CAP subsidies and productivity of the EU farms

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Abstract
The paper investigates the impact of the Common Agricultural Policy (CAP) subsidies on farm total factor productivity (TFP) in the European Union (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 the Farm Accountancy Data Network (FADN) samples for the EU-15 countries. Our main findings are clear: subsidies impact negatively farm productivity in the period before the decoupling reform was implemented; after decoupling the effect of subsidies on productivity is more nuanced as in several countries it turned positive.

Key words: CAP subsidies, investment, productivity, micro data, EU farms
JEL: D24, L00, Q12, Q18

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1 Introduction

The European Union (EU) farm sector is heavily subsidized. Annually, EU spends around 50 billion EUR on the Common Agricultural Policy (CAP) with the primary aim to support farmers' income and improve the environmental impact of agricultural production. The main part of CAP subsidies is disbursed in the form of decoupled direct payments, so called Single Payment Scheme (SPS). Other types of subsidies include coupled payments to farm crop or animal activities and Rural Development Payments (RDP). The coupled subsidies were significantly reduced with the introduction of decoupled payments by the 2003 CAP reform. The current EU subsidy system will be applied until 2013. However, the 2011 European Commission proposal for the post-2013 CAP suggests maintaining the current subsidy system largely unchanged after 2013 (European Commission, 2011).

The decoupling of the EU subsidies is related to the WTO trade liberalization process aimed at reduction of distortionary (coupled) agricultural support (Meléndez-Ortíz et al., 2009)[1]. Decoupled payments in principle should have no impact on production decisions of farmers and therefore should not distort world markets. Several papers, however, argue that indeed even decoupled subsidies will still affect input use and production of farms. In particular, direct payments reduce credit market imperfections and farmers' risk aversion but also induce distortionary allocative effects, all of which will affect farmer's input use and output decisions (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; Carpentier et al., 2012). In the same time, the increasing volatility of global food commodity markets and rising food security concerns in developing countries

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

propel calls for maintaining the support of agricultural production leading to farm investment and adoption of productivity enhancing modern technology (FAO, 2011). European Commission explicitly mentions in its proposal for the CAP post-2013 the challenge of food security and the goal of the EU to support long-term food supply potential to contribute to growing world food demand (European Commission 2010, 2011).

The impact of subsidies on agricultural production is well documented in the literature (e.g., Ridier and Jacquet, 2002; Serra et al., 2006; Carpentier et al., 2012; Weber and Key, 2012), but significantly less attention has been devoted to the impacts of subsidies on productivity of farms. Subsidies may have positive impact on farm production and at the same time negative impact on farm productivity. Furthermore, analysing the impact of subsidies on productivity is important because long-run competitiveness and real incomes in the sector are primarily driven by productivity growth rather than by growth of production. Several studies (e.g., Lagerkvist, 2005; Sckokai and Moro, 2009; Vercammen, 2007) also analyse the impact of subsidies on farm investment behaviour, but legitimate analysis of the affect of subsidies on farm productivity is still missing in the literature.

Given the extent of subsidisation of farms in the EU and other developed countries, the impact of subsidies on productivity is an important issue because investments induced by subsidies might not necessarily be reflected in productivity gains. On the one hand, subsidies alleviate the farm credit constraint and reduce risk aversion which would have a positive impact on farm productivity, but, on the other hand, softening of the farm budget constraint, allocative inefficiencies and distribution of subsidies to less productive farms may affect productivity negatively. The overall response of productivity to subsidies thus depends on which effect prevails and on the type of subsidies. There are different channels through which coupled subsidies affect investment and productivity vis-à-vis decoupled subsidies.

The existing empirical literature focuses mostly on coupled subsidies and employs a two stage estimation approach whereby efficiency measures are estimated in the first stage without controlling for subsidy effects and then those efficiency measures are regressed on subsidies in the second stage (e.g. Giannakas et al., 2001; Latruffe et al., 2009; Lakner, 2009; Sauer and Park, 2009; Zhu and Oude Lansink, 2010; Latruffe et al., 2011). The disadvantage of this two stage approach is that it does not incorporate explicitly subsidies into a structural productivity algorithm and thus may not necessarily capture fully various channels (e.g., credit constraint, risk attitudes, allocative inefficiencies) through which farm productivity is affected. This approach therefore will result in biased estimates of the overall impact of farm subsidies.

