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CAP Subsidies and the Productivity of EU Farms

ABSTRACT

This paper investigates the impact of subsidies from the common agricultural policy on the total factor productivity of farms in the EU. We employ a structural, semi-parametric estimation algorithm, directly incorporating the effect of subsidies into a model of unobserved productivity. We empirically study the effects using samples from the Farm Accountancy Data Network for EU-15 countries. Our main findings are clear: subsidies had a negative impact on farm productivity in the period before the decoupling reform was implemented; after decoupling the effect of subsidies on productivity was more nuanced, as in several countries it turned positive.

Key words: CAP subsidies, investment, productivity, micro data, EU farms

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1. Introduction

The EU farm sector is heavily subsidised. Annually, the EU spends around €50 billion on the common agricultural policy (CAP) with the primary goal of supporting farmers' income and alleviating the environmental impact of agricultural production. Certainly, CAP subsidies impact on farm sector productivity as well.

There are two competing, policy-relevant arguments regarding the impact of agricultural subsidies on productivity. In the context of the trade liberalisation process of the World Trade Organisation (WTO), the discussion centres on the distortionary impact of subsidies on agricultural markets (including on productivity) and how the effects differ among different types of subsidies. Following the WTO agenda, many countries have decoupled their agricultural subsidies with the aim of reducing distortionary agricultural support (Meléndez-Ortíz et al., 2009).[1]Numerous papers, however, argue that indeed even decoupled subsidies may still affect production decisions and the productivity of farms.[2]Yet, recent developments in world markets, leading to increasing volatility of global food commodity prices and mounting concerns about food security in developing countries, are spurring calls to maintain the agricultural support stimulating farm investment and the adoption of productivity-enhancing modern technology (FAO, 2011). The European Commission explicitly mentions in its proposal for the post-2013 CAP the challenge of food security, and the EU's goal to support the long-term potential of food supply and meet the growing world food demand (European Commission, 2010a, 2011).

The impact of subsidies on agricultural production, input allocation and income distribution is well documented in the literature,[3]but significantly less attention has been devoted to the

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[1] The eastern enlargement and budgetary problems of the EU have also affected the decoupling of farm subsidies.

[2] See Lagerkvist (2005), Ahearn et al. (2006), Goodwin and Mishra (2005, 2006), Vercammen (2007), Key and Roberts (2009), Whitaker (2009), Ciaian and Swinnen (2009), Bhaskar and Beghin (2010) and Carpentier et al. (2012).

[3] See for example, Alston and James (2002), Ridier and Jacquet (2002), Lagerkvist (2005), Goodwin and Mishra (2006), Serra et al. (2006), Sckokai and Moro (2009), Vercammen (2007), Féménia et al. (2010), Carpentier et al. (2012) and Weber and Key (2012).

impact of subsidies on the productivity of farms. Theoretical studies suggest that subsidies may have a positive impact on farm production and at the same time a negative impact on farm productivity (Hennessy, 1998; Ciaian and Swinnen, 2009). Still, these studies are inconclusive in predicting the exact relationship between agricultural subsidies and productivity, while the empirical literature finds mixed effects. The existing empirical studies employ a two-stage estimation approach, whereby efficiency measures are estimated in a first stage without controlling for subsidy effects, and then those efficiency measures are regressed on subsidies in a second stage.[4] The disadvantage of such a two-stage approach is that it does not explicitly incorporate subsidies into a structural estimation algorithm and thus it cannot capture their true effect on productivity. The approach therefore results in biased estimates of the overall impact of subsidies on productivity.

The present paper aims at filling the gap in the literature by investigating the impact of CAP subsidies on (aggregate) farm productivity, applying a structural productivity estimation approach based on Olley and Pakes (1996).We explicitly model unobserved productivity and directly incorporate the effects of subsidies into a structural, semi-parametric estimation algorithm. We apply the algorithm to the Farm Accountancy Data Network (FADN) dataset and estimate total factor productivity (TFP)[5] for large and representative samples of farms in the EU-15 over the period 1990–2008. Furthermore, special attention is paid to the significant change of regime through the decoupling of subsidies by the 2003 CAP reform. The paper compares the impact of subsidies on farm productivity before and after decoupling. We find that subsidies had a negative impact on productivity until the implementation of the decoupling reform. Afterwards, the effect of subsidies on farm productivity became more nuanced, as in several EU-15 countries it turned positive. In all cases the magnitude of the effect was small but economically important. From a policy perspective, this finding is important at least in the EU context, as according to the recent European Commission proposal the EU subsidy system is likely to continue after 2013.

The paper is organised as follows. Next, we review relevant theoretical and empirical literature and set out our empirical approach. In section 3, we present our estimation algorithm. In section 4, we describe the FADN data and report the results of the production function estimation. In section 5, we verify the effects of subsidies on farm productivity by means of generalised method of moments (GMM) regressions. Section 6 summarises our findings and concludes.

2. Subsidies and productivity: Findings in the literature

Theoretical studies show that there are various channels through which subsidies impact on (aggregate) productivity (De Long and Summers, 1991; Blomstrom et al., 1996; Rajan and Zingales, 1998). They may either increase or decrease productivity and thus the net effect may be either positive or negative. The negative impact of subsidies on productivity may result from *allocative (and technical) efficiency losses* owing to distortions in the production structure and factor use, soft budget constraints and the shift of subsidies to less productive enterprises. The positive impact may stem from *investment-induced productivity gains* caused by the interaction of credit and risk attitudes with subsidies (subsidy-induced credit access, a lower cost of borrowing, a reduction in risk aversion and an increase in productive investment).

Subsidies may negatively affect farm productivity because they distort the production structure of recipient farms, leading to allocative inefficiency. Recipient farms may modify their behaviour and start investing in subsidy-seeking activities that are relatively less

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[4] See for instance, Giannakas et al. (2001), Latruffe et al. (2009), Lakner (2009), Sauer and Park (2009), Zhu and Oude Lansink (2010), Latruffe et al. (2011) and Mary (2012).

[5] In this paper we define TFP as Hicks-neutral Solow residual, similar to Olley and Pakes (1996).

productive (Baumol, 1990; Alston and James, 2002). Allocative inefficiency may also be a result of distortions in input use. Subsidies give recipient farms an incentive to change their capital–labour ratio, which can lead to allocative inefficiency, i.e. over-investment in subsidised inputs. Subsidies may also give rise to technical inefficiency if they are captured by the farms, as higher profits lead to slack, a lack of effort and disinclination to seek cost-improving methods (Leibenstein, 1966). Similarly, Kornai (1986) argues that subsidisation might give rise to soft budget constraints, which would lead to inefficient use of resources. If the budget constraint is hard, the farm will continually adjust to (unfavourable) external conditions by behaving in an entrepreneurial manner. If the budget constraint is soft, productive efforts are no longer imperative; the subsidy provider acts like an insurer taking over the moral hazard, while the insured (recipient farms) are less careful in protecting their wealth. Finally, subsidies may end up being transferred to less productive farms by policy-makers 'with special interests', or as Olson (1982) asserts, subsidies may reduce the rate at which resources are reallocated from one activity to another in response to new technologies or market conditions.

The literature on credit constraints and risk behaviour in agriculture (e.g. Blancard et al., 2006; Ciaian and Swinnen, 2009; Kumbhakar and Bokusheva, 2009; Hüttel et al., 2010) asserts a positive relationship between subsidies and productivity. If farms are credit rationed, then subsidies may provide an additional source of financing, either directly by increasing farms' financial resources or indirectly through improved access to formal credit. In other words, for credit-rationed farms subsidies may serve as a substitute for credit. Studies find that credit-constrained farms invest less and have lower allocative efficiency, which would improve as a result of subsidies.[6] Cheaper credit would stimulate investments and input use, thus leading to improved farm performance. Farms that are not credit constrained may also be affected if subsidies present a cheaper source of financing than the credit available from the financial markets. Furthermore, Hennessy (1998) suggests that under uncertainty, subsidies affect markets through a wealth effect: subsidies affect farmers' wealth and thus their risk attitudes. For example, farmers may be more willing to expand production through certain types of activities or employ additional factors that would otherwise be viewed as too risky (Roche and McQuinn, 2004).

The negative effect of subsidies (*allocative efficiency loss*) is likely negatively and the positive effect (*investment-induced productivity gain*) is likely positively correlated with decoupling; thus one can expect that coupled subsidies will have a smaller positive or a larger negative impact on productivity relative to decoupled subsidies. First, the efficiency loss is stronger for coupled subsidies than for decoupled ones because farm eligibility for coupled payments is directly linked to farm factor and production decisions, which lead to higher allocative inefficiency. For the decoupled subsidies, the link to farm activities is weaker (Dewbre et al., 2001; Guyomard et al., 2004; Courleux et al., 2008).[7] Farm decisions are distorted by coupled subsidies towards subsidised activities and away from productivity-motivated activities. Second, the investment-induced productivity gain through the credit and risk channels is likely smaller for coupled than for decoupled payments (e.g. Ciaian and Swinnen, 2009). The conditionality of coupled subsidies increases the monitoring costs of financial institutions if subsidies are used by credit-constrained farms as collateral for investment loans. For decoupled payments, the certainty of payment is higher given their link to land assets, which is relatively costless to monitor and less subject to production risk.

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[6] See Feder (1985) and Feder et al. (1990), and more recently, Blancard et al. (2006), Kumbhakar and Bokusheva (2009) and Hüttel et al. (2010).

[7] Farms receive CAP decoupled subsidies irrespective of their production and input use decisions, whereas CAP coupled subsides are related to the production of specific products or input use. The recipients of the decoupled payments need to fulfil only the so-called 'cross-compliance conditions', which means that to get subsidies, among other things, farms need to fulfil some agri-environmental conditions.

