FACTOR MARKETS

Comparative Analysis of Factor Markets for Agriculture across the Member States

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Synthesis Report on the Impact of Capital Use

ABSTRACT

This paper examines the drivers of productivity in EU agriculture from a factor markets perspective. Using econometrically estimated production elasticities and shadow prices of factors for a set of eight EU member states, we focus on field crop farms represented in the FADN database for the years 2002-08. As it turned out that output reacts most elastically to materials input, we investigate this factor further and find different rationing regimes represented in different member states. Marginal return on materials is low in Denmark and West Germany, but significantly above typical market interest rates in East Germany, Italy and Spain. In the latter countries and in Denmark it also increased towards the end of the observed period. This finding is consistent with a perception of tightening funding access, possibly induced or reinforced by the unfolding financial crisis. Marginal returns to land, labour and fixed capital are generally low. We conclude that the functioning of factor markets plays a crucial role for productivity growth, but that factor market operations display considerable heterogeneity across EU member states.

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Synthesis Report on the Impact of Capital Use

Martin Petrick and Mathias Kloss*

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1. Introduction

In recent years, exploding food prices on world markets have conspicuously signalled that global resources for agricultural production are indeed scarce (FAO, 2009). How farm productivity could be raised has recaptured attention of the global media (e.g. Parker, 2011) and food riots have been reported from several developing countries. Compared to other world regions, agricultural productivity growth has been stagnating in Europe and especially the EU (Coelli and Rao, 2005; Piesse and Thirtle, 2010). Coincidentally with recent food price increases, a new debate among econometricians about very basic methodological issues in measuring productivity at the firm level has gained momentum (Levinsohn and Petrin, 2003; Ackerberg et al., 2007).

In this contribution, we take a factor market perspective on productivity and structural change. We aim to provide a more detailed insight into the results that were reported in our previous research within the "Factor Markets" research project (Petrick and Kloss, 2013b), by using a number of graphical summary charts. Our goal in this research was to answer the following questions: Which factors are the bottlenecks for productivity growth? What does micro-data tell us about the efficiency of factor markets in EU agriculture? In order to tackle these questions we empirically estimated production elasticities and shadow prices of factors, based on individual farm data from eight EU member states. We discussed and implemented recent innovations in the estimation of production functions. Our focus was on field crop farms represented in the FADN database for the years 2002-08.

So far, the assessment of factor productivities within the "Factor Markets" research project has revealed the following insights. In an analysis of Finnish dairy farms, Heikkilä et al. (2012) find that output responds most elastically to materials and fixed capital inputs. Rizov et al. (2013) confirm and extend this view to the EU-15. By aggregating over different farm types, they recover materials elasticities ranging between 0.59 for Greece and 0.87 for Sweden while labour and fixed capital productivities are rather low. This finding is in contrast to recent estimates by Mundlak et al. (2012), according to whom there are significant returns to land and fixed capital in a cross-country sample of developing and developed countries. Ciaian et al. (2012) relate productivity to credit constraints and find that farms in Central and Eastern Europe are credit constrained with respect to variable inputs and capital investment, but not with regard to land and labour.

Our own empirical estimates also suggest that the materials elasticity is quite high, above 0.6, while labour, land and fixed capital display much lower output elasticities. The assumption of constant returns to scale is widely supported empirically. The shadow price analysis reveals considerable heterogeneity across EU countries. In France, Spain, Italy and East Germany, we observe marginal returns on materials much above typical market interest rates, especially towards the end of the observed period. This is consistent with a perception of

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constrained access to funding, possibly induced by the unfolding financial crisis (Petrick and Kloss, 2013a). For Denmark, West Germany and Poland, returns on materials are low, which is consistent with an over-utilisation of inputs. In general, the remuneration of labour, land, and fixed capital is quite low, except for Denmark.

In the following section 2, we briefly summarise the methodological issues discussed in more detail in Petrick and Kloss (2013b). Section 3 describes the dataset. Section 4 presents the empirical results. Section 5 concludes.

2. Identification problems in production function estimation and approaches to their solution

Denote y_{it} the natural logarithm of farm *i*'s output Y at time t, A_{it} land use of this farm, L_{it} labour, K_{it} fixed capital and M_{it} materials or working capital. These four factors of production are observed by the econometrician. ω_{it} is an aggregate, farm-specific, time-varying factor that is anticipated by the farmer at the time of decision-making about current production, but unobserved by the econometrician. ε_{it} is a productivity shock not anticipated by the farmer, or simply measurement error. Assuming a linear structure of the model and the availability of panel data, the econometrician's problem is to recover farm productivity determined by the following equation:

$$y_{it} = f(A_{it}, L_{it}, K_{it}, M_{it}) + \omega_{it} + \varepsilon_{it}, \quad (1)$$

where $f(.)$ is the production function.

Because ω_{it} will likely be correlated with the other input choices, estimation of (1) is subject to an *endogeneity problem* (Marschak and Andrews, 1944). The production elasticities of the observed factors are not identified, as the compound error term $\omega_{it} + \varepsilon_{it}$ is not identically and independently distributed (i.i.d.). Regressing output on observed input levels using OLS and choosing an appropriate functional form for $f(.)$ will produce biased estimates. A typical OLS result may be that the coefficients of labour and materials are upward biased, while those of land and capital are downward biased. Much of the methodological literature on production function estimation is concerned with precisely this issue (see the instructive review in Griliches and Mairesse, 1998).

According to the standard theoretical setup, all observed factors are assumed to be control variables and are treated as being fully flexible. The typical assumption (e.g. Chambers, 1988) is then that output and all factors are traded on perfectly competitive markets so that on each of the markets all farmers face the same one price for the traded good. Furthermore, it is assumed that the technology represented by $f(.)$ is identical for all farmers included in the estimating sample. If all farmers also face the same price on each of the input markets, there is nothing in the model that induces heterogeneous factor use across farms except for the unobserved ω_{it}. This is the *collinearity problem* pointed out recently by Bond and Söderbom (2005) and Ackerberg et al. (2007). Factor use across firms varies only with the unobserved ω_{it}, so that again the different production elasticities are not identified.

In the following, we briefly present and subsequently show results for two alternative ways of identification (see Petrick and Kloss, 2013b for a fuller treatment). One is based on additively separable, time-invariant firm characteristics, the other on the monotonous coevolution of unobserved productivity shocks with observed firm characteristics.

The key idea of the first approach is that ω_{it} can be further decomposed into:

$$\omega_{it} = \gamma_t + \eta_i + v_{it}, \quad (2)$$

where γ_t is a time-specific shock that is identical for all farms in t, η_i is a farm-specific fixed effect that does not vary over time, and v_{it} is the remaining farm- and time-specific productivity shock. If they are not anticipated by the manager, v_{it} is subsumed into ε_{it}. If the production function is linearly separable in the logs of observed and unobserved factors, a commonly used functional form is Cobb Douglas, so that the function can be written as $y_{it} = \alpha^A a_{it} + \alpha^L l_{it} + \alpha^K k_{it} + \alpha^M m_{it} + \gamma_t + \eta_i + \varepsilon_{it}$, with lower case letters denoting logs, α^X the coefficients to be estimated, and X a shorthand for the observed production factors $X \in \{A, L, K, M\}$. Applying the usual 'within' transformation, the fixed effect η_i is "swept out" of the equation. This model has found widespread application at different levels of aggregation. The effect of γ_t is typically taken into account by including time dummies into the model.

A crucial assumption is that v_{it} is an innovation orthogonal to observed factor use so that all unobserved factors are indeed either time invariant or the same for all farms. Empirical applications have also found that the within transformation removes (too) much variance from some of the variables, particular those which exhibit little variation over time (Griliches and Mairesse, 1998, pp. 180-185). As a consequence, the signal-to-noise ratio of these factors is reduced and the estimated coefficients are biased downwards (Griliches and Hausman, 1986). Finally, without further assumptions, the collinearity problem is not addressed at all by this approach.

