95 or at 99% confidence level. Due to large size of the employed data sample, the significance level of the estimated coefficients is rather high. Moreover, all coefficients are positive, hence they have the expected signs.

The upper part of Tables 3 and 4 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 the FE and RE specifications. Though not reported, the coefficient β_a (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 3 and 4 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 the range

Table 3: Fixed effects panel data estimates

		CF		IF	
		coeff	std err	coeff	std err
$\ln Q$	β_a	0.126**	(0.092)	0.102**	(0.084)
	β_v	0.665***	(0.011)	0.695***	(0.003)
	β_k	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 (9) and (10) 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.

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 previous studies, as banks are hardly willing to accept rented land and capital as collateral.

The estimation results for IF are different from the CF estimates. In particular, the estimated different coefficients of the determinants of credit constraints are different. For IF the largest estimated coefficients are 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. These results are in line with the underlying theoretical model from section 3 and previous

Table 4: Random effects panel data estimates

		CF		IF	
		coeff	std err	coeff	std err
$\ln Q$	β_a	0.124**	(0.072)	0.113**	(0.054)
	β_v	0.658***	(0.009)	0.690***	(0.003)
	β_k	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 (9) and (10) 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.

studies (*Bhattacharyya et* al 1996; *Binswanger* and *Rosenzweig* 1986).

Table 5 reports the 3SLS estimation results. The 3SLS estimation results are rather similar to those reported in Tables 3 - 4 . All estimates reported in Table 5 are significant either at 95 or 99% confidence level. All coefficients are positive, which is in line with the theoretical model and previous studies. According to Table 5, most of the estimated coefficients are larger for 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 the empirical implementation of the underlying theoretical model presented in section 3. Given that in addition to the standard panel data issues, the 3SLS estimator also addresses potential endogeneity of explanatory variables, it is our preferred specification for calculating the structural parameters.

Table 5: Three-stage least-squares panel data estimates

		CF		IF	
		coeff	std err	coeff	std err
$\ln Q$	β_a	0.1396**	(0.0623)	0.1258**	(0.1040)
	β_v	0.6245***	(0.0105)	0.6747***	(0.0035)
	β_k	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 (9) and (10) 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 price shock between farm types

5.1 Base run

Applying the theoretical model developed in section 3 and the parameters estimated in section 4 we solve the model for the base year, which yields a vector of base run equilibrium values. They suggest that even though the model parameters have been estimated econometrically based on the observed data, the true base year data cannot be replicated exactly by the simulation model. The reasons for these small deviations are, for example, estimation error, measurement error, or disequilibrium in the base year data (in the model we assume market equilibrium). However, the simulation-observation deviations are rather small - on average less than 4.3%.

The 2004 baseline data are reported in Table 6. Overall for the TE, 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 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

Table 6: Baseline data for TE, 2004

	Unit	IF	CF	Total
Output	Share, %	72	28	100
Total utilised 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	166	165

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

total used. IF own 63% of used land. Subsidies do not differ significantly between farm types 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 price changes on farm production and input use are elasticities of credit constraint (equation 2). The estimated elasticities are reported in Table 7. All parameters are farm-type specific, but not country-specific, as in the estimations we pooled the FADN data for all TE countries together.[9] The elasticities for almost all components of the credit constraint have higher elasticity for CF than for IF. The only exception is the price of capital. These differences in elasticities between farm types 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 7: 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 5.

[9]The sample size is too small for estimating and identifying the elasticities both by farm type and country.

5.2 Simulation results

We examine the impact of price increase on agricultural input and output markets in 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 8 reports simulation results for the four scenarios considered. All reported results are percentage changes relative to the baseline scenario. The results of scenario 1 show that output price increase by 40% leads to substantial increase in production and input use. This is caused by two effects: direct price effect and indirect price effect. First, higher output prices directly increase the 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, which further increases input use and farm output.

The results reported in Table 8 suggest important differences between different types of farms. The increase in output and input use is considerably stronger for CF than for IF. This is mainly due to 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 7). As profits increase with output price increase, CF are able to secure more additional credit than IF, leading also to a stronger increase in output and input use. In the same time, with higher farm profitability also the land values increase. This allows farms to obtain more credit, because the collateral value of land increases. Given that IF own more land 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 7). Hence, the overall effect of price increase by 40% has stronger effect on credit for CF than for IF. 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 8).