Findings in the empirical literature are mixed and inconclusive even though negative relations between CAP subsidies and productivity tend to prevail. In general, studies focus on the effects of coupled subsidies in narrowly defined agricultural industries. Latruffe et al. (2009) find a negative impact of coupled CAP subsidies on the efficiency of French farms specialised in cereals, oilseeds and beef production. Lakner (2009) shows that the agri-environmental payments and investment programmes have a negative effect on the efficiency of organic dairy farms in Germany. The estimates of Zhu and Oude Lansink (2010) indicate that the negative efficiency effects of coupled subsidies prevail for crop farms in Germany, the Netherlands and Sweden. Similarly, Zhu et al. (2012) find that both output-related and input-related CAP subsidies had a negative impact on dairy farm efficiency in Germany and the Netherlands between 1995 and 2004, but no significant impact in Sweden. Their results also imply that a higher degree of coupling in farm support negatively affects farm efficiency. Latruffe et al. (2011) report a negative impact of total subsidies on dairy farms in seven EU countries (Denmark, France, Germany, Ireland, Spain, the Netherlands and the UK) for the period 1990–2007. Latruffe et al. (2011) also study the first years of decoupled payment implementation and their results indicate that in all countries except Denmark, the average technical efficiency was lower after decoupling. In contrast, Sauer and Park (2009) find a positive influence of organic subsidies on technical efficiency changes and technological changes for organic dairy farms in Denmark in the period 2002–04. Yee et al. (2004) also find a positive relation between the TFP of US farms and public expenditure on investment in research, extension and infrastructure. Mary (2012) estimates the impact of various types of CAP subsidies on the efficiency of French crop farms for the period 1996–2003. The coupled CAP payments (i.e. set-aside premiums, least favoured area payments and livestock subsidies) are found to have a negative impact on productivity. In contrast, targeted coupled subsidies that are not automatic but subject to project approval, such as investment and environmental measures, are found to have no significant impact on productivity. Furthermore, Mary (2012) finds that the Agenda 2000 reform (i.e. partial decoupling) had a positive impact on aggregate productivity.

3. Estimation strategy: Linking productivity and subsidies

3.1 Behavioural framework

Our strategy for estimating productivity is built on the Olley and Pakes (1996) approach, which entails modelling unobserved productivity (TFP) and directly controlling for the effects of subsidies in the estimation algorithm.[8] The strength of the approach lies in its flexibility in accommodating the specificities of the economic problem of interest and its efficiency in dealing with estimation biases. First, it allows us to control for the classic simultaneity bias (Marshak and Andrews, 1944) when estimating production functions, without having to rely on instruments. This is important, as we do not have good instruments available. The second advantage is that we can easily control for potential selection bias due to non-random exits.

We extend the Olley and Pakes (1996) algorithm by explicitly allowing farm decisions and the market environment (factor markets and demand conditions) to be affected by the CAP subsidies, which we directly introduce into the underlying structural model of the farm. The single period profit function of farm j at time t is $\pi(k_{jt}, s_{jt}, \omega_{jt}, \vec{e}_{jt}) - c(i_{jt}, s_{jt}, \vec{e}_{jt})$, where k_{jt} and ω_{jt} are the logs of the farm's state variables, capital and (unobserved) productivity respectively, while i_{jt} is the log of the farm's investment. Both restricted profit $\pi(.)$ and adjustment cost $c(.)$ also depend on farm subsidies s_{jt} and on $\vec{e}_{jt}$, which represents the

[8] We do not estimate the effect of any particular channel through which subsidies interact with productivity; we estimate the net effect of allocative efficiency loss and the investment-induced productivity gain caused by subsidies.

economic environment that farms face at a particular point in time; $\vec{e}_{jt}$ captures the effects of input prices, demand conditions and industry characteristics. As in Olley and Pakes (1996), all these factors are assumed to change over time.

The incumbent farm maximises its expected value of both current and future profits according to

$$V(k_{jt},s_{jt},\omega_{jt},\vec{e}_{jt}) = \max\begin{cases} \Phi(k_{jt},s_{jt},\omega_{jt},\vec{e}_{jt}), \\ \max_{i_{jt}} \{\pi(k_{jt},s_{jt},\omega_{jt},\vec{e}_{jt}) - c(i_{jt},s_{jt},\vec{e}_{jt}) + \\ \beta E[V(k_{jt+1},s_{jt+1},\omega_{jt+1},\vec{e}_{jt+1}) \mid k_{jt},s_{jt},\omega_{jt},\vec{e}_{jt},i_{jt}]\}. \end{cases} \tag{1}$$

The Bellman equation explicitly considers two farm decisions. First is the exit decision: $\Phi(k_{jt},s_{jt},\omega_{jt},\vec{e}_{jt})$ represents the sell-off value of the farm. Second is the investment decision i_{jt}, which solves the interior maximisation problem. Under the assumption that equilibrium exists and that the difference in profits between the farm continuing and exiting is increasing in ω_{jt}, we can write the optimal decision rule of a farm to remain in production as

$$\mathrm{X}_{jt} = \begin{cases} 1 & if \quad \omega_{jt} \geq \overline{\omega}_t(k_{jt},s_{jt},\vec{e}_{jt}) \\ 0 & \qquad otherwise \end{cases} \tag{2}$$

and the investment demand function as

$$i_{jt} = i_t(k_{jt},s_{jt},\omega_{jt},\vec{e}_{jt}). \tag{3}$$

The threshold function $\overline{\omega}_t(.)$ as well as $i_t(.)$ is determined as part of the Markov-perfect Nash equilibrium in decisions (Ericson and Pakes, 1995; Olley and Pakes, 1996) and depends on the state variables and the characteristics of the economic environment, including subsidies and factor prices. In the context of the CAP, farm capital stock might be related to the level of subsidies, which would lead to more capital-intensive farms. By incorporating the information on subsidies into the investment demand and exit rule explicitly, we can better control for differences in market conditions than when only controlling through the capital stock. Conditional on staying in production, the farm has to decide about its inputs, labour (l) and materials (m) use and investment (i). Investment determines the capital stock at the beginning of each period. The law of capital accumulation is given by $k_{jt} = (1 - \delta)k_{jt-1} + i_{jt-1}$, where δ is the depreciation rate of capital.

As in Olley and Pakes (1996), we assume that investment is monotonically increasing in productivity conditioned on the level of subsidies received.[9] Pakes (1994) discusses the conditions under which the investment demand function is strictly monotonic in ω_{jt}. Abel and Eberly (1994) and several related papers, in a slightly different context, extend the analysis of monotonicity of investment and disinvestment regarding firm fundamentals and show that monotonicity brakes only at zero investment values.[10] Recently, Hüttel et al. (2010) applied this result to an investment analysis of the German farm. Given monotonicity, investment can be inverted to generate the productivity function

[9] The monotonicity needed in Olley and Pakes (1996) only requires the marginal product of capital to be increasing in productivity. In fact we argue here that the subsidy crucially improves monotonicity in the relationship between investment and productivity (in line with De Long and Summers, 1991 and Rajan and Zingales, 1998).

[10] We note that observations with zero net investment represent a very small proportion (between 0.5 and 3.3%) in every country sample that we use in our empirical analysis.

$$\omega_{jt} = h_t(i_{jt}, k_{jt}, s_{jt}, \vec{e}_{jt}) . \quad (4)$$

Furthermore, productivity is assumed to evolve according to a first-order Markov process with transition probability $p(\omega_{jt} \mid \omega_{jt-1})$ and to be determined by a set of distributions conditional on the information at time t, which includes past (realised) productivity shocks. Given this distribution set, both the exit and investment decisions will crucially hinge upon the farm's perception of the distribution of the future market structure given current information (past productivity). The decisions that farms take will in turn generate the distribution of the future market structure (Maskin and Tirole, 1988).

3.2 Estimation algorithm

Our estimation algorithm is similar to the one in Olley and Pakes (1996) except for the fact that the first-stage estimation and the survival equation include the subsidy variable and additional economic environment controls (as in Rizov and Walsh, 2009 and 2011).[11] This way we have introduced subsidies as an additional control in the state space in the dynamic programme of the firm. The production function we estimate is specified as

$$y_{jt} = \beta_0 + \beta_m m_{jt} + \beta_l l_{jt} + \beta_k k_{jt} + \omega_{jt} + v_{jt}, \quad (5)$$

where y_{jt} is a log of gross real output and v_{jt} is a random error term with a zero mean.

Incorporating the productivity (inverted investment demand) function (4) into the production function (5) gives us

$$y_{jt} = \beta_0 + \beta_m m_{jt} + \beta_l l_{jt} + \beta_k k_{jt} + h_t(i_{jt}, k_{jt}, s_{jt}, \vec{e}_{jt}) + v_{jt} . \quad (6)$$

In equation (6), as in Olley and Pakes (1996), the productivity function $h_t(.)$ is treated non-parametrically using a polynomial. The non-parametric treatment, however, results in collinearity and requires $h_t(.)$, k_{jt} and the constant to be combined into a function $\phi_t(i_{jt}, r_{jt}, e_{jt}, k_{jt}, a_{jt})$, such that equation (5) becomes

$$y_{jt} = \beta_m m_{jt} + \beta_l l_{jt} + \phi_t(i_{jt}, k_{jt}, s_{jt}, \vec{e}_{jt}) + v_{jt} , \quad (7)$$

which forms the first stage of our estimation algorithm and is estimated using OLS. In equation (7) subsidies are allowed to interact with the terms of the polynomial in capital and investment.[12]

In the first stage of the estimation algorithm we can only identify materials and labour coefficients, while the capital coefficient has to be identified in the second stage of the algorithm. As in the original Olley and Pakes (1996) paper, farm labour is treated as a variable and non-dynamic input, which is a function of the state variables, including subsidies, and for which decisions are always made during the current period – an assumption introducing additional variation in the labour demand (Ackerberg et al., 2007). Materials are also treated as a fully variable and non-dynamic input on which decisions are

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[11] The market environment control vector $\vec{e}_{ji}$ includes farm specialisation, location information at the NUTS3 (Nomenclature of Territorial Units for Statistics) level and a time trend.