The second approach avoids the main disadvantage of any fixed effects approach to unobserved heterogeneity, which is the typically low variance of the transformed variables. It rather attempts to proxy ω_{it} by a non-parametric control function which itself contains only observed firm characteristics. Olley and Pakes (1996) were the first to suggest log investment as an observed characteristic driven by ω_{it}. However, one problem that arises from using investment as a proxy is zero observations for certain years and firms. Levinsohn and Petrin (2003) therefore proposed materials instead of investment as a proxy of ω_{it}. The assumption is that materials evolve monotonously with the unobserved productivity characteristic, so that the effect of the latter can be inverted out. Materials are assumed to be a fully variable factor and thus part of the production function.

If the control function fully captures the influence of ω_{it}, it solves the endogeneity problem and provides a useful alternative to the fixed effects approaches described before. As we discuss in Petrick and Kloss (2013b), the presence of adjustment frictions implied by this approach is plausible in agriculture, although it is unlikely to capture a fully dynamic decision process of factor adjustment. Another problem with the procedure suggested by Olley/Pakes and Levinsohn/Petrin is that it does not solve the collinearity problem. As discussed at length by Ackerberg et al. (2006), unless one is willing to make very unintuitive assumptions on measurement error or timing, there is no data generation process that separately identifies the coefficients of the fully variable factors in either of the two approaches.

3. Data

The EU's Farm Accountancy Data Network (FADN) provides a stratified farm-level data set that holds accountancy data for 25 of the 27 EU member states. The stratification criteria are region, economic size and type of farming. The farm universe consists of all farms with more than one hectare or those with less than one hectare that provide the market with a specified amount of output. From this universe all non-commercial farms are excluded in order to arrive at the field of observation. To be classified as a commercial farm, a farm must exceed a certain economic size. In addition, farms are classified by type of farming.

In the present study, we only use field crop farms (TF1), to justify the assumption of a homogenous state of technology across farms. We produce separate results for the following countries:

- Denmark (DK)
- France (FR)
- Germany East (DEE)
- Germany West (DEW)
- Italy (IT,

- Poland (PL)
- Slovakia (SK)
- Spain (ES)
- United Kingdom (UK)

For every country and sector in the study, we created a panel data set covering the years from 2001 up to 2008. For Poland and Slovakia, we use only data for the years 2006-2008 for the estimation, although shadow prices are also computed for 2005.[1] A small number of duplicates in the data were dropped. In total, 27,639 observations were included in the EU-wide sample.

The variables and their measurement are readily available in the codebooks provided by FADN. Output is measured as the total farm output in euros. Labour is measured by the time worked in hours by total labour input on the farm, including both hired and family labour. The total utilised agricultural area is our land input in ha. It includes owned and rented land, and land in sharecropping.

In this study, the material or working capital input is proxied by total intermediate consumption in euros. It consists of total specific costs and overheads arising from production in the accounting year. Among others, it includes feed, fuel, lubricants, water, electricity and seed. Fixed capital inputs are approximated by using the opening valuation of assets (machinery and buildings). Table 1 summarises the variable definitions and gives the actual FADN codes.

Table 1. Selection of variables

FADN code	Variable description
Outputs	
SE131	Total output (EUR)
Inputs	
SE011	Labour input (hours)
SE025	Total utilised agricultural area (ha) = land
SE275	Total intermediate consumption (EUR) = materials
L.SE450 + L.SE455	Opening valuation of machinery and buildings (EUR) = fixed capital

Note: L. denotes the one-year lag.
Sources: Authors, FADN data.

All monetary values are deflated to real values in 2005 prices using price indices by Eurostat. Output was deflated by the agricultural output price index. Fixed capital and investment were deflated by the agricultural input price index for goods and services contributing to agricultural investment, and materials by the agricultural input price index for goods and services currently consumed in agriculture.

Outliers were identified on the basis of the fixed capital productivity per farm (real SE131/(real (L.SE450 + L.SE455))). Observations were dropped for the production function estimation if their value was beyond the median ± 1.5 the interquartile range (IQR). Furthermore, we only included farms which had some minimum panel representation in the data. Farms had to be present in the data for at least four years in a row, for Slovakia for at least three years. Descriptive statistics are given in the appendix.

[1] This was done to maintain data consistency with the dynamic panel data models analysed in Petrick and Kloss (2013b).

4. Results

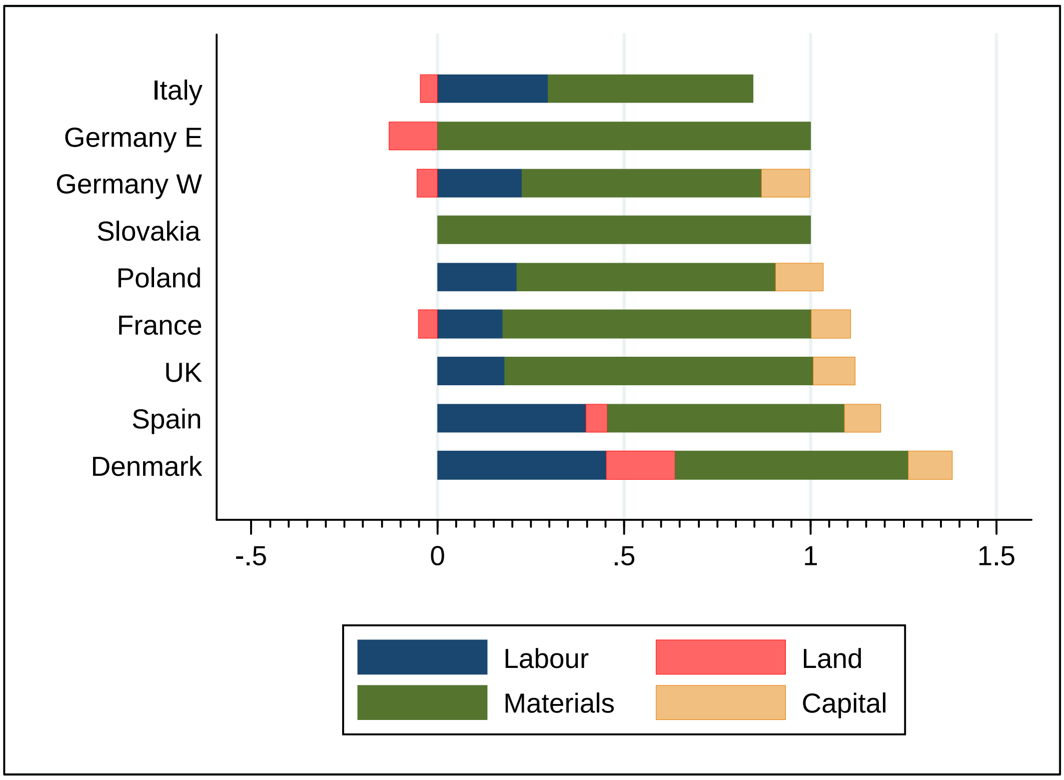
For the present study, we estimated five models per country: OLS Cobb Douglas, OLS 'within', Translog Cobb Douglas, Translog 'within', Cobb Douglas Levinsohn/Petrin. Generally, the interest was to detect systematic differences across estimators and countries, and to assess their practical implementation. Detailed results tables are presented in the appendix, which includes an overview table for each country containing the results for the five models. All estimations were performed with Stata 12. For the Levinsohn/Petrin estimators we employed the user-written routine `levpet` (Petrin et al., 2004).

The 'within' Translog was obtained by interacting the groupwise demeaned logs of factors and using an appropriate degree of freedom correction. Other than by simply calling a panel estimation command with the interacted variables in logs, this procedure ensures that levels are effectively eliminated from the regression. Estimates (see appendix) displayed remarkably uniform features across countries. The OLS Translog produced unreasonable results throughout, e.g. reflected in the coexistence of negative production elasticities for some factors and elasticities bigger than one for others (at sample means). The 'within' Translog elasticities, on the other hand, were typically close to the 'within' Cobb Douglas at sample means, and the interaction terms of the Translog were often not jointly different from zero.