There are a few non-agricultural sector studies explicitly investigate the relationship between subsidies and productivity (e.g., Lee 1996; Beason and Weinstein 1996; Bergstrom 2000), also in a two stage estimation framework. Their findings are inconclusive, however, and depend on the type of subsidy and economic context. Moreover, the empirical findings from this literature cannot be fully extrapolated to agriculture as the nature of sectors is not the same (e.g., with respect to credit constraint, risk, and technology) as well as the type of subsidies differs in several respects. In agriculture, and in particular in the case of the CAP, most subsidies are disbursed annually in the form of income support and represent a regular cash flow to farms,[2] whereas in non-agricultural sectors subsidies tend to be targeted (coupled) to a specific firm activity (e.g., R&D investment) and are in general one-off payment. For this reason, different channels may operate in agriculture through which subsidies impact productivity than is the case of non-agricultural sectors and hence the overall impact will likely differ.

[2] CAP subsidies are disbursed as part of multiannual financial framework following the EU budgetary planning.

The present paper aims to fill the gap in the literature by investigating the impact of the EU CAP subsidies on farm productivity directly controlling for various channels linking subsidies and productivity and using an advanced productivity estimation technique following modelling ideas in Olley and Pakes (1996) and Ackerberg et al. (2007). We explicitly model unobserved productivity and directly incorporate the effects of subsidies into a structural semi-parametric estimation algorithm. Our empirical analysis is based on the Farm Accountancy Data Network (FADN) dataset. We estimate total factor productivity (TFP) for a large and representative sample of farms in the EU-15 over the period 1990-2008. Furthermore, special attention is paid to the significant change of regime with the decoupled subsidies introduction by the 2003 CAP reform. The paper compares the impact of subsidies on farm productivity before and after decoupling. We find that overall, subsidies impact negatively productivity until the implementation of the decoupling reform. After the decoupling 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 efefct is small but economically important.The results provide insights into the effectiveness of the decoupling in terms of reducing the distortionary effects of CAP subsidies on farm behaviour. From policy perspective this is relevant 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 motivate our empirical approach. In section 3 we present our estimation algorithm. In section 4 we describe the FADN data that we use in our empirical analyses and report production function estimation results. In section 5 we verify the effect of subsidies on farm productivity by the means of GMM regressions. Section 6 summarises our findings and concludes.

2 Subsidies and productivity: Findings in the literature

There is a large literature on the implications of public policy for investment and economic growth. De Long and Summers (1991) and Rajan and Zingales (1998) among others suggest that there may be market failure justifications for public subsidisation of enterprises. However, even if market failures warrant government interventions, subsidisation of investment is not unproblematic (Blomstrom et al., 1996). Financing of subsidies gives rise to deadweight losses and subsidies themselves lead to both allocative and technical inefficiencies. Thus, it is far from clear whether subsidisation of investments is good or bad for productivity and long-term growth. The findings of empirical studies are also mixed. A study of Korea by Lee (1996) and another of Japan by Beason and Weinstein (1996) both find negative effect of subsidies on productivity growth. Bergstrom (2000) finds positive effect of capital subsidies on firm (investment) growth but no effect on productivity in Sweden. Hyytinen and Toivanen (2005) show, for the case of Finland, that subsidies disproportionately improve the growth (R&D investment) of firms from industries that are relatively more dependent on external finance; R&D investment is believed to directly lead to improvement in productivity.

Even though subsidisation often leads to growth in investment, employment and output the ultimate question is whether productivity is affected. Growth of productivity is important for long-term economic growth (Nickell, 1996). Subsidies may help improve firm productivity if firm technological development is simulated or firms are facilitated to better utilise economies of scale. However, public subsidies may end up being transferred to less productive firms by policy makers "with special interest", 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. Subsidies may negatively affect firm productivity through two more channels. First, a subsidy gives the recipient firm an incentive to change its capital-labour ration which can lead to allocative inefficiency, i.e., over-investment in capital. Second, subsidisation may give rise to technical inefficiency if subsidies are captured by the firm's stakeholders as higher profits leading to slack, lack of effort and not seeking 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 firm will continuously 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 (subsidy recipients) are less careful in protecting their wealth. Another extreme may occur when the firms - potential subsidy recipients completely modify their behaviour, if the pay-off is sufficiently high, and start actively investing in subsidy seeking activities which are relatively less productive (e.g., Baumol, 1990).