[12] In addition, to control for the nature of the subsidies, we use a dummy variable capturing the effect during the period after the decoupling of subsidies, which was actually implemented in 2005–06 across the EU-15. We fully interact the dummy with the terms of the polynomial in the first-stage estimation equation.

always made after labour is chosen and given the contemporaneous realisation of productivity.[13] In the first stage, we also estimate $\hat{\phi}_t$, which allows us to express ω_{jt} for use in the second stage as

$$\hat{\omega}_{jt} = \hat{\phi}_{jt} - \beta_0 - \beta_k k_{jt}. \quad (8)$$

Note that the first stage is not affected by endogenous selection because ϕ_t fully controls for the unobserved productivity, while by construction, ν_{jt} represents unobserved factors that are not known by the farmer before investment and exit decisions are made. In contrast, the second stage of the estimation algorithm is affected by endogenous selection because the exit decision in period t depends directly on ω_{jt}.

To clarify the timing of production decisions and their impact on the selection bias, we decompose ω_{jt} into its conditional expectation given current information (past productivity) and a residual: $\omega_{jt} = E[\omega_{jt} \mid \omega_{jt-1}] + \xi_{jt} = g(\omega_{jt-1}) + \xi_{jt}$. By construction, ξ_{jt} is uncorrelated with information in t-1 and thus with k_{jt}, which is chosen prior to time t. Note that the farm's exit decision in period t depends directly on ω_{jt} and thus the exit decision will be correlated with ξ_{jt} . This correlation relies on the assumption that farms exit production quickly, in the same period when the decision is made. If exit is decided in the period before the actual exit occurs, then even though there is a selection per se, exit will be uncorrelated with ξ_{jt} . To account for the impact of endogenous selection on productivity we extend the g(.) function as in Olley and Pakes (1996):

$$\omega_{jt} = g'(\omega_{jt-1}, \hat{P}_{jt}) + \xi_{jt}, \quad (9)$$

where $\hat{P}_{jt}$ is the estimated propensity-to-exit score, which controls for the impact of selection on the expectation of ω_{jt} , i.e. farms with lower survival probabilities that do survive to time t likely have higher ω_{jt} than those with higher survival probabilities. We estimate $\hat{P}_{jt}$ non-parametrically using a probit model with a polynomial approximation. Note that we again extend the state variable set with information on subsidies, which are important determinants of a farm's exit decision.[14]

[13] We consider demand for materials, similar to labour demand, to be a function of the state variables and subsidies. In addition, we assume that labour also affects demand for materials: $m_{jt} = m_t(\omega_{jt}, k_{jt}, s_{jt}, l_{jt}, \vec{e}_{jt})$, however, the timing of decisions on labour and materials demand differs within each period. We note that the partial dependence of materials on labour demand brings additional variation, which breaks the possible collinearity with the non-parametric function in equation (7).

[14] In our FADN data, exit from the sample is affected not only by the decision of the farm to exit production as described in our behavioural framework, but also by the survey design and selection rules. Given the possibility that FADN selection rules might not be random but are affected by farm productivity and the allocation of subsidies, controlling for selection remains important. FADN selection rules may not be random because they depend on the importance of farm types in the total population. For example, if the importance of a certain farm type decreases in the total population, then also the number of these farms in the FADN sample will be reduced. This is done to preserve the representativeness of the FADN sample. If the selection is in fact random, then the selection correction is still perfectly valid; it just should not change the estimates by much (Ackerberg et al., 2007).

The capital coefficient is identified in the second stage of our estimation algorithm. Incorporating equations (9) and (8) into equation (5) gives us

$$y_{jt} - \widehat{\beta}_m m_{jt} - \widehat{\beta}_l l_{jt} = \beta_k k_{jt} + g'(\hat{\phi}_{jt-1} - \beta_k k_{jt-1}, \widehat{P}_{jt}) + \varepsilon_{jt}, \tag{10}$$

where the two β_0 terms are encompassed in the non-parametric function, *g'*(.) and ε_{jt} is a composite error term comprised of ν_{jt} and ξ_{jt}. The lagged $\hat{\phi}_{jt-1}$ variable is obtained from the first-stage estimates at the *t*-1 period. Because the conditional expectation of ω_{jt} given current information depends on ω_{jt-1}, we need to use estimates of $\hat{\phi}$ from the *t*-1 period. Equation (10) is estimated by a non-linear least squares search routine approximating *g'*(.) with a polynomial.[15]

Similar to Olley and Pakes (1996), we use the estimated (consistent) production function coefficients to obtain unbiased farm-specific, time-varying, total factor productivity (*tfp*) measures as residuals from the production function:

$$tfp_{jt} = \exp(y_{jt} - \hat{\beta}_m m_{jt} - \hat{\beta}_l l_{jt} - \hat{\beta}_k k_{jt}). \tag{11}$$

Clearly, the modified two-stage estimation algorithm has an impact on the estimated production function coefficients. Compared with the OLS estimator, we expect materials and labour coefficients to be lower, since materials and labour demands have a stronger positive correlation with the productivity shock. The direction of the bias in the capital coefficient is less clear, as it has an impact both through the selection equation and directly through the productivity shock. However, the variation in the capital stock that is attributed to the variation in output – purified from the variation in materials and labour – is now conditioned on the subsidy level of the farm and other economic environment controls. Due to the positive correlation between regional productivity and the subsidy level, farms receiving higher per-unit subsidies – on average – tend to be more capital intensive.[16] Therefore, in order to recover the correct estimates of the production function, it is important to control for the effect of subsidies that works both through the instantaneous productivity shock impacting materials and labour demand and over time through the capital accumulation process. Thus, the resulting *tfp* measures are obtained controlling for the fact that market conditions are different and evolve differently according to the level and nature of the subsidies received by farms.[17]

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[15] Woodridge (2009) presents a concise, one-stage formulation of the original Olley and Pakes (1996) algorithm using a GMM estimator, which is more efficient but less flexible than the standard Olley-Pakes methodology.

[16] CAP subsidies are not assigned randomly to farms but depend on regional productivity levels. Farms located in more productive regions receive higher subsidies than farms located in less productive regions. Historically, this is related to the coupled subsidies, as their value was determined by regional yields and animal herd sizes. With the 2003 CAP reform, coupled subsidies were decoupled from production but the regional variation in subsidies was largely preserved.

[17] More highly subsidised farms might experience faster technological change. Therefore, we checked whether technological change was affected by the level of subsidies by interacting the time trend with subsidies, in addition to the fully interacted polynomial. The results were not different from those reported in the paper.

4. Data and productivity estimates

We apply our estimation algorithm to the FADN country samples, which are compiled and maintained by the European Commission. FADN is a European system of sample surveys that take place each year and collect detailed structural and accountancy data on EU farms. In total, there is information on about 150 variables on farm structure, yields, outputs, inputs, costs, incomes, subsidies and taxes, and various other financial variables. FADN is the only source of micro-economic data that is harmonised, as the bookkeeping principles are the same across all EU member states. FADN is representative of the commercial agricultural holdings in the whole of the EU (European Commission, 2010b). Holdings are selected to take part in the surveys on the basis of sampling plans established at the level of each region in the EU. The yearly FADN samples cover approximately 80,000 farms and about 90% of the utilised agricultural land in the EU-27.

The panel we employ in the study covers the period 1990–2008 and includes the commercial farms defined as in Sckokai and Moro (2009) in all EU-15 member states.[18] Our goal is to estimate unbiased TFP measures at the farm level, within six (FADN) farm-type samples, for each country, and to document the aggregate productivity levels and changes over time and by farm type.[19] Furthermore, our ultimate goal is to estimate the effect of CAP subsidies on farm TFP. The strategy of our empirical analysis implies that we run regressions within the six farm-type samples for each country, which leaves us with 83 farm-type country samples, with a sufficient number of observations to apply our estimation algorithm. The estimated samples account for about 85% of the FADN EU-15 farms.

The summary statistics for the regression variables are reported in Table 1 and the detail definitions, based on the FADN (2010) codebook, are presented in appendix 1. The summary statistics show substantial heterogeneity of (average) farms across the EU-15. There is some evidence of a north–south divide, but with several exceptions when various indicators are considered. In Germany, the Netherlands and Denmark, farms are more capital intensive and invest more; these farms are also the largest in terms of output. Not too different from this group of countries is Italy, where farms are also relatively large in terms of capital and investment but less so in terms of output. The Greek and Portuguese farms are the least capital intensive, invest the least and are the smallest in terms of output. Farm employment varies less compared to capital across the EU-15 countries, with farms in the Netherlands, the UK and Germany appearing to be largest in terms of labour employed.

There is an even more pronounced north–south differentiation between the member states when average subsidies per farm are considered, which is largely determined by the differences in farm size. For northern European countries, average farm subsidies range roughly between €16,000 and €35,000 (with the highest subsidies being paid to Finnish farms), while for southern European countries the subsidies are around or less than €8,000 per farm. This relationship also holds for subsidy per unit of labour employed. Yet, when subsidy per unit of capital is considered, the picture is quite the opposite – southern European farms are more heavily subsidised.

[18] For Austria, Finland and Sweden, which entered the EU in 1995, the period of analysis is 1996–2008.

[19] The six farm types comprise field crop farms, horticultural and vine farms, specialised dairy farms, other grazing livestock farms, poultry and pig meat farms, and mixed farms.