4.1 Comparison of estimators

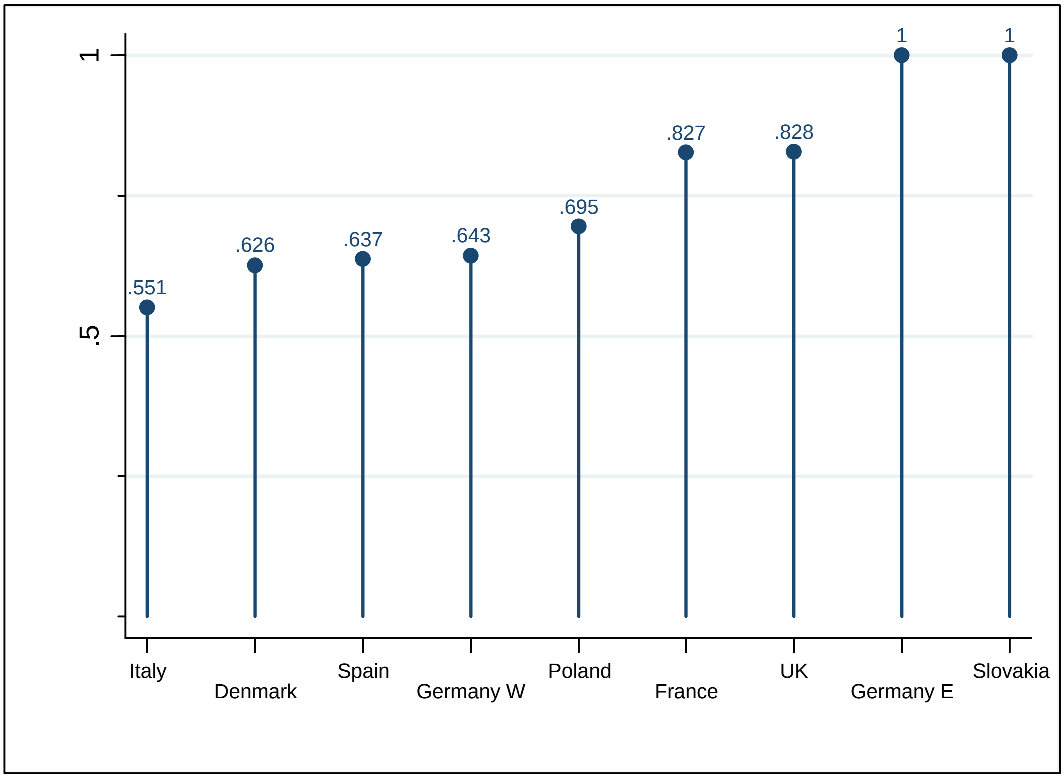
As a general tendency, factor elasticities were found to be low for labour, land and capital, and high for materials (Figure 1). Estimates for the first three of these factors are in the range of 0.2 and lower, sometimes not significantly different from zero or even significantly negative. The production elasticity of materials ranges from 0.55 to 1.0 (Figure 2). In summary, output reacts most elastically to a change in material use.

Figure 1. Cobb Douglas production elasticities in comparison



Notes: Results for field crop farms in EU countries based on Levinsohn/Petrin estimator.
Source: Authors.

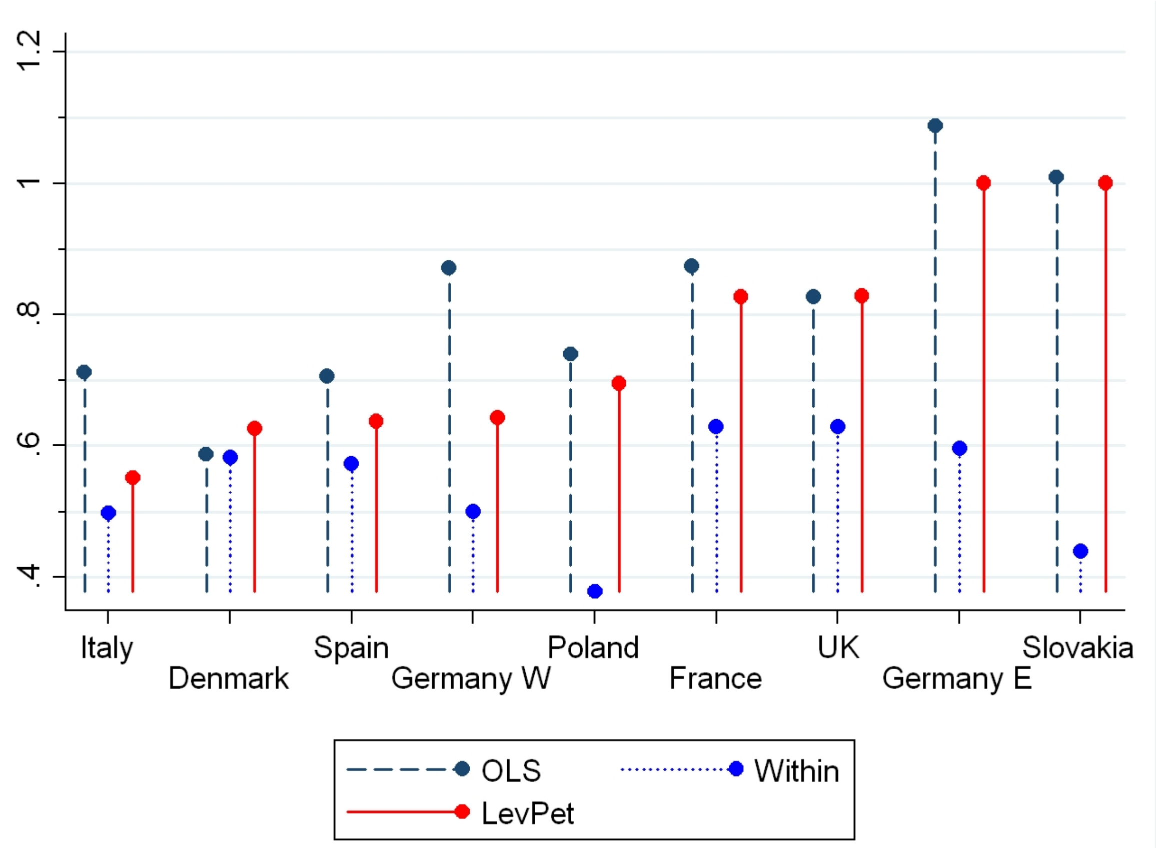
Figure 2. Elasticities of materials per country



Notes: Results for field crop farms in EU countries based on Levinsohn/Petrin estimator.
Source: Authors.

Since output reacts most elastically to materials, we analysed the bias to this estimate introduced by the choice of different estimators. As noted before, OLS estimates of the output elasticity tend to be upward and 'within' downward biased for particularly variable factors. They may thus be considered as an upper and lower boundary for the true value. Figure 3 indicates that indeed the Levinsohn/Petrin estimator commonly produces elasticities of materials which are just between OLS and 'within'. The two exceptions are Denmark and the United Kingdom. For the UK, the OLS elasticity exceeds the Levinsohn/Petrin elasticity by just 0.01. This result supports the view that the Levinsohn/Petrin estimator may be taken as a plausible alternative to the received estimators if one is willing to accept the theoretical problems in the identification of labour and land (which the other estimators share).

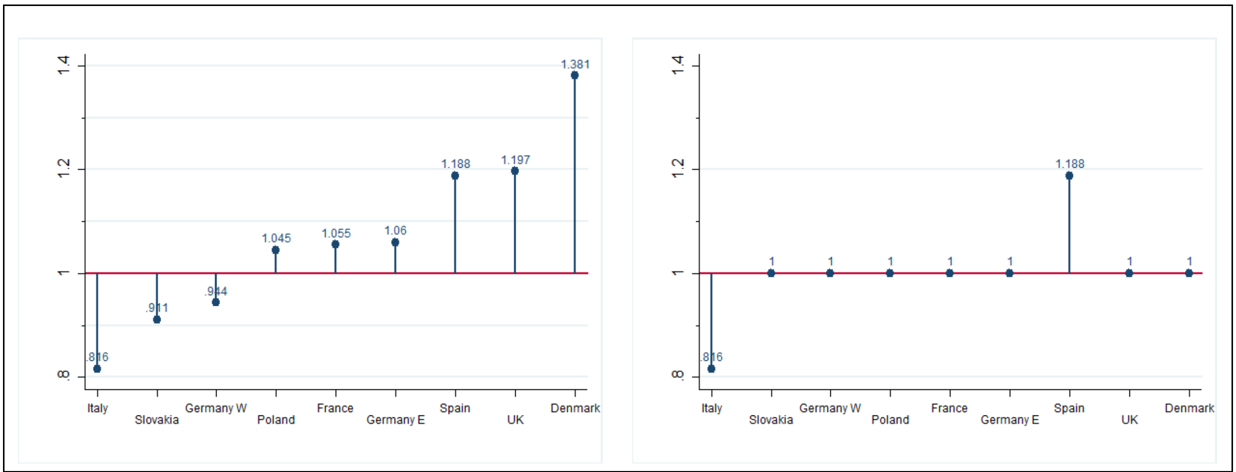
Figure 3. Elasticity of materials: Comparison of estimators



Source: Authors.