Considering specifically agricultural sector subsidies, there is a variety of studies addressing mostly effects on investment, input use and output but there are only a few studies directly exploring the impact of subsidies on farm productivity. Subsidies (coupled and decoupled) may affect farm behaviour and agricultural markets through several channels. If farms are credit rationed, then subsidies may provide additional source of financing either directly by increasing farms' financial resources or indirectly through the improved access to formal credit. In other words, for credit rationed farms subsidies may serve as a substitute for credit. Credit unconstrained farms may also be affected, if subsidies represent a cheaper source of financing than the credit available on the financial markets. In both cases, the increased access to credit affects farm factor use and investment (Vercammen, 2007; Ciaian and Swinnen, 2009). Another channel suggested by Hennessy (1998) is that under uncertainty (decoupled) subsidies distort markets through wealth effect. Subsidies affect farmers' wealth and this can affect risk attitudes. For example, farmers may be more willing to expand production with certain type of activities or employ additional factors that would otherwise be viewed as too risky (Roche and McQuinn, 2004). In related research, Lagerkvist (2005) examines how uncertainty of area payment reform implementation affects farmers' farmland investment incentives. Policy uncertainty leads to inefficiency by making farmers more inclined to over-invest in land before the reform date if they expect that the reform will reduce their area payment. Sckokai and Moro (2009) examine the impact of CAP arable crop regime on farm investment and output and find that an increase in intervention price significantly affects farm investment while other types of policy changes have much smaller impact. There is no micro data study on the direct effects of subsidies on farm productivity.

The literature on credit constraints in agriculture (e.g., Feder, 1985, Feder et al., 1990, and more recently Blancard et al., 2006, Ciaian and Swinnen, 2009, Kumbhakar and Bokusheva, 2009, Hüttel et al., 2010), similar to the general literature on market failure and subsidisation also suggests a channel through which farm subsidies might affect (increase) investment and production. For the credit constraint farms subsidies relax the constraint and improve access to finance. The studies find that credit constraint farms invest less and have lower allocative efficiency which would improve as a result of subsidies. However, the link between technical efficiency (productivity) and credit constraints is not explicitly modelled and studied in this literature. An exception is the paper by Kumbhakar and Bokusheva (2009) who assert (footnote 8) that the relationship between technical efficiency and credit constraints is complex and will differ by farm type. They also point that the approach of the existing studies is to estimate, in a first step, technical efficiency/inefficiency and then, in a second step, to link it to the measure of credit (expenditure) constraint which makes it impossible to model the relationship prior to estimation and it can only be evaluated *ex-post*.

Overall, the findings from empirical studies on the agricultural sector are inconclusive, however negative relation between subsidies and efficiency tend to prevail particularly in studies on the CAP. In general they analyse the effects of coupled subsidies and focus on narrowly defined agricultural industries. Latruffe et al. (2009) find a negative impact of coupled CAP subsidies on efficiency for French farms specialised in cereal and oilseeds and beef production. Lakner (2009) shows that the agri-environmental payments and investment programs have a negative effect on the efficiency of organic dairy farms in Germany. Estimates of Zhu and Oude Lansink (2010) indicate that negative efficiency effects of coupled subsidies prevail for crop farms in Germany, the Netherlands and Sweden. Latruffe et al. (2011) report negative impact of total subsidies on dairy farms in seven EU countries (Denmark, France, Germany, Ireland, Spain, the Netherlands, and UK) for the period 1990-2007. Latruffe et al. (2011) also cover the early period when decoupled payments are implemented and their results indicate that in all countries with exception of Denmark, the average technical efficiency was highest in the period prior to decoupling while the lowest level of technical efficiency is observed during the decoupling period. In contrast, Sauer and Park (2009) find a positive influence of organic subsidies on technical efficiency change and technological change for organic dairy farms in Denmark. Yee et al. (2004) also find positive relation between total factor productivity of US farms and public expenditure in investment in public research, extension and infrastructure.