Table 1. Summary statistics

Country	Investment (s.d.)	Capital (s.d.)	Labour (s.d.)	Materials (s.d.)	Output (s.d.)	Subsidies (s.d.)	Exits (No.obs)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Belgium	43.7	881.9	5131	76.3	141.0	23.0	0.14
	(282.5)	(686.8)	(2618)	(67.4)	(106.3)	(14.8)	(14482)
Denmark	112.8	1429.5	4932	201.6	327.3	27.0	0.26
	(526.6)	(1763.7)	(4713)	(208.2)	(332.1)	(28.5)	(17543)
Germany	84.1	1841.1	5336	113.4	172.4	31.2	0.12
	(2497.1)	(5461.1)	(7990)	(199.7)	(285.9)	(78.3)	(74777)
Greece	3.0	173.9	4301	14.8	38.2	7.1	0.20
	(43.9)	(115.4)	(2518)	(13.0)	(22.4)	(10.5)	(17883)
Spain	32.8	304.7	3399	29.3	60.3	8.2	0.15
	(1251.6)	(2188.1)	(1776)	(39.5)	(57.9)	(11.9)	(58502)
France	58.5	658.8	3821	67.7	117.2	21.5	0.13
	(587.1)	(1220.8)	(2533)	(52.9)	(91.4)	(22.0)	(93420)
Ireland	49.6	817.6	3711	42.9	73.1	16.2	0.16
	(240.3)	(649.8)	(1361)	(25.3)	(46.3)	(14.9)	(8230)
Italy	57.0	901.1	4701	30.9	73.1	7.9	0.29
	(950.7)	(1735.9)	(2805)	(41.7)	(84.2)	(53.7)	(99433)
Luxembourg	26.7	1047.6	3697	69.5	117.0	31.8	0.08
	(145.6)	(471.1)	(1260)	(36.8)	(56.3)	(22.7)	(4807)
Netherlands	111.1	1588.7	6358	182.2	314.9	16.7	0.17
	(765.3)	(1700.5)	(6191)	(206.8)	(326.5)	(24.2)	(17290)
Austria	16.1	370.6	4178	33.6	63.6	19.6	0.06
	(63.6)	(190.5)	(1499)	(19.6)	(32.7)	(11.9)	(17248)
Portugal	3.6	152.4	5176	30.1	49.2	8.3	0.21
	(56.2)	(119.9)	(2826)	(27.5)	(37.3)	(17.1)	(12343)
Finland	13.4	322.4	4577	67.0	83.0	34.7	0.10
	(64.5)	(219.1)	(2450)	(50.1)	(70.1)	(24.8)	(7176)
Sweden	55.1	818.4	3725	98.1	132.1	28.3	0.11
	(424.3)	(832.4)	(1750)	(75.0)	(111.0)	(26.8)	(6645)
UK	33.5	990.3	5488	95.1	142.4	31.6	0.17
	(299.6)	(781.2)	(3687)	(82.2)	(132.3)	(32.1)	(38405)

Notes: Mean and standard deviation (s.d.) are reported for each variable. All monetary variables are measured in 2000 (€ thousand). Labour is measured in total full-time equivalent hours worked annually. The average annual exit rate (Exits) capture farms exiting the sample because of both exiting production and the sampling rules. The total number of observations (No.obs) is reported.

In Table 2 the production function coefficients estimated from the 83 samples are presented for each EU-15 member state by aggregating over farm types using output shares as weights. There is substantial variation across countries, as the materials coefficient ranges between 0.59 for Greece and 0.87 for Sweden; the labour coefficient ranges between 0.07 for Ireland and 0.26 for Spain and Denmark; and the capital coefficient is between 0.05 for Ireland and 0.12 for Austria. Farms in most, especially northern European countries, exhibit constant or increasing returns to scale, while farms in countries like Greece and Italy are characterised by slightly decreasing returns. The (aggregated) adjusted R^2 from the second stage of the estimation algorithm is quite high, above 0.90 for every country set of regressions, suggesting high goodness of fit.

Table 2. Production function coefficients and productivity estimates

Country	**b_m (s.e.)**	**b_l (s.e.)**	**b_k (s.e.)**	**Adj.R^2 (No.obs)**	***TFP* index (*TFP* growth)**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Belgium	0.68	0.24	0.08	0.98	1.10
	(0.03)	(0.04)	(0.02)	(10693)	(-0.63)
Denmark	0.72	0.26	0.08	0.97	1.02
	(0.02)	(0.02)	(0.02)	(10697)	(-0.06)
Germany	0.84	0.17	0.07	0.93	1.05
	(0.01)	(0.01)	(0.01)	(54037)	(+0.63)
Greece	0.59	0.22	0.07	0.99	0.73
	(0.02)	(0.02)	(0.02)	(11957)	(+0.43)
Spain	0.60	0.26	0.07	0.98	1.09
	(0.01)	(0.02)	(0.01)	(32121)	(+1.98)
France	0.74	0.21	0.08	0.97	1.01
	(0.01)	(0.01)	(0.01)	(71274)	(+0.24)
Ireland	0.80	0.07	0.05	0.98	1.23
	(0.02)	(0.02)	(0.02)	(6088)	(-0.59)
Italy	0.62	0.20	0.07	0.98	1.10
	(0.01)	(0.01)	(0.01)	(56977)	(+2.05)
Luxembourg	0.68	0.24	0.10	0.99	0.99
	(0.03)	(0.03)	(0.02)	(3799)	(+0.63)
Netherlands	0.70	0.27	0.11	0.98	1.04
	(0.01)	(0.02)	(0.01)	(12800)	(-0.61)
Austria	0.62	0.20	0.12	0.99	1.36
	(0.02)	(0.02)	(0.02)	(13228)	(+1.44)
Portugal	0.64	0.20	0.07	0.97	0.96
	(0.02)	(0.03)	(0.01)	(8341)	(+1.89)
Finland	0.68	0.16	0.11	0.93	1.67
	(0.03)	(0.02)	(0.02)	(5364)	(-0.78)
Sweden	0.87	0.11	0.06	0.95	1.20
	(0.03)	(0.02)	(0.01)	(4626)	(-0.47)
UK	0.80	0.22	0.08	0.94	0.99
	(0.01)	(0.02)	(0.01)	(27680)	(+0.18)

Notes: *TFP* index is an aggregate productivity measure in levels; *TFP* growth is the aggregate annual percentage growth. The total number of observations (No.obs) reported is from the second-step estimated sample.

In the last column (6) of Table 2, both a productivity index (level) and a growth rate are reported for each EU-15 country. These two aggregate productivity measures (*TFP* index and *TFP* growth) are weighted averages of farm-level productivity measures using output shares as weights, within and between farm types, thus capturing the farm and sector composition effects. As explained by Van Biesebroeck (2008), productivity is intrinsically a relative concept. Therefore, for comparative purposes, within each EU-15 country, we define our farm productivy measure in levels following Olley and Pakes (1996) as $TFP_{jt} = tfp_{jt} / \overline{tfp_t}$, where $\overline{tfp_t}$ is the average productivity of all farms in period *t*; the farm productivity growth is defined as $\Delta TFP_{jt} = \log(tfp_{jt} / tfp_{jt-1})$.

The *TFP* index ranges between 0.73 in Greece and 1.67 in Finland; a higher index suggests that relatively more productive farms and farm sectors dominate, i.e. they have larger market shares. Overall, by this measure, the northern European countries appear to have more productive farm sectors. The comparison of the *TFP* growth measures is interesting: average annual growth ranges between -0.78% in Finland and +2.05% in Italy. Six small, northern European countries show negative productivity growth, while the three largest EU-15 countries, Germany, France and the UK, all show small but positive productivity growth. The highest average, annual productivity growth is recorded by the southern European countries, Italy, Portugal and Spain.

5. Impact of subsidies on productivity: GMM regression analysis

Our strategy in this section is to verify the effect of subsidies on farm productivity. Subsidies are widely used in EU agriculture and the large majority of farms have received subsidies in one way or another. Thus, we do not have an easy way to identify treatment and control groups. Furthermore, we are interested here in the impact of subsidies on productivity of the agricultural sector as a whole. Therefore, we verify the relationship by means of regression analysis using the same FADN country samples we used to estimate farm productivity (tfp_{jt}). We note that this verification analysis is different from the two-stage analysis in previous productivity studies, because in our productivity estimation algorithm we have explicitly accounted for the effect of subsidies, and thus our productivity measures are not biased.

For verification purposes, we specify an estimating equation, linking farm productivity and subsidies, using as a basis the inverted investment demand $\omega_{jt} = h_t(i_{jt}, k_{jt}, s_{jt}, \vec{e}_{jt})$ formulated in equation (4). We point out that in estimating farm productivity we have explicitly built the effect of subsidies into the productivity estimation algorithm (see section 3) and in this section we seek only to demonstrate the effect by means of regression analysis. We estimate two specifications, in which the dependent variable is measured in levels ($\log(tfp_{jt})$) and in growth rates ($\log(tfp_{jt}/tfp_{jt-1})$) respectively. The explanatory variables, defined in previous sections, are investment (i_{jt}), capital (k_{jt}), subsidies (s_{jt}) and subsidies interacted with a dummy capturing the effect of decoupling (sx_{it}); sets of year and farm sector controls are also included in every specification. As the main explanatory variables in the estimating equations are not strictly exogenous and likely serially correlated, we treat them as predetermined; considering the regressors as endogenous does not change the results reported.

We estimate the productivity and subsidies relationship by Blundell and Bond's (1998) two-step system GMM.[20] Table 3 reports the regression results (with a two-step robust covariance matrix) for levels and growth rates for each of the EU-15 countries. For all regressions, the diagnostic tests for no second-order autocorrelation, AR(2), and for the validity of instruments, Hansen-J, are satisfied. We find clear evidence that the effect of subsidies before decoupling is negative even though the magnitude of the coefficients is quite small (between zero and a 3.7% decrease in TFP when subsidies double). Overall, for all countries except Portugal and Finland, subsidy coefficients in both the level and the growth equations have negative signs. In terms of productivity level, we find a negative and statistically significant effect for seven of the EU-15 countries. In terms of productivity growth, the effect is negative and statistically significant for ten of the EU-15 countries. Thus, for the period before the decoupling of subsidies, no significant negative effect is found in only four of the EU-15 countries and in no country is a positive effect is evident. These results are consistent with findings by previous productivity studies that employ a two-stage approach to identify the CAP subsidy impact on farm efficiency (e.g. Latruffe et al., 2009; Lakner, 2009; Zhu and Oude Lansink, 2010).