Point estimates for the elasticity of scale (i.e. the sum of the four output elasticities) fluctuate around 1.0, with higher values for Denmark and the United Kingdom (Figure 4, left chart). However, statistically, only Italy and Spain differ significantly from zero (Figure 4, right chart). Given the previous findings on production elasticities, OLS estimates of scale elasticities tend to be higher than 1.0 while 'within' elasticities tend to be lower. Overall, the scale elasticity in European crop farming appears to be close to one.

Figure 4. Returns to scale per country



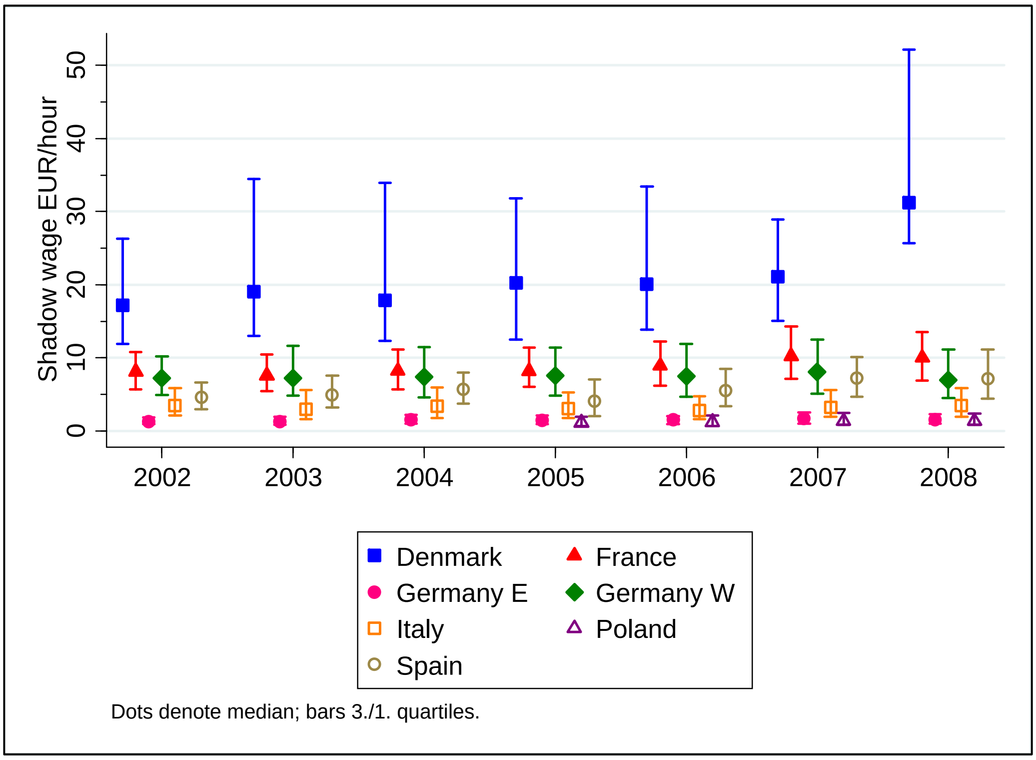
Notes: Results for field crop farms in EU countries based on Levinsohn/Petrin estimator. Left: Point estimates. Right: Not significantly different from 1 displayed as 1.

Source: Authors.

4.2 Distribution of shadow prices

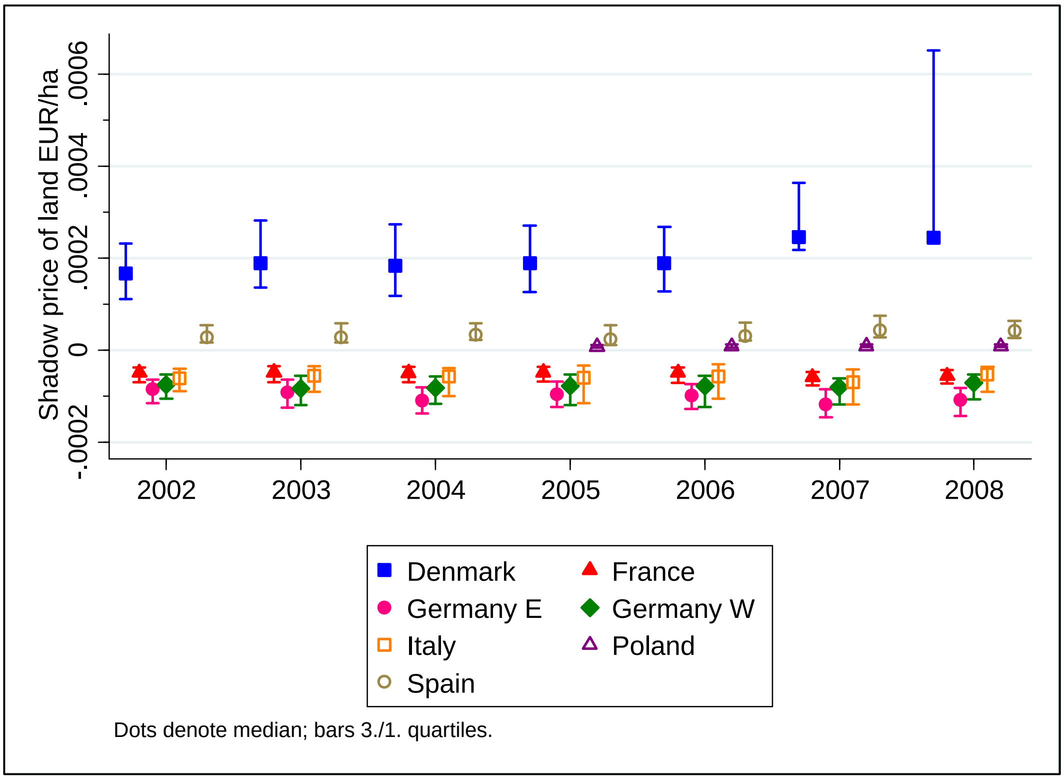
To ease the economic interpretation of the findings, we computed farm-individual shadow prices for all farms used in the estimations. To this end, we multiplied the production elasticities obtained from the Levinsohn/Petrin estimator with the farm-specific average factor productivities. For the two capital variables, net returns equal to the marginal value product minus one were calculated, so that they can be compared with market interest rates for credit (Petrick and Kloss, 2012, p. 2). The distribution of the shadow prices for the four factors and seven particularly interesting subsamples is illustrated in Figures 5-8 by using plots displaying the median, first and third quartile of the distribution.