If the prices for both variable and fixed capital increase by 40% (scenario 2 in Table 8), then the effect is reverse to the result obtained under the 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 the collateral value of non-land agricultural assets

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

Table 8: Simulation results for TE (percentage change relative to baseline)

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Output price	40.0	0	40.0	40.0
Variable capital price	0	40.0	40.0	20.0
Fixed capital price	0	40.0	40.0	20.0
IF				
Output	51.3	-37.4	-4.2	18.2
Land	-3.1	3.8	0.9	-1.7
Variable input	47.6	-36.9	-5.4	16.0
Fixed capital	121.0	-58.4	-4.7	41.4
CF				
Output	67.6	-44.7	-4.3	24.3
Land	8.1	-8.3	0.6	4.6
Variable capital	59.2	-41.6	-5.1	20.5
Fixed capital	145.8	-63.0	-4.8	48.9

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

and augments farm credit. Better access to credit reduces the negative effect of lower profits and lower land assets resulting from higher input prices.

Assuming input and output prices rising by the same rate (40% in scenario 3 in Table 8) the impact on the use of inputs and output is relatively small. This is because the 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 8), then the effect is similar to scenario 1. However, the effect is smaller than in scenario 1, because the 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, the land renting of IF declines.

5.3 Robustness and sensitivity

In order to assess the robustness of the presented results, we perform extensive sensitivity analysis. 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 on 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 type of farms reacts to changes in relative prices. 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 different types of 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 transition economies. We find that higher output prices increase profitability and lead to higher input use and production. This is the 'direct channel'. These results are in line with the previous literature (*Briggeman*, *Towe* and *Morehart* 2008). 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, they benefit relatively more from increase in output prices. 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 a 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 this case our results would imply that, in relative terms, raising food prices might reduce farm profits and farmer income in TE and DE. Hence, not only consumers but also agricultural producers in DE and TE would loose from the increasing food prices. This in turn may require the developed countries to reconsider their bioenergy support and development aid policies, which are co-responsible for the recent food price shock.

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7 Appendix

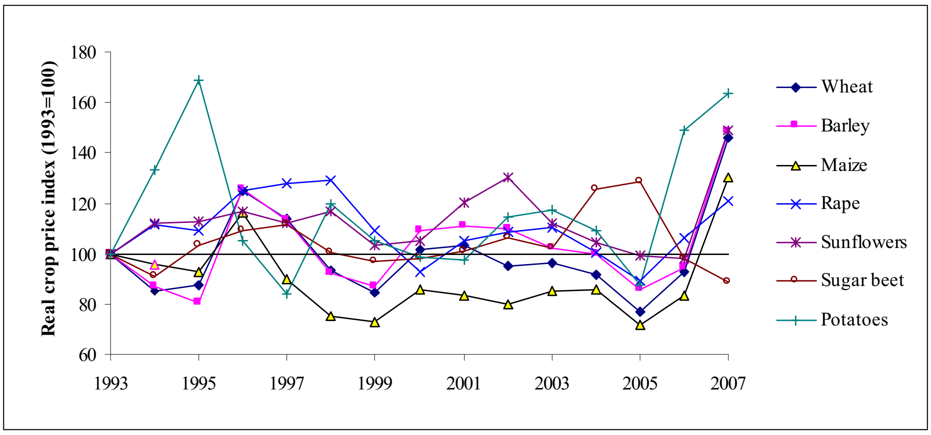

Figure 1: Development of real average crop prices in TE (1993=100). Source: Authors' calculations based on Eurostat (2008) data.

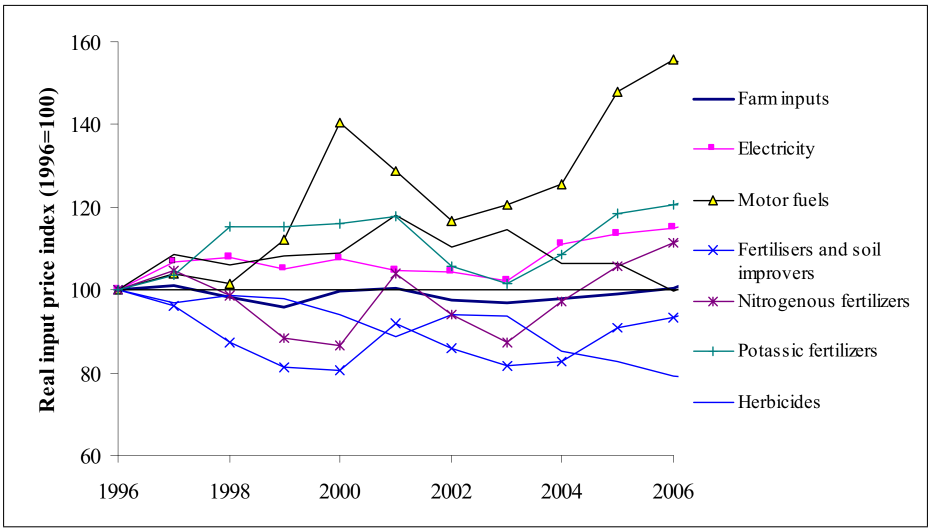

Figure 2: Development of real average input prices in TE (1996=100). Source: Authors' calculations based on Eurostat (2008) data.