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[20] To compensate for the downward bias of the two-step estimates, a finite-sample correction to the two-step covariance matrix derived by Windmeijer (2005) is applied.

Table 3. GMM estimates of the impact of subsidies on productivity

Country	**Specification**	**b_I (s.e.)**	**b_K (s.e.)**	**b_S (s.e.)**	**b_{SX} (s.e.)**	**AR(2) Hansen J**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Belgium	Level	0.010	0.075	-0.001	0.009	0.121
		(0.005)	(0.045)	(0.002)	(0.011)	(0.324)
	Growth	0.002	0.040	-0.003	0.006	0.178
		(0.001)	(0.024)	(0.002)	(0.011)	(0.461)
Denmark	Level	0.002	-0.314	**-0.012**	**0.010**	0.205
		(0.001)	(0.074)	**(0.002)**	**(0.003)**	(0.194)
	Growth	0.002	-0.180	-0.003	**0.012**	0.183
		(0.001)	(0.056)	(0.002)	**(0.004)**	(0.344)
Germany	Level	0.008	-0.103	**-0.002**	-0.001	0.082
		(0.002)	(0.018)	**(0.001)**	(0.001)	(0.229)
	Growth	0.004	-0.104	**-0.003**	-0.001	0.114
		(0.001)	(0.018)	**(0.001)**	(0.001)	(0.215)
Greece	Level	0.006	-0.105	**-0.037**	**-0.017**	0.181
		(0.002)	(0.055)	**(0.006)**	**(0.007)**	(0.402)
	Growth	0.002	-0.036	**-0.035**	**-0.020**	0.286
		(0.001)	(0.016)	**(0.005)**	**(0.010)**	(0.537)
Spain	Level	0.003	-0.179	-0.003	**0.015**	0.228
		(0.001)	(0.057)	(0.002)	**(0.002)**	(0.198)
	Growth	0.003	-0.130	**-0.008**	**0.007**	0.361
		(0.001)	(0.050)	**(0.002)**	**(0.002)**	(0.399)
France	Level	0.004	0.063	**-0.005**	**0.008**	0.111
		(0.002)	(0.031)	**(0.001)**	**(0.002)**	(0.295)
	Growth	0.004	0.047	**-0.007**	**0.011**	0.115
		(0.002)	(0.026)	**(0.001)**	**(0.002)**	(0.312)
Ireland	Level	0.008	0.067	-0.002	**0.029**	0.221
		(0.004)	(0.036)	(0.002)	**(0.015)**	(0.418)
	Growth	0.008	0.030	**-0.008**	0.019	0.104
		(0.004)	(0.015)	**(0.003)**	(0.012)	(0.372)
Italy	Level	0.002	0.014	-0.003	0.001	0.094
		(0.001)	(0.004)	(0.003)	(0.001)	(0.120)
	Growth	0.005	0.048	-0.002	**0.017**	0.195
		(0.003)	(0.021)	(0.002)	**(0.005)**	(0.210)
Luxembourg	Level	0.003	0.021	**-0.003**	**0.054**	0.225
		(0.001)	(0.011)	**(0.001)**	**(0.016)**	(0.580)
	Growth	0.004	0.030	**-0.005**	**0.042**	0.098
		(0.002)	(0.011)	**(0.002)**	**(0.016)**	(0.321)
Netherlands	Level	0.002	-0.188	-0.001	0.003	0.080
		(0.001)	(0.036)	(0.001)	(0.001)	(0.229)
	Growth	0.002	-0.281	**-0.004**	0.001	0.117
		(0.001)	(0.071)	**(0.002)**	(0.001)	(0.198)

Table 3. Continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Austria	Level	0.002	-0.084	**-0.009**	-0.009	0.224
		(0.001)	(0.029)	**(0.002)**	(0.010)	(0.154)
	Growth	0.009	-0.062	**-0.012**	-0.005	0.168
		(0.004)	(0.009)	**(0.002)**	(0.012)	(0.188)
Portugal	Level	0.002	0.002	0.004	0.004	0.106
		(0.001)	(0.001)	(0.004)	(0.006)	(0.115)
	Growth	0.015	0.024	0.004	0.008	0.241
		(0.007)	(0.008)	(0.004)	0.008)	(0.298)
Finland	Level	0.007	0.070	0.015	**0.039**	0.221
		(0.003)	(0.028)	(0.017)	**(0.020)**	(0.351)
	Growth	0.008	0.058	0.017	**0.055**	0.102
		(0.004)	(0.022)	(0.012)	**(0.018)**	(0.282)
Sweden	Level	0.009	0.086	-0.003	0.002	0.248
		(0.003)	(0.036)	(0.006)	(0.006)	(0.526)
	Growth	0.006	0.036	**-0.019**	-0.008	0.150
		(0.002)	(0.018)	**(0.008)**	(0.005)	(0.138)
UK	Level	0.013	-0.150	**-0.013**	**-0.005**	0.219
		(0.006)	(0.043)	**(0.002)**	**(0.002)**	(0.438)
	Growth	0.010	-0.153	**-0.009**	-0.003	0.193
		(0.003)	(0.035)	**(0.002)**	(0.002)	(0.278)

Notes: The estimated samples cover the period 1991–2008 (1996–2008 for Austria, Finland and Sweden). The diagnostics reported are the p-values for the AR(2) test and for the Hansen J test (in parentheses). In all the estimated equations, the year and farm type controls are included. The coefficients of the subsidy variable (pre- and post-decoupling), where significant at 5% or better, are denoted in **bold**.

For the period after decoupled subsidies, where introduced the effect on farm productivity is more diverse. In fact, for ten of the EU-15 countries the subsidy coefficient is positive even though it is statistically significant for only six countries in the level equation as well as in the growth equation. We find a statistically significant negative effect in only two countries: about 2% (when subsidies double) in both the level and the growth equations for Greece, while for the UK we find a small negative effect of 0.5% (if subsidies double) solely in the level equation. Interestingly, the group of countries for which a switch of effect, from negative to positive after decoupling is observed, is mixed, including both northern and southern member states. Overall, after decoupling we find that subsidies have either no effect or a small positive effect on productivity in the majority of the EU-15 countries. Our findings are consistent with those of Zhu et al. (2012) and Mary (2012). They do not investigate the decoupled payments but consider the impact of partial decoupling (e.g. the introduction of Agenda 2000). The former study finds that a higher degree of coupling in farm support negatively affects farm efficiency, whereas the latter study finds that the Agenda 2000 reform had a positive impact on productivity.

Clearly the impact of subsidies depends on their type. Our results provide evidence that coupled subsidies indeed distort farm behaviour (e.g. production structure or input allocation, or both) leading to productivity loss. Furthermore, owing to the allocative inefficiency, monitoring costs and payment uncertainty, coupled subsidies are expected to stimulate less credit and hence also intensify less productive investment compared with decoupled payments. It should further be noted that a significant part of the coupled payments could be leaked away to other agents through changes in market prices; the effect diminishes farms' benefits from subsidies. The leakage is positively correlated with coupling because it implies a stronger link of subsidies to farm activities and thus a stronger impact on the aggregate price level (Floyd, 1965; Alston and James, 2002).

Compared with coupled subsidies, the results indicate that in countries where positive effects are observed, decoupled subsidies likely affect farm productivity through the 'credit channel'. Subsidies allow farms to improve their credit position or reduce the cost of borrowing for investments (or both), thus boosting their productivity. Furthermore, the observed positive effect could also stem from subsidies reducing risk aversion, which ensures that the farm productivity adjustment is more active. For the cases where a negative effect of subsidies after decoupling is still observed, this could be owing to either insignificant market imperfections (credit problems) in the agricultural sector (e.g. Germany, the UK and Sweden) or partial decoupling[21] (e.g. Greece) or a combination of the two factors (e.g. Austria). For example, if farm credit problems are insignificant, there is minor or no gain from subsidising credit and investment. Partial decoupling means that a share of subsidies is kept coupled with the introduction of the Single Payment Scheme in 2005–06, which may lead to efficiency losses because of the persistence of production distortions that may offset partly or fully the gains from alleviating market imperfections.

6. Summary and conclusion

The focus of this paper is on evaluating the impact of CAP subsidies on the total factor productivity of EU commercial farms. The paper also documents aggregate productivity differences across the EU member states and FADN farm types (sectors) using micro data. We build a structural model of the unobserved productivity directly incorporating the effects of farm subsidies and adapt the semi-parametric estimation algorithm proposed by Olley and Pakes (1996) to estimate the parameters of production functions within the FADN farm-type samples, for each of the EU-15 countries over the period 1990–96 to 2008. We control for differences in the economic environment across narrowly defined spatial units and model productivity as a non-parametric function of investment and state variables, including farm subsidies, which greatly enhances our ability to obtain consistent estimates of the production function parameters and thus back out unbiased TFP measures at the farm level.

We aggregate the farm productivity by country and farm type and find some evidence that the aggregate productivity level and growth systematically differ between the northern and southern sets of European countries. Our farm-level regression analysis, for each of the EU-15 countries, clearly demonstrates the impact of CAP subsidies on farm TFP. We find that subsidies had a negative impact on farm productivity in the period before the decoupling reform was implemented; after decoupling, in 2005–06, the effect of subsidies on productivity was more nuanced, as in several countries it turned positive. Theoretically, the impact of subsidies on productivity is a net effect of allocative efficiency losses and the investment-induced productivity gains caused by the interaction of market imperfections with the subsidy. We do not identify the two effects separately; we only infer their relative importance from the net effect. A caveat we need to acknowledge is that our results are based on an EU-15 sample, which consists of the more developed economies in Europe where market failures are less pronounced. The results might be different for a sample of the less developed new member states, where the credit-alleviation effect of subsidies might be stronger.