Figure 5. Distribution of shadow wages per country and year



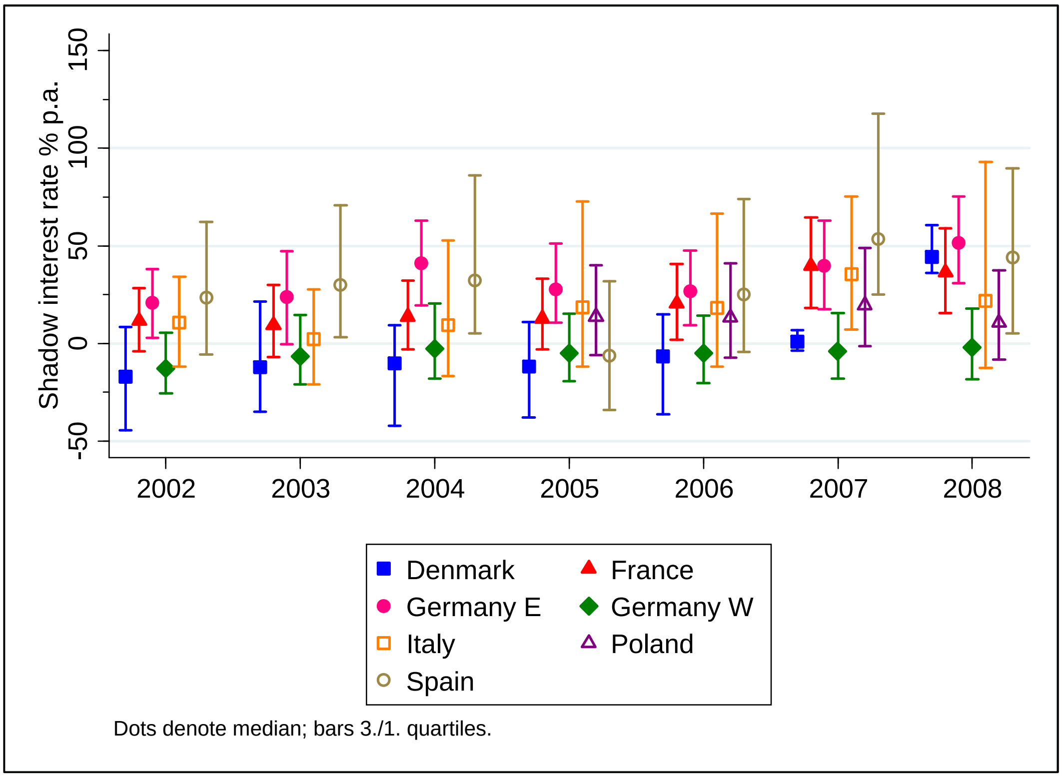
Notes: Results for field crop farms in EU countries based on Levinsohn/Petrin estimator.
Source: Authors.

Figure 6. Distribution of shadow land rents per country and year



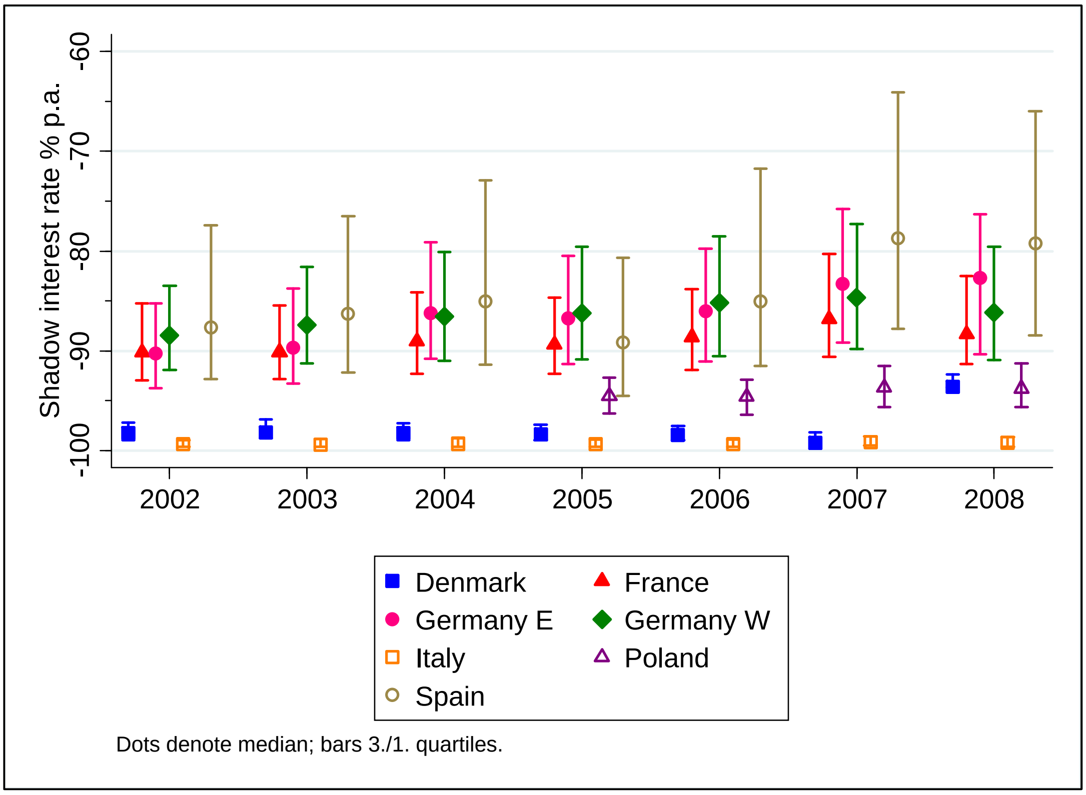
Notes: Results for field crop farms in EU countries based on Levinsohn/Petrin estimator.
Source: Authors.

Figure 7. Distribution of shadow interest rates of materials per country and year



Notes: Results for field crop farms in EU countries based on Levinsohn/Petrin estimator.
Source: Authors.

Figure 8. Distribution of shadow interest rates of capital per country and year



Notes: Results for field crop farms in EU countries based on Levinsohn/Petrin estimator.
Source: Authors.

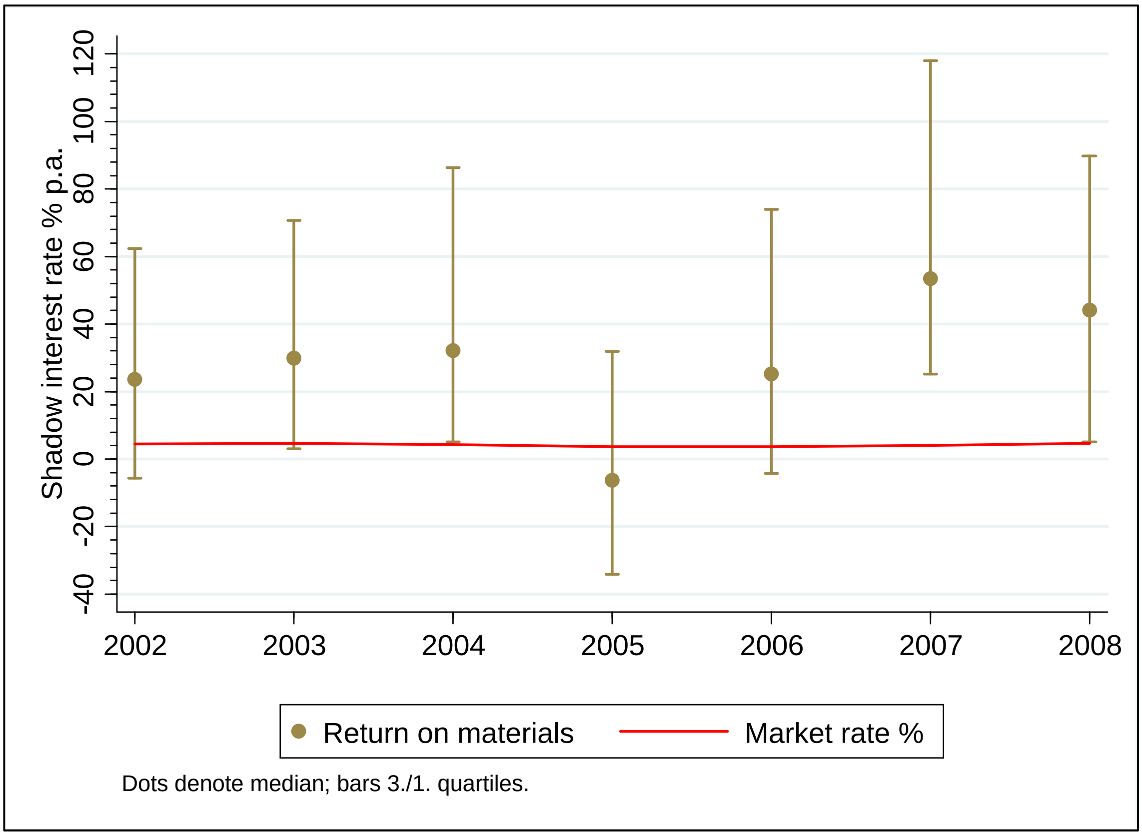
The findings from the plots are not too surprising given the results presented in the previous section. The shadow prices of the factors labour, land and fixed capital tend to be quite low. The median shadow wage in agriculture is below €9/hour in France and West Germany throughout the years; in Italy and Spain it is below €5/hour for most of the period. East Germany and Poland even exhibit values below €2/hour. Denmark stands out with a value fluctuating at around €20/hour. Shadow land rents are only minimally different from zero throughout. Shadow prices of fixed capital are negative in all subsamples, with medians per country and year in the range of -85 to -100%. Furthermore, there is considerable variation for some of the subsamples.