All these empirical studies follow a two-stage approach where the efficiency parameters estimated in the first stage are regressed on subsides in the second stage. In our view testing for a relationship between subsidies (or credit constraints) and productivity, *ex-post*, is admitting that there was information that should have been used in the model of the unobserved productivity while estimating it in the first instance. Therefore in the next section we propose a structural semi-parametric approach which allows directly incorporating the effects of subsidies in the model of unobserved productivity. Following our discussion on the findings in the literature, we assert that the impact of subsidies on productivity is a net effect of efficiency loss (due to distortion in farm production structure and factor allocation, soft budget constraint, shift of subsidies to less productive farms) and the investment-induced productivity gain caused by interaction of farm credit and risk attitudes with subsidies (lower cost of borrowing, subsidy-induced credit access, reduction in risk aversion, increase in productive investment).

The former effect is likely negatively and the latter effect is likely positively correlated with decoupling implying that coupled subsidies may have a smaller positive or a larger negative impact on productivity relative to decoupled ones. First, the efficiency loss is stronger for coupled subsidies than for decoupled ones because farm eligibility for former payments are directly linked to farm factor and production decisions which leads to higher allocative inefficiency, whereas for the latter the linkage to farm activities is weaker[3]. Farm decisions are distorted by coupled subsidies towards subsidised activities away from productivity motivated activities. Second, the investment-induced productivity gain through the credit and risk channel is likely smaller for coupled than for decoupled payments. The conditionality of coupled subsidies increases monitoring costs of financial institutions if subsidies are used by credit constrained farms as collateral for investment loans. Financial institutions have to check what farms produce to identify the size of coupled subsidies. Furthermore, the amount and the receipt of coupled subsidies is uncertain because of their link to farm activities which in general are associated with both sectoral or farm specific risks

[3] While CAP decoupled subsidies farms receive irrespective of their production decisions, CAP coupled subsides are related to production of specified products or input use. For example farm receives specific tomatoes subsidy only when it produces tomatoes. The recipients of the CAP decupled payment need to fulfil only the so-called cross-compliance conditions which require good agricultural practices, implying, among other things, that environmental criteria have to be satisfied on cultivated land. Farms receive decoupled payments irrespective if they produce or not. Only land use may be affected in certain circumstances because they are disbursed on per hectare basis (Guyomard et al., 2004; Dewbre et al., 2001, Courleux, et al., 2008).

such as weather effect, diseases, etc. Both monitoring cost and payment uncertainty may increase cost of loan and/or reduce financial institutions' willingness to provide credit backed by coupled subsidies. For decoupled payments, the certainty of payment is higher due to their linkage to land assets which is relatively costless to monitor and is less subject to production risk.

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 (technical efficiency) and directly controlling for the effects of subsidies in the estimation algorithm. The strength of the approach lies in its flexibility to accommodate the specificities of the economic problem of interest and its efficiency in dealing with estimation biases. First, it allows us to control for the simultaneity bias 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 the approach controls for potential selection bias in estimating production functions. We extend the Olley and Pakes (1996) approach by explicitly allowing farm decisions and market environment (factor markets and demand conditions) to be affected by the CAP subsidies which we directly introduce into the underlying structural model.

Let farm behaviour be described as follows. The farm maximizes its expected present value of both current and future profits. Current profits are assumed to be a function of the farm's state variables, capital (k) and productivity (ω). Factor prices are assumed to be common across farms. At every period the farm faces three decisions. First, it has to decide whether to continue its operations or not whereby it receives a one-time sell-off value and never reappears again. Conditional on staying in the market 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 t denotes the time and j is the farm index.

Productivity is assumed to evolve according to a first-order Markov process, $p(\omega_{jt} \mid \omega_{jt-1})$ and to be determined by a set of distributions conditional on the information at time t. The information includes past (realised) productivity shocks. Given this distribution set, both the exit and investment decision will crucially hinge upon 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 a distribution for the future market structure (Maskin and Tirole, 1988).