Our findings are consistent with the literature emphasising the inefficiencies of public subsidisation of production and at the same time lend support to the EU policy of decoupling CAP subsidies. The results suggest that the decoupled payments are less distortive and

[21] With the introduction of decoupled payments, countries could still allocate part of the total subsidy envelope to coupled payments, such as arable crop payments, sheep and goat payments, and the suckle cow premium (Council of the European Union, 2003). Examples of countries that maintained a significant level of coupled payments include Austria, Greece, Italy and Portugal.

enhance productivity, which is consistent with the WTO's priorities. From a food security perspective, the evidence indicates possible improvements in future food availability through the increasing productive capacity of the EU's agricultural sector. The 2011 European Commission proposal for the post-2013 CAP suggests maintaining the decoupled subsidies system after 2013, thus likely ensuring continued future enhancement of EU farm productivity. Our analyses suggest that the positive productivity effect of decoupled subsidies is likely induced by correcting for inefficiencies in the agricultural sector related to credit access and risk attitudes. However, one should be careful in drawing conclusions regarding general welfare implications from this, since the analysis does not account for the distortions of the taxation funding the subsidy.

References

Abel, A. and J. Eberly (1994), "A unified model of investment under uncertainty", *American Economic Review*, 84(5), 1369–384.

Ackerberg, D., L. Benkard, S. Berry and A. Pakes (2007), "Econometric tools for analyzing market outcomes", in J.J. Heckman and E.E. Leamer (eds), *Handbook of Econometrics*, Vol. 6A, Amsterdam: Elsevier/North-Holland, pp. 4171–276.

Ahearn, M.C., H. El-Osta and J. Dewbre (2006), "The impact of coupled and decoupled government subsidies on off-farm labor participation of U.S. farm operators", *American Journal of Agricultural Economics*, 88(2), 393–408.

Alston, J.M. and J.S. James (2002), "The Incidence of Agricultural Policy", in B.L. Gardner and G.C. Rausser (eds),*Handbook of Agricultural Economics*, Vol. 2B, Amsterdam: Elsevier/North-Holland, pp. 1689–749.

Baumol, W.J. (1990), "Entrepreneurship: Productive, Unproductive, and Destructive", *Journal of Political Economy*, 98(5), 893–921.

Bhaskar, A. and J.C. Beghin (2010), "Decoupled Farm Payments and the Role of Base Updating under Uncertainty", *American Journal of Agricultural Economics*, 92(3), 849–58.

Blancard, S., J.P. Boussemart, W. Briec and K. Kerstens (2006), "Short- and long-run credit constraints in French agriculture: A directional distance function framework using expenditure-constrained profit functions", *American Journal of Agricultural Economics*, 88(2), 351–64.

Blomström, M., R.E. Lipsey and M. Zejan (1996), "Is Fixed Investment the Key to Economic Growth?", *Quarterly Journal of Economics*, 111, February, 267–76.

Blundell, R. and S. Bond (1998), "Initial conditions and moment restrictions in dynamic panel data models", *Journal of Econometrics*, 87, 115–43.

Carpentier, A., A. Gohin and C. Heinzel (2012), *Production Effects of Direct Payments to Active for a Microeconomic Dynamic and Stochastic Analysis*, Paper prepared for the 123rd EAAE Seminar, Dublin, 23-24 February.

Ciaian, P. and J.F.M. Swinnen (2009), "Credit market imperfections and the distribution of policy rents", *American Journal of Agricultural Economics*, 91(4), 1124–139.

Courleux, F., H. Guyomard, F. Levert and L. Piet (2008), *How the EU Single Farm Payment should be Modelled: Lump-sum Transfers, Area Payments or… what else?*, Working Paper SMART – LERECO N°08-01, INRA, Rennes.

Council of the European Union (2003), Regulation (EC) No. 1782/2003 of 29 September 2003 establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers and amending Regulations (EEC) No. 2019/93, (EC) No. 1452/2001, (EC) No. 1453/2001, (EC) No. 1454/2001, (EC) 1868/94, (EC) No. 1251/1999, (EC) No. 1254/1999, (EC) No. 1673/2000, (EEC) No. 2358/71 and (EC) No. 2529/2001, OJ L 270, 29.09.2003.

De Long, J.B. and L.H. Summers (1991), "Equipment investment and economic growth", *Quarterly Journal of Economics*, 106, May, 445–502.

Dewbre, J., J. Antón and W. Thompson (2001), "The Transfer Efficiency and Trade Effects of Direct Payments", *American Journal of Agricultural Economics*, 83, 1204–14.

Ericson, R. and A. Pakes (1995), "Markov-perfect industry dynamics: A framework for empirical work", *Review of Economic Studies*, 62, 53–82.

EU KLEMS (2011), Growth and Productivity Accounts, November 2009 release, updated March 2011 (http://www.euklems.net).

European Commission (2010a), Communication on the CAP towards 2020: Meeting the Food, Natural Resources and Territorial Challenges of the Future,COM(2010) 672 final, Brussels, 18 November.

————(2010b), *EU Farm Economics Overview: FADN 2007*, DG AGRI, Brussels, September.

————(2011), *Proposal for a regulation of the European Parliament and of the Council establishing rules for direct payments to farmers under support schemes within the framework of the Common Agricultural Policy*, COM(2011), 625, Brussels, 19 October.

Farm Accounting Data Network (FADN) (2010), "Farm Accounting Data Network: An A to Z of Methodology" (http://ec.europa.eu/agriculture/rica//pdf/site_en.pdf).

Feder, G. (1985), "The relation between farm size and farm productivity: The role of family labour, supervision and credit constraints", *Journal of Development Economics*, 18(2-3), 297–313.

Feder, G., L. Lau, J. Lin and X. Luo (1990), "The relationship between credit and productivity in Chinese agriculture: A microeconomic model of disequilibrium", *American Journal of Agricultural Economics*, 72(5), 1151–57.

Féménia, F., A. Gohin and A. Carpentier (2010), "The Decoupling of Farm Programs: Revisiting the Wealth Effect", *American Journal of Agricultural Economics*, 92(3), 836–48.

Floyd, J.E. (1965), "The Effects of Farm Price Supports on the Return to Land Labour in Agriculture", *Journal of Political Economy*, 73(2), 148–58.

Food and Agriculture Organization (FAO) (2011),*State of Food Insecurity in the World 2009*, Rome.

Giannakas, K., R. Schoney and V. Tzouvelekas (2001), "Technical Efficiency, Technological Change and Output Growth of Wheat Farms in Saskatchewan", *Canadian Journal of Agricultural Economics*, 49(2), 135–52.

Goodwin B.K. and A.K. Mishra (2005), "Another Look at Decoupling: Additional Evidence on the Production Effects of Direct Payments", *American Journal of Agricultural Economics*, 87(5), 1200–10.

———— (2006), "Are 'Decoupled' Farm Payments Really Decoupled? An Empirical Evaluation", *American Journal of Agricultural Economics*, 88(1), 73–89.

Guyomard, H., C. Le Mouël and A. Gohin (2004), "Impacts of Alternative Agricultural Income Support Schemes on Multiple Policy Goals", *European Review of Agricultural Economics*, 31(2), 125–48.

Hennessy, D.A. (1998), "The production effects of agricultural income support polices under uncertainty", *American Journal of Agricultural Economics*, 80(1), 46–57.

Hüttel, S., O. Mußhoff and M. Odening (2010), "Investment reluctance: Irreversibility or imperfect capital markets?", *European Review of Agricultural Economics*, 37(1), 51-76.

Key, N. and M.J. Roberts (2009), "Nonpecuniary benefits to farming: Implications for supply response to decoupled payments", *American Journal of Agricultural Economics*, 91(1), 1–18.

Kornai, J. (1986), "The Soft Budget Constraint", *Kyklos*, 39(1), 3–30.

Kumbhakar, S. and R. Bokusheva (2009), "Modelling farm production decisions under an expenditure constraint", *European Review of Agricultural Economics*, 36(3), 343–67.

Lagerkvist, C.J. (2005), "Agricultural policy uncertainty and farm level adjustments: The case of direct payments and incentives for farmland investment", *European Review of Agricultural Economics*, 32(1), 1–23.

Lakner, S. (2009), *Technical efficiency of organic milk-farms in Germany - The role of subsidies and of regional factors*, IAAE 2009 Conference, 16-22 August, Beijing.

Latruffe, L., B.E. Bravo-Ureta, V.H. Moreira, Y. Desjeux and P. Dupraz (2011), *Productivity and Subsidies in European Union Countries: An Analysis for Dairy Farms using Input Distance Frontiers*, EAAE 2011 International Congress, 30 August–2 September, Zurich.

Latruffe, L., H. Guyomard and C. Le Mouël (2009), *The Role of Public Subsidies on Farms' Managerial Efficiency: An Application of a Five-Stage Approach to France*, Working Paper SMART-LERECO No. 09-05, INRA, Rennes.

Leibenstein, H. (1966), "Allocative Efficiency vs. '*X* Efficiency'", *American Economic Review*, 56(3), 392–415.

Marshak, J. and W.H. Andrews (1944), "Random simultaneous equations and the theory of production", *Econometrica*, 50, 649–70.

Mary, S. (2012), "Assessing the Impacts of Pillar 1 and 2 Subsidies on TFP in French Crop Farms", *Journal of Agricultural Economics*, online and forthcoming in print.

Maskin, E. and J. Tirole (1988), "A theory of dynamic oligopoly: I&II", *Econometrica*, 56, 549–600.