The distributional plots on the marginal return to materials deserve a closer look (Figure 7). As materials use is variable on a short-term basis, it reacts quickly to fluctuations in the economic environment. In the observed study period, the financial crisis was epitomised by the emerging US subprime crisis in 2007 and the collapse of the investment bank Lehman Brothers in 2008. The shock waves of the crisis hurt the various EU member countries quite differently, and there is little analysis available so far how they affected access to working capital in agriculture. Indeed, both the cross country as well as the dynamic variation reveal interesting patterns in this regard. Across countries, West Germany is the only country where the median farm exhibited negative marginal returns on working capital throughout the entire period. This is consistent with an excess capital use and the absence of funding constraints, and possibly reflects the strong position of the German agricultural banking sector during the crisis. A similarly strong banking sector based on a mortgage banking model is present in Denmark, where farms also displayed negative shadow prices for materials until 2006. However, Danish farms are typically much higher leveraged than their European counterparts (Petrick and Kloss, 2013a). Danish farms were thus hit harder by the emerging financial crisis, consistent with notably rising shadow rates for the years 2007 and 2008 in Figure 7.

At the other end of the spectrum, farms in Spain and East Germany show high shadow rates on working capital, with an upward tendency over the observed period. Also many Italian farms are in the range above 50% interest. Spain and Italy are countries with very low leverage in the agricultural sector, but also with banks suffering from the crisis. Farms may thus have been forced to reduce their use of working capital, particularly after the onset of the crisis. East German agriculture is dominated by corporate farms which are often based on rented land. Capital access is less easy to obtain for them than for West German family farms, and may have become more difficult during the crisis. France and Poland are somewhere in the middle of the field.

Figure 9 plots the marginal return on working capital against the average market interest rate for Spain over the observed period, calculated as the annual interest payments in percentage of outstanding loans. In the two crisis years 2007 and 2008, the shadow price is notably higher than the market rate. This finding supports the view that quantity rationing on the credit market was prevalent in these years.

Figure 9. Spanish field crop farms: Marginal return on materials vs. market interest rate

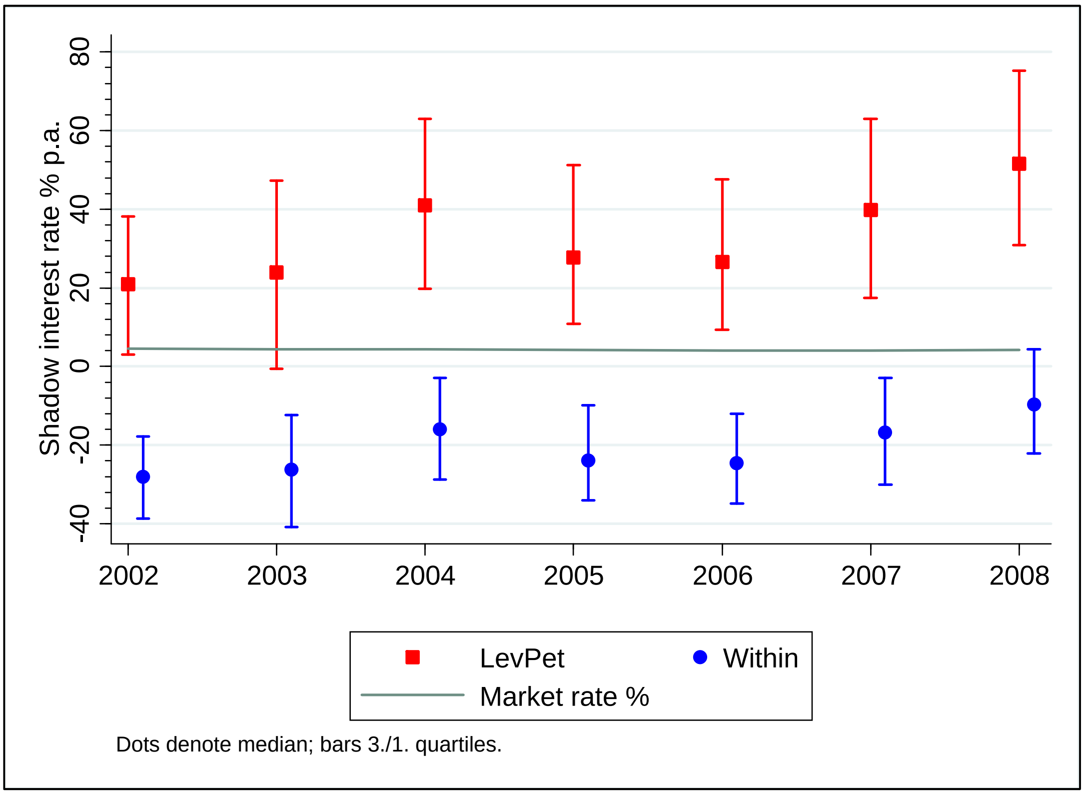


Notes: Results for field crop farms in EU countries based on the Levinsohn/Petrin estimator. 'Market rate' is ratio of annual interest payments to all outstanding loans.

Source: Authors.

We conclude this section with another comparison of estimators. Figure 10 plots marginal returns on working capital based on the 'within' and Levinsohn/Petrin estimators against the average market interest rate as defined before. The figure indicates that the choice of estimator can lead to completely opposite conclusions: whereas the Levinsohn/Petrin estimator suggests quantity rationing throughout, the supposedly downward biased 'within' estimator is consistent with a smooth capital access over the entire period.

Figure 10. Comparison of estimators: East German field crop farms – marginal return on materials



Note: Results for field crop farms in EU countries based on Levinsohn/Petrin estimator.
Source: Authors.

5. Conclusions

The aim of this study was to examine the drivers of productivity in EU agriculture from a factor markets perspective. This focus drew our attention to the approaches proposed by Olley and Pakes (1996) and Levinsohn and Petrin (2003), which use heterogeneous frictions in factor adjustment as an identification strategy in production function estimation. In light of the comprehensive literature on adjustment frictions on rural land, labour and capital markets, we regard the presence of adjustment costs as particularly relevant for the production factors that are of key interest in agricultural applications. On the other hand, we argue that the assumptions underlying 'within' regression are fairly strong and implausible for the case of agriculture, as they neglect the potentially important unobserved factors that vary over time (Petrick and Kloss, 2013b).

In the empirical section, we provide results for OLS Cobb Douglas and Translog, 'within' Cobb Douglas and Translog, as well as Levinsohn/Petrin Cobb Douglas models. Each model was estimated separately for panels of field crop farms in Denmark, France, East and West Germany, Italy, Poland, Slovakia, Spain and the United Kingdom. We also provide shadow price calculations for all four factors per country, based on the Levinsohn/Petrin estimates. From the applied perspective, OLS and 'within' display the biases expected from the literature. OLS typically overestimated the materials coefficient, while 'within' underestimated it. Extending the received Cobb Douglas specification to a Translog generally did not generate illuminating insights. Either the results were obviously implausible or little different from Cobb Douglas. Levinsohn/Petrin produced more plausible results and may be taken as an easy-to-implement alternative to the received estimators. Given the conceptual problems in identifying the supposedly flexible inputs labour and land, which the other estimators share, this is only a second-best choice. Additional information, such as can be obtained from the direct elicitation of input supply constraints, may be used in the future to solve this remaining identification problem.