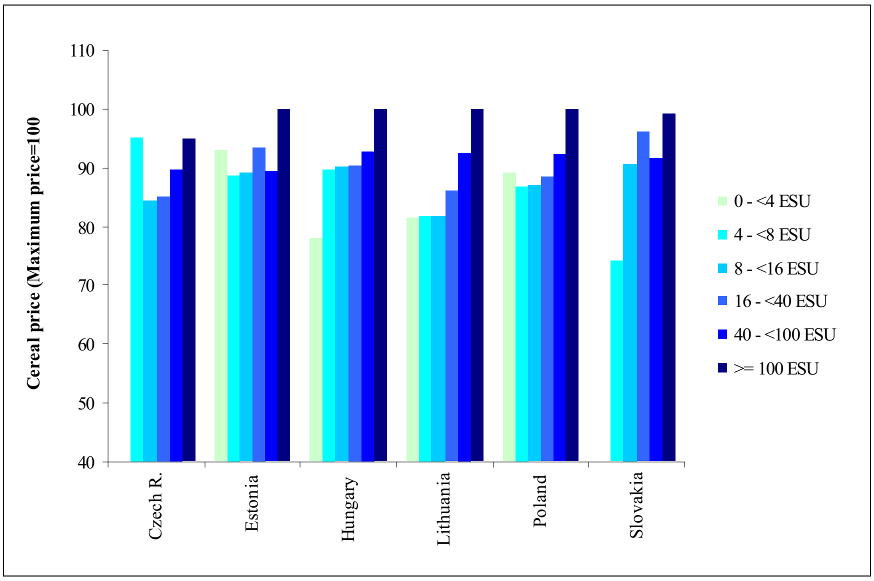

Figure 3: Nominal farm gate cereal prices by farm size in TE (average prices for 2004-2006). Notes: ESU: European farm size Unitits. The value of one ESU is defined as a fixed number of EUR/ECU of Farm Gross Margin.

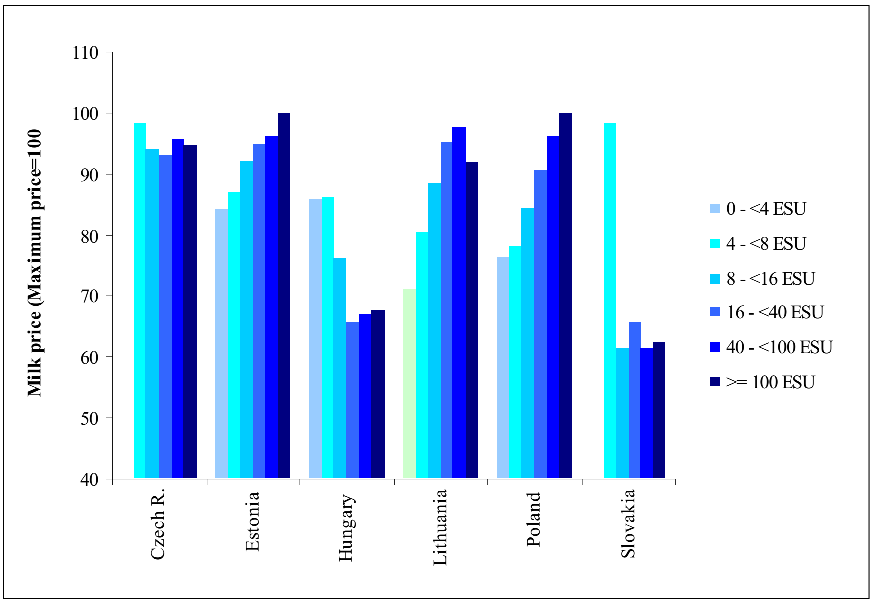

Figure 4: Nominal farm gate milk prices by farm size in TE (average prices for 2004-2006). Notes: ESU: European farm size Unitits. The value of one ESU is defined as a fixed number of EUR/ECU of Farm Gross Margin.