Meléndez-Ortíz, R., C. Bellmann and J. Hepburn (2009), *Agricultural Subsidies in the WTO Green Box: Ensuring Coherence with Sustainable Development Goals*, Cambridge: Cambridge University Press.

Olley, S. and A. Pakes (1996), "The dynamics of productivity in the telecommunications equipment industry", *Econometrica*, 64(6), 1263–97.

Olson, M. (1982), *The Rise and Decline of Nations: Economic Growth, Stagflation, and Social Rigidities*, New Haven, CT: Yale University Press.

Pakes, A. (1994), "Dynamic structural models, problems and prospects: Mixed continuous discrete controls and market interactions", in J.-J. Laffont and C. Sims (eds), *Advances in Econometrics: The Sixth World Congress of the Econometric Society*, Vol. II, Chapter 5, New York, NY: Cambridge University Press, pp. 171–260.

Rajan, R.G. and L. Zingales (1998), "Financial dependence and growth", *American Economic Review*, 88, 559–87.

Ridier, A. and F. Jacquet (2002), "Decoupling direct payments and the dynamic of decisions under price risk in cattle farms", *Journal of Agricultural Economics*, 53(3), 549–65.

Rizov, M. and P. Walsh (2009), "Productivity and trade orientation of UK manufacturing", *Oxford Bulletin of Economics and Statistics*,71(6), 821–49.

————(2011), "Is there a rural-urban divide? Location and productivity of UK manufacturing", *Regional Studies*, 45(5), 641–56.

Roche, M. and K. McQuinn (2004), "Riskier product portfolio under direct payments", *European Review of Agricultural Economics*, 31, 111–23.

Sauer, J. and T. Park (2009), "Organic farming in Scandinavia – Productivity and market exit", *Ecological Economics*, 68(8-9), 2243–54.

Sckokai, P. and D. Moro (2009), "Modelling the impact of the CAP Single Farm Payment on farm investment and output", *European Review of Agricultural Economics*, 36(3), 395–423.

Serra, T., D. Zilberman, B.K. Goodwin and A. Featherstone (2006), “Effects of decoupling on the mean and variability of output”, *European Review of Agricultural Economics,* 33(3), 269–88.

Van Biesebroeck, J. (2008), “The sensitivity of productivity estimates: Revisiting three important debates”, *Journal of Business and Economics Statistics,* 26(3), 311–28.

Vercammen, J. (2007), “Farm bankruptcy risk as a link between direct payments and agricultural investment”, *European Review of Agricultural Economics*, 34(4), 479–500.

Weber. J.G. and N. Key (2012), “How much do decoupled payments affect production? An instrumental variable approach with panel data”, *American Journal of Agricultural Economics,* 94(1), 52–66.

Whitaker, J.B. (2009), “The varying impacts of agricultural support programs on U.S. farm household consumption”, *American Journal of Agricultural Economics,* 91(3), 569–80.

Windmeijer, F. (2005), “A finite sample correction for the variance of linear efficient two-step GMM estimators”, *Journal of Econometrics,* 126(1), 25-51.

Wooldridge, J. (2009), “On estimating form-level production functions using proxy variables to control for unobservables”, *Economics Letters,* 104(3), 112-114.

Yee, J., M. Ahearn and W. Huffman (2004), “Links among farm productivity, off-farm work, and farm size in the Southeast”, *Journal of Agricultural and Applied Economics,* 36(3), 591-603.

Zhu, X. and A. Oude Lansink (2010), “Impact of CAP Subsidies on Technical Efficiency of Crop Farms in Germany, the Netherlands and Sweden”, *Journal of Agricultural Economics,* 61(3), 545-564.

Zhu, X., R.M. Demeter and A. Oude Lansink (2012), “Technical efficiency and productivity differentials of dairy farms in three EU countries: The role of CAP subsidies”, *Agricultural Economics Review,* 13(1), 66-92.

Appendix 1. Definitions of regression variables

All monetary variables are transformed to real values using the EU KLEMS (2011) agricultural sector output and input deflators with 2000 as a base year. In the definitions of regression variables, we refer to the FADN variable codes (FADN, 2010).

Output is defined as the real value of total annual output (SE131). *Labour* is total full-time equivalent labour input (SE011) measured in hours worked annually. *Materials* measure variable costs and consist of total annual specific costs (SE281) plus total annual farming overheads (SE336), which represent current costs that are not linked to specific lines of production. Total annual specific costs include all variable costs incurred in crop and animal production (e.g. fertilizers, seeds and crop protection products). Total farming overheads also contain the current costs of machinery and buildings as well as the costs of contractors linked to work carried out by contractors and to machinery hire. In their nature these costs are variable, as the decisions on them are usually made within the current period. Furthermore, it is impossible to separate and capitalise the cost of machinery rented from the contactors' labour costs. Therefore we add all these to our variable cost measure.

Subsidies include all payments to farms – total subsidies excluding subsidies on investment (SE605) plus subsidies on investment (SE406). Thus, our measure of subsidies captures all the external cash flows paid to the farm under various CAP components. To capture the change in regime and in the nature of subsidies after decoupling, we also interact the subsidy variable with a dummy indicating the time of implementation of the decoupling policy. The dummy equals one from 2005 onwards for Austria, Belgium, Denmark, Germany, Ireland, Italy, Luxembourg, Portugal, Sweden and the UK; it equals one from 2006 onwards for Finland, France, Greece, the Netherlands and Spain.

Calculating our *capital* measure is more complicated. In FADN, the reported total fixed assets (SE441) only cover the capital owned by the farm. However, leasing in land and buildings is widespread in EU agriculture (Sckokai and Moro, 2009). For our analysis, we need a measure of total fixed capital used in production. Therefore our strategy, similar to Olley and Pakes (1996) is to estimate the capital value of assets rented long term and add it to the value of the total fixed assets owned. We do the calculations in two steps: first, we determine the rental value of land and buildings. Second, we estimate the rate of return on land and buildings for narrowly defined spatial units and eight farm types (NUTS3 and by FADN TF8). Finally, we discount the rental payments using the estimated rate of return as the discount rate.

To calculate the rental payment per hectare, we divide the rent paid (SE375) for farmland and buildings by the utilised agricultural area (UAA)rented (SE030). The value of land and buildings owned is calculated using the balance sheet value of land, permanent crops and quotas (SE446), and buildings (SE450). To calculate the land and buildings price per hectare, we divide this value by the difference of total UAA (SE025) and the UAA rented (SE030). Then we calculate the rate of return by dividing the rental payment per hectare by the price per hectare. From the farm-specific rates of return we calculate median rates of return for narrowly defined special units – for each NUTS3 region by FADN TF8 farm type. We note that using the regional median rather than the farm-specific rate of return circumvents inconsistencies in data, such as the coexistence of positive values of rent paid and zero values of UAA rented. Finally, we use the median rates of return to discount (in perpetuity) the total rental payments (SE375), which gives us the capital value of the land and buildings rented. *Capital* (the total fixed capital) used in production is a sum of the value of the capital rented and the total fixed assets owned (SE441).

Investment (I) is the total net investment and it is constructed in a manner similar to Olley and Pakes (1996) and Rizov and Walsh (2009) from the annually observed, total fixed capital stock (K) using the perpetual inventory method: $I_t = K_{t+1} - (1\text{-}\delta)\, K_t$, where t is the time period and δ is the depreciation rate. Thus, our investment measure captures investment in total fixed capital, both owned and rented.

Appendix 2. Production function coefficients and productivity estimates

Table A1. Production function coefficients and productivity estimates

Country	**Farm sector**	**b_m (s.e.)**	**b_l (s.e.)**	**b_k (s.e.)**	**Adj.R^2 (No.obs)**	***TFP* index (*TFP* growth)**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Belgium	FC	0.66	0.17	0.12	0.99	1.02
		(0.06)	(0.05)	(0.02)	(1019)	(-0.38)
	HC	0.59	0.39	0.05	0.98	1.07
		(0.02)	(0.04)	(0.02)	(1765)	(+0.46)
	MK	0.66	0.14	0.08	0.99	2.23
		(0.02)	(0.03)	(0.02)	(2589)	(+3.94)
	PA	0.73	0.25	0.16	0.96	0.21
		(0.03)	(0.04)	(0.02)	(1818)	(-3.85)
	PP	0.72	0.18	0.10	0.98	0.72
		(0.06)	(0.06)	(0.01)	(1005)	(-1.72)
	MX	0.76	0.16	0.07	0.99	0.69
		(0.02)	(0.03)	(0.02)	(2497)	(-0.86)
Denmark	FC	0.64	0.42	0.08	0.96	0.73
		(0.03)	(0.03)	(0.03)	(1763)	(+0.34)
	HC	0.66	0.45	0.05	0.92	0.68
		(0.02)	(0.02)	(0.01)	(1785)	(+0.07)
	MK	0.66	0.20	0.18	1.00	0.97
		(0.02)	(0.02)	(0.01)	(3395)	(-0.66)
	PP	0.78	0.15	0.06	0.99	1.54
		(0.01)	(0.02)	(0.01)	(1547)	(-0.21)
	MX	0.79	0.23	0.04	0.96	1.02
		(0.02)	(0.02)	(0.02)	(2207)	(+0.31)
Germany	FC	0.85	0.22	0.08	0.91	0.94
		(0.01)	(0.01)	(0.01)	(12135)	(+1.35)
	HC	0.70	0.29	0.06	0.97	1.47
		(0.01)	(0.02)	(0.01)	(7191)	(+0.04)
	MK	0.82	0.14	0.07	0.98	1.63
		(0.01)	(0.01)	(0.01)	(16358)	(-1.42)
	PA	0.84	0.18	0.06	0.93	0.95
		(0.01)	(0.01)	(0.01)	(1745)	(+0.88)
	PP	0.86	0.12	0.06	0.91	1.21
		(0.02)	(0.02)	(0.01)	(1987)	(-0.63)
	MX	0.92	0.14	0.06	0.89	0.90
		(0.01)	(0.01)	(0.01)	(14621)	(+1.15)
Greece	FC	0.62	0.22	0.05	0.99	0.59
		(0.02)	(0.02)	(0.02)	(6020)	(+0.48)
	HC	0.47	0.27	0.14	0.99	0.68
		(0.03)	(0.04)	(0.03)	(3181)	(+1.01)
	MK	0.54	0.23	0.12	0.99	0.56
		(0.01)	(0.01)	(0.01)	(120)	(+1.43)
	PA	0.51	0.13	0.10	1.00	1.66
		(0.03)	(0.03)	(0.02)	(1720)	(+1.06)
	PP	0.54	0.23	0.12	0.99	0.54
		(0.01)	(0.01)	(0.01)	(111)	(-2.32)
	MX	0.51	0.09	0.05	1.00	2.00
		(0.03)	(0.04)	(0.02)	(805)	(+2.14)