Our estimates show a consistent picture of very low production elasticities for labour, land and fixed capital, whereas the elasticity of materials is above 0.6 for most of the countries. As a consequence, shadow prices for the three fixed factors are also very low. The median shadow wage in agriculture is below €9/hour in France and West Germany throughout the years; in Italy and Spain it is below €5/hour for most of the period. East Germany and Poland even exhibit values below €2/hour. Shadow land rents are typically close to zero. The net return on fixed capital is in the range of -85 to -100%. This finding suggests an excess utilisation of fixed production factors in EU agriculture. Further outflow of factors may be necessary to bring returns up to factor remuneration in other sectors.

The Levinsohn/Petrin estimates used to calculate these figures shed a different light on the shadow price of working capital (materials). The findings suggest that credit rationing is an issue in agricultural finance markets in the EU, particularly with regard to short-term lending in East Germany, Italy, and Spain after the onset of the financial crisis in 2007. In other words, improving the availability of working capital is the most promising way to increase agricultural productivity, whereas land, labour and fixed capital are not among the bottleneck factors of EU arable farming. We conclude that the functioning of factor markets plays a crucial role for productivity growth, but that factor market operations display considerable heterogeneity across EU member states.

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Appendix: Data & results tables

Table A1. Descriptive statistics

	Denmark				France				Germany (East)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Output (ths EUR)	183.3	278.2	3.1	2733.4	158.4	115.9	5.2	1574.7	550.2	1020.0	5.5	9242.1
Labour (ths hours)	2.8	3.9	0.1	49.0	3.1	2.3	1.2	38.2	15.4	29.6	2.2	268.1
Land (ha)	123.4	174.0	3.3	1760.0	144.9	83.2	3.6	647.4	540.9	648.3	2.3	5155.9
Materials (ths EUR)	109.4	167.2	6.9	1844.0	104.8	64.5	5.7	698.9	385.6	686.5	15.8	6534.7
Capital (ths EUR)	868.1	1431.4	42.3	21381.0	158.8	127.3	2.8	1379.8	509.6	725.4	14.7	6591.7
No. of observations	818				5330				1448			
No. of farms	209				1031				292			

	Germany (West)				Italy				Poland			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Output (ths EUR)	152.7	140.0	12.8	2114.7	61.4	124.8	0.8	2165.2	40.1	50.5	0.9	904.6
Labour (ths hours)	4.1	3.4	1.1	93.9	3.6	4.5	0.0	98.7	4.5	3.1	0.6	43.2
Land (ha)	93.6	61.1	0.5	429.5	44.6	74.9	0.6	723.3	49.0	62.7	1.6	666.1
Materials (ths EUR)	97.4	74.5	11.4	789.5	28.3	59.9	0.5	1102.5	23.5	29.8	1.4	500.5
Capital (ths EUR)	152.5	125.6	11.1	1008.0	121.4	227.3	2.7	4360.4	81.3	81.9	4.5	999.6
No. of observations	3030				5053				3090			
No. of farms	573				1362				1030			

	Slovakia				Spain				United Kingdom			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Output (ths EUR)	531.4	538.2	11.5	2228.1	41.6	37.2	0.0	768.1	281.0	342.3	8.7	3548.6
Labour (ths hours)	37.6	39.0	1.3	176.7	2.7	1.5	0.1	23.9	6.2	5.2	0.3	51.8
Land (ha)	776.3	735.7	30.2	3299.6	73.2	68.2	2.5	897.6	249.3	182.2	17.8	1178.5
Materials (ths EUR)	403.0	378.3	9.6	1709.7	19.9	17.8	0.4	248.5	183.1	169.3	12.6	1606.1
Capital (ths EUR)	836.0	1129.2	8.1	5869.2	30.7	34.0	0.8	551.7	236.6	214.7	10.0	1522.9
No. of observations	146				7917				807			
No. of farms	56				1400				189			

Source: Authors based on FADN data.

Table A2. Results production function estimations Denmark

	OLS Cobb Douglas		**OLS** Translog		**Within** Cobb Douglas		**Within** Translog		**Levinsohn/Petrin** Cobb Douglas	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Labour	0.461***	0.035	0.958***	0.265	0.205***	0.048	0.203***	0.029	0.453***	0.042
Land	0.191***	0.033	0.802**	0.369	0.254***	0.073	0.252***	0.045	0.184***	0.060
Materials	0.587***	0.033	0.237	0.346	0.582***	0.054	0.580***	0.031	0.626***	0.115
Capital	0.136***	0.025	1.120***	0.301	-0.033	0.040	0.001	0.023	0.118**	0.056
N	818		818		818		818		818	
Elasticity of scale	1.375***	0.015			1.008***	0.078			1.381***	0.279
p-value const. ret. to scale	<0.001				0.919				0.051	
R^2	0.950		0.957		0.598		0.599			
p-value coeff. jointly zero	<0.001		<0.001		<0.001		<0.001		<0.001	
p-val. interact. terms jtly. zero			<0.001				0.037			

Table A3. Results production function estimations France

	OLS Cobb Douglas		**OLS** Translog		**Within** Cobb Douglas		**Within** Translog		**Levinsohn/Petrin** Cobb Douglas	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Labour	0.161***	0.008	-0.206	0.210	0.105***	0.030	0.101***	0.014	0.175***	0.010
Land	-0.040***	0.009	0.145	0.129	0.265***	0.064	0.274***	0.029	-0.052***	0.013
Materials	0.874***	0.013	1.477***	0.226	0.629***	0.042	0.585***	0.018	0.827***	0.057
Capital	0.142***	0.007	0.109	0.143	0.037***	0.012	0.032***	0.006	0.106***	0.013
N	5330		5330		5330		5330		5330	
Elasticity of scale	1.137***	0.008			1.036***	0.054			1.055***	0.0642
p-value const. ret. to scale	<0.001				0.508				0.367	
R^2	0.877		0.882		0.507		0.494			
p-value coeff. jointly zero	<0.001		<0.001		<0.001		<0.001		<0.001	
p-val. interact. terms jtly. zero			0.016				0.003			

Notes: Year dummies included in all models. *** (**, *) significant at the 1% (5%, 10%) level, based on standard errors robust to clustering in groups. Standard errors in Levinsohn/Petrin based on bootstrapping with 20 replications.

Table A4. Results production function estimations Germany (East)

	OLS Cobb Douglas		**OLS** Translog		**Within** Cobb Douglas		**Within** Translog		**Levinsohn/Petrin** Cobb Douglas	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Labour	-0.009	0.021	-0.039	0.194	0.030	0.031	0.023	0.015	0.043	0.042
Land	-0.111***	0.029	1.38***	0.189	0.378***	0.063	0.433***	0.031	-0.131***	0.045
Materials	1.088***	0.028	0.260	0.301	0.596***	0.054	0.607***	0.028	1.000***	0.087
Capital	0.109***	0.017	0.403	0.285	0.008	0.024	-0.031***	0.011	0.152	0.139
N	1448		1448		1448		1448		1448	
Elasticity of scale	1.076***	0.008			1.011***	0.067			1.06***	0.186
p-value const. ret. to scale	<0.001				0.868				0.738	
R^2	0.950		0.956		0.525		0.509			
p-value coeff. jointly zero	<0.001		<0.001		<0.001		<0.001		<0.001	
p-val. interact. terms jtly. zero			<0.001				<0.001			

Table A5. Results production function estimations Germany (West)

	OLS Cobb Douglas		**OLS** Translog		**Within** Cobb Douglas		**Within** Translog		**Levinsohn/Petrin** Cobb Douglas	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Labour	0.210***	0.012	-0.755**	0.331	0.093***	0.027	0.090***	0.013	0.226***	0.021
Land	-0.052***	0.010	1.106***	0.198	0.252***	0.051	0.265***	0.023	-0.055***	0.020
Materials	0.871***	0.014	1.266***	0.253	0.499***	0.029	0.499***	0.014	0.643***	0.076
Capital	0.120***	0.010	0.154	0.243	0.044***	0.015	0.039***	0.007	0.130*	0.068
N	3030		3030		3030		3030		3030	
Elasticity of scale	1.148***	0.012			0.889***	0.061			0.944***	0.063
p-value const. ret. to scale	<0.001				3.3, 0.070				0.619	
R^2	0.861		0.869		0.327		0.329			
p-value coeff. jointly zero	<0.001		<0.001		<0.001		<0.001		<0.001	
p-val. interact. terms jtly. zero			<0.001				0.269			

Notes: Year dummies included in all models. *** (**, *) significant at the 1% (5%, 10%) level, based on standard errors robust to clustering in groups. Standard errors in Levinsohn/Petrin based on bootstrapping with 20 replications.

Table A6. Results production function estimations Italy

	OLS Cobb Douglas		**OLS** Translog		**Within** Cobb Douglas		**Within** Translog		**Levinsohn/Petrin** Cobb Douglas	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Labour	0.318***	0.012	-0.307**	0.151	0.097***	0.019	0.103***	0.012	0.296***	0.016
Land	-0.036***	0.009	0.127	0.119	0.314***	0.052	0.299***	0.028	-0.046***	0.013
Materials	0.712***	0.012	1.130***	0.154	0.497***	0.027	0.499***	0.016	0.551***	0.080
Capital	0.093***	0.009	-0.098	0.146	-0.024	0.027	-0.047***	0.016	0.015	0.037
N	5053		5053		5053		5053		5053	
Elasticity of scale	1.087***	0.009			.884***	0.056			0.816***	0.073
p-value const. ret. to scale	<0.001				0.038				0.072	
R^2	0.846		0.857		0.348		0.350			
p-value coeff. jointly zero	<0.001		<0.001		<0.001		<0.001		<0.001	
p-val. interact. terms jtly. zero			<0.001				0.036			

Table A7. Results production function estimations Poland

	OLS Cobb Douglas		**OLS** Translog		**Within** Cobb Douglas		**Within** Translog		**Levinsohn/Petrin** Cobb Douglas	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Labour	0.208***	0.014	-1.026***	0.332	0.151***	0.041	0.150***	0.029	0.212***	0.019
Land	0.008	0.012	0.590**	0.282	0.345***	0.062	0.348***	0.046	0.011	0.014
Materials	0.740***	0.017	1.842***	0.375	0.378***	0.030	0.378***	0.021	0.695***	0.045
Capital	0.214***	0.012	-0.900***	0.344	-0.007	0.036	-0.007***	0.026	0.127**	0.056
N	3090		3090		3090		3090		3090	
Elasticity of scale	1.171***	0.012			0.867***	0.078			1.045***	0.058
p-value const. ret. to scale	<0.001				0.087				0.580	
R^2	0.901		0.905		0.237		0.239			
p-value coeff. jointly zero	<0.001		<0.001		<0.001		0.001		<0.001	
p-val. interact. terms jtly. zero			0.227				0.368			

Notes: Year dummies included in all models. *** (**, *) significant at the 1% (5%, 10%) level, based on standard errors robust to clustering in groups. Standard errors in Levinsohn/Petrin based on bootstrapping with 20 replications.

Table A8. Results production function estimations Slovakia

	OLS Cobb Douglas		**OLS** Translog		**Within** Cobb Douglas		**Within** Translog		**Levinsohn/Petrin** Cobb Douglas	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Labour	-0.032	0.056	-0.525	0.527	-0.230*	0.127	-0.170*	0.097	-0.104	0.076
Land	-0.165**	0.081	0.550	0.800	0.537***	0.101	0.472***	0.102	-0.150	0.133
Materials	1.009***	0.086	0.639	0.850	0.439***	0.118	0.447***	0.116	1.000***	0.150
Capital	0.149***	0.041	0.955	1.006	0.025	0.064	0.006	0.055	0.166	0.115
N	146		146		146		146		146	
Elasticity of scale	0.961***	0.028			0.771***	0.173			0.911***	0.125
p-value const. ret. to scale	0.168				0.193				0.652	
R^2	0.939		0.951		0.594		0.601			
p-value coeff. jointly zero	<0.001		<0.001		<0.001		<0.001		<0.001	
p-val. interact. terms jtly. zero			0.530				0.458			

Table A9. Results production function estimations Spain

	OLS Cobb Douglas		**OLS** Translog		**Within** Cobb Douglas		**Within** Translog		**Levinsohn/Petrin** Cobb Douglas	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Labour	0.407***	0.013	-1.029***	0.226	0.190***	0.024	0.195***	0.011	0.398***	0.024
Land	0.063***	0.008	-1.214***	0.151	0.264***	0.043	0.270***	0.020	0.057***	0.019
Materials	0.706***	0.011	2.557***	0.206	0.572***	0.025	0.592***	0.011	0.637***	0.065
Capital	0.005	0.008	1.279**	0.629	0.016	0.021	-0.013	0.010	0.097*	0.054
N	7917		7917		7917		7917		7917	
Elasticity of scale	1.182***	0.014			1.042***	0.052			1.188***	0.079
p-value const. ret. to scale	<0.001				0.421				0.017	
R^2	0.703		0.716		0.458		0.449			
p-value coeff. jointly zero	<0.001		<0.001		<0.001		<0.001		<0.001	
p-val. interact. terms jtly. zero			0.686				0.183			

Notes: Year dummies included in all models. *** (**, *) significant at the 1% (5%, 10%) level, based on standard errors robust to clustering in groups. Standard errors in Levinsohn/Petrin based on bootstrapping with 20 replications.

Table A10. Results production function estimations United Kingdom

	OLS Cobb Douglas		**OLS** Translog		**Within** Cobb Douglas		**Within** Translog		**Levinsohn/Petrin** Cobb Douglas	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Labour	0.196***	0.021	0.169	0.211	0.237***	0.055	0.203***	0.028	0.179***	0.036
Land	0.082***	0.028	1.647***	0.319	0.347***	0.096	0.363***	0.050	0.076	0.046
Materials	0.827***	0.030	-0.182	0.363	0.629***	0.072	0.562***	0.040	0.828*	0.139
Capital	0.065***	0.020	0.042	0.281	0.014***	0.029	-0.019	0.016	0.113***	0.064
N	807		807		807		807		807	
Elasticity of scale	1.170***	0.015			1.226***	0.085			1.197***	0.101
p-value const. ret. to scale	<0.001				0.008				0.167	
R^2	0.910		0.915		0.589		0.579			
p-value coeff. jointly zero	<0.001		<0.001		<0.001		<0.001		<0.001	
p-val. interact. terms jtly. zero			0.397				<0.001			

Notes: Year dummies included in all models. *** (**, *) significant at the 1% (5%, 10%) level, based on standard errors robust to clustering in groups. Standard errors in Levinsohn/Petrin based on bootstrapping with 20 replications.

FACTOR MARKETS

Comparative Analysis of Factor Markets for Agriculture across the Member States

245123-FP7-KBBE-2009-3

The Factor Markets project in a nutshell

Title	Comparative Analysis of Factor Markets for Agriculture across the Member States
Funding scheme	Collaborative Project (CP) / Small or medium scale focused research project
Coordinator	CEPS, Prof. Johan F.M. Swinnen
Duration	01/09/2010 – 31/08/2013 (36 months)
Short description	Well functioning factor markets are a crucial condition for the competitiveness and growth of agriculture and for rural development. At the same time, the functioning of the factor markets themselves are influenced by changes in agriculture and the rural economy, and in EU policies. Member state regulations and institutions affecting land, labour, and capital markets may cause important heterogeneity in the factor markets, which may have important effects on the functioning of the factor markets and on the interactions between factor markets and EU policies. The general objective of the FACTOR MARKETS project is to analyse the functioning of factor markets for agriculture in the EU-27, including the Candidate Countries. The FACTOR MARKETS project will compare the different markets, their institutional framework and their impact on agricultural development and structural change, as well as their impact on rural economies, for the Member States, Candidate Countries and the EU as a whole. The FACTOR MARKETS project will focus on capital, labour and land markets. The results of this study will contribute to a better understanding of the fundamental economic factors affecting EU agriculture, thus allowing better targeting of policies to improve the competitiveness of the sector.
Contact e-mail	info@factormarkets.eu
Website	www.factormarkets.eu
Partners	17 (13 countries)
EU funding	1,979,023 €
EC Scientific officer	Dr. Hans-Jörg Lutzeyer

SEVENTH FRAMEWORK PROGRAMME