Table A1. Continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Spain	FC	0.58	0.30	0.07	0.98	0.56
		(0.02)	(0.02)	(0.01)	(3213)	(+4.06)
	HC	0.45	0.42	0.06	0.99	2.15
		(0.01)	(0.02)	(0.01)	(10223)	(+1.52)
	MK	0.65	0.11	0.08	0.99	0.97
		(0.01)	(0.01)	(0.01)	(9446)	(+0.68)
	PA	0.55	0.34	0.02	0.98	0.80
		(0.02)	(0.02)	(0.01)	(4879)	(+0.49)
	PP	0.65	0.23	0.05	0.98	0.68
		(0.01)	(0.03)	(0.01)	(2186)	(+0.65)
	MX	0.64	0.23	0.05	0.98	0.66
		(0.02)	(0.03)	(0.01)	(2174)	(+2.02)
France	FC	0.81	0.16	0.11	0.96	0.74
		(0.02)	(0.01)	(0.01)	(22019)	(+0.10)
	HC	0.58	0.34	0.10	0.98	1.71
		(0.01)	(0.01)	(0.01)	(15664)	(+1.19)
	MK	0.74	0.14	0.07	0.99	1.37
		(0.01)	(0.01)	(0.01)	(11166)	(-1.39)
	PA	0.78	0.15	0.06	0.97	0.78
		(0.01)	(0.01)	(0.01)	(10543)	(-0.95)
	PP	0.78	0.20	0.04	0.98	1.11
		(0.02)	(0.03)	(0.01)	(1176)	(-1.01)
	MX	0.86	0.16	0.04	0.93	0.73
		(0.02)	(0.03)	(0.01)	(10706)	(+0.68)
Ireland	FC	0.81	0.11	0.06	0.98	0.64
		(0.02)	(0.02)	(0.01)	(258)	(-3.07)
	MK	0.80	0.05	0.04	0.99	1.43
		(0.02)	(0.02)	(0.01)	(3736)	(-1.42)
	PA	0.79	0.19	0.13	0.93	0.86
		(0.04)	(0.04)	(0.03)	(1627)	(+4.80)
	MX	0.81	0.22	0.06	0.89	0.60
		(0.05)	(0.05)	(0.03)	(467)	(+0.41)
Italy	FC	0.66	0.22	0.08	0.98	0.59
		(0.01)	(0.01)	(0.01)	(16278)	(+2.05)
	HC	0.52	0.26	0.09	0.99	1.54
		(0.01)	(0.01)	(0.01)	(20616)	(+2.12)
	MK	0.77	0.08	0.07	0.99	0.93
		(0.01)	(0.01)	(0.01)	(9274)	(+1.94)
	PA	0.66	0.15	0.03	0.99	1.29
		(0.01)	(0.01)	(0.01)	(5738)	(-1.07)
	MX	0.70	0.10	0.06	0.99	0.85
		(0.01)	(0.01)	(0.01)	(5071)	(+0.70)
Luxembourg	HC	0.51	0.39	0.15	0.99	2.58
		(0.06)	(0.09)	(0.04)	(261)	(+1.51)
	MK	0.65	0.26	0.10	1.00	0.93
		(0.02)	(0.01)	(0.03)	(2468)	(+0.66)
	PA	0.75	0.16	0.09	0.98	1.73
		(0.02)	(0.03)	(0.03)	(477)	(-1.84)
	MX	0.87	0.13	0.09	0.94	0.73
		(0.04)	(0.04)	(0.04)	(593)	(+0.99)

Table A1. Continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Netherlands	FC	0.73	0.20	0.16	0.98	0.61
		(0.02)	(0.02)	(0.02)	(2169)	(+0.11)
	HC	0.67	0.32	0.08	0.98	1.22
		(0.01)	(0.01)	(0.01)	(4016)	(-0.73)
	MK	0.73	0.23	0.16	0.99	1.29
		(0.02)	(0.01)	(0.02)	(3958)	(-0.72)
	PA	0.73	0.47	0.06	0.89	0.88
		(0.05)	(0.08)	(0.03)	(484)	(-0.70)
	PP	0.78	0.17	0.06	0.98	1.59
		(0.03)	(0.03)	(0.01)	(1734)	(+0.36)
	MX	0.78	0.24	0.10	0.96	0.54
		(0.03)	(0.05)	(0.02)	(439)	(+2.60)
Austria	FC	0.67	0.20	0.18	0.99	0.83
		(0.03)	(0.03)	(0.03)	(2471)	(+0.67)
	HC	0.57	0.39	0.24	0.96	0.70
		(0.05)	(0.06)	(0.05)	(891)	(+3.97)
	MK	0.56	0.19	0.12	0.99	1.90
		(0.02)	(0.02)	(0.02)	(5279)	(+1.03)
	PA	0.56	0.21	0.15	0.99	1.02
		(0.03)	(0.03)	(0.04)	(1304)	(+3.39)
	PP	0.86	0.14	0.11	0.95	0.90
		(0.04)	(0.03)	(0.02)	(1048)	(+3.04)
	MX	0.72	0.20	0.05	0.98	0.97
		(0.03)	(0.02)	(0.02)	(2235)	(-3.11)
Portugal	FC	0.63	0.24	0.02	0.96	1.52
		(0.03)	(0.03)	(0.01)	(1162)	(+1.34)
	HC	0.53	0.43	0.09	0.92	0.53
		(0.03)	(0.04)	(0.03)	(2225)	(+1.63)
	MK	0.70	0.09	0.07	0.99	1.01
		(0.03)	(0.01)	(0.02)	(3468)	(+1.77)
	PA	0.62	0.18	0.02	0.98	1.16
		(0.03)	(0.05)	(0.01)	(731)	(+0.21)
	PP	0.74	0.24	0.10	0.98	1.77
		(0.05)	(0.07)	(0.04)	(255)	(+4.50)
	MX	0.63	0.22	0.02	0.96	1.17
		(0.01)	(0.01)	(0.01)	(500)	(+1.40)
Finland	FC	0.85	0.23	0.13	0.82	0.73
		(0.05)	(0.05)	(0.04)	(825)	(+0.24)
	HC	0.73	0.32	0.08	0.89	0.75
		(0.04)	(0.05)	(0.03)	(510)	(-0.21)
	MK	0.52	0.13	0.11	1.00	2.28
		(0.03)	(0.02)	(0.01)	(2911)	(-0.57)
	PA	0.85	0.20	0.07	0.82	0.71
		(0.02)	(0.02)	(0.01)	(184)	(+1.52)
	PP	0.85	0.16	0.03	0.87	0.75
		(0.05)	(0.06)	(0.01)	(426)	(-0.97)
	MX	0.84	0.20	0.08	0.82	0.61
		(0.02)	(0.02)	(0.02)	(508)	(-2.11)

Table A1. Continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sweden	FC	0.85	0.13	0.06	0.96	0.93
		(0.07)	(0.05)	(0.03)	(982)	(-0.23)
	MK	0.88	0.12	0.03	0.91	1.43
		(0.02)	(0.02)	(0.01)	(2539)	(-0.93)
	PA	0.84	0.30	0.11	0.74	0.71
		(0.07)	(0.10)	(0.04)	(222)	(+0.91)
	PP	0.87	0.14	0.05	0.93	0.82
		(0.04)	(0.06)	(0.02)	(309)	(-1.36)
	MX	0.93	0.12	0.05	0.76	0.85
		(0.02)	(0.02)	(0.01)	(574)	(+1.88)
UK	FC	0.75	0.27	0.06	0.94	1.41
		(0.02)	(0.02)	(0.01)	(5551)	(-0.22)
	HC	0.78	0.28	0.07	0.87	0.84
		(0.03)	(0.03)	(0.02)	(1245)	(-0.10)
	MK	0.83	0.17	0.09	0.97	0.92
		(0.01)	(0.01)	(0.01)	(7543)	(-0.65)
	PA	0.88	0.26	0.08	0.94	0.72
		(0.02)	(0.02)	(0.01)	(10159)	(+0.98)
	PP	0.70	0.31	0.05	0.96	2.10
		(0.04)	(0.04)	(0.02)	(810)	(+0.45)
	MX	0.82	0.24	0.05	0.92	0.92
		(0.02)	(0.03)	(0.02)	(2372)	(+0.55)

Notes: The farm type codes are FC – field crop farms; HC – horticulture, wine and greenhouse farms; MK – milk farms; PA – pasture farms; PP – poultry and pig meat farms; MX – mixed farms. The *TFP* index is an aggregate productivity measure in levels and the *TFP* growth is the aggregate annual percentage growth over all farms in each farm type for the period 1991–2008 (1996–2008 for Austria, Finland and Sweden).

Comparative Analysis of Factor Markets for Agriculture across the Member States

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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.
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Partners	17 (13 countries)
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