We modify the standard Olley and Pakes (1996) framework described above in a manner similar to Rizov and Walsh (2009) by introducing subsidies as an additional control in the state space. This way we control for the various channels linking subsidies and productivity discussed in previous sections. Thus, the decisions to invest and to exit production will depend on whether a farm receives subsidies and on their amount. Farms exit whenever they draw a productivity shock that is lower than some threshold value which depends on the capital stock of the farm. In the context of the CAP farm capital stock is related to the level of subsidies which tend to lead to more capital intensive farms. By incorporating the subsidies information 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. Note that the investment demand function and the exit rule in Olley and Pakes (1996) are a solution to a complicated dynamic programming problem and it depends on all the primitives of the model like output demand, sunk costs, form of conduct in the industry (Ackerberg et al., 2007). All these factors are now conditioned on the level of subsidies farms receive.

More formally, we explicitly take into account that more highly subsidised farms have relatively higher factor demands (e.g., due to the credit channel effect of subsidies or allocative effects) when decisions are made about investment and continuing production. This means that the investment equilibrium relationship can be represented by the investment demand function

$$i_{jt} = i_t(\omega_{jt}, k_{jt}, s_{jt}, \vec{e}_{ji}), \tag{1}$$

where s_{jt} denotes subsidies and $\vec{e}_{ji}$ captures other characteristics of the market environment similar to Rizov and Walsh (2011). The market environment control vector $\vec{e}_{ji}$ includes farm specialisation and location information at NUTS3 level and a time trend. Note, here we assume that the investment decision at time t depends on the capital stock which is predetermined at t through the investment decision at $t - 1$.

As in Olley and Pakes (1996) we assume that investment is monotonically increasing in productivity conditioned on the level of subsidies received.[4] 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.[5] Recently Hüttel et al. (2010) apply this result to investment analysis of the German farm. Given monotonicity investment can be inverted to generate the productivity function

$$\omega_{jt} = h_t(i_{jt}, k_{jt}, s_{jt}, \vec{e}_{jt}). \tag{2}$$

[4] 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 information crucially improves the monotonicity in the relationship between investment and productivity by removing the credit market imperfections (in line with De Long and Summers, 1991 and Rajan and Zingales, 1998) that some farms may possibly face.

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

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 exit decision rule as

$$\mathrm{X}_{jt} = \begin{cases} 1 & if \quad \omega_{jt} \geq \overline{\omega}_t(k_{jt}, s_{jt}, \vec{e}_{jt}) \\ 0 & \qquad otherwise \end{cases}, \qquad (3)$$

where $\overline{\omega}_t$ is a threshold value.[6] The 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 will depend on the state variables and the characteristics of the economic environment including subsidies and factor prices.

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 will now include the subsidy variable and additional economic environment controls. This way we have introduced subsidies as an additional control in the state space in the dynamic program of the firm. The production function we estimate is specified as

$$y_{jt} = \beta_0 + \beta_m m_{jt} + \beta_l l_{jt} + \beta_k k_{jt} + \omega_{jt} + v_{jt}, \qquad (4)$$

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

Substituting the productivity (inverted investment demand) function (2) into the production function (4) gives us:

$$y_{jt} = \beta_0 + \beta_m m_{jt} + \beta_l l_{jt} + \beta_k k_{jt} + h_t(i_{jt}, k_{jt}, s_{jt}, \vec{e}_{jt}) + v_{jt}. \qquad (5)$$

[6] One could also let the sell-off value be higher for more highly subsidised farms, however, this would not change the solution to the dynamic problem as long as the rate at which sell-off value increases with capital stock is lower than the rate of the continuation value.

In Equation (5) 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 $h_t(.)$, the constant and k_{jt} terms to be combined into a function $\phi_t(i_{jt}, r_{jt}, e_{jt}, k_{jt}, a_{jt})$ such that Equation (5) becomes

$$y_{jt} = \beta_m m_{jt} + \beta_l l_{jt} + \phi_t(i_{jt}, k_{jt}, s_{jt}, \vec{e}_{jt}) + \nu_{jt}, \tag{6}$$

which forms the first stage of our estimation algorithm and is estimated using OLS. In Equation (6) subsidies are introduced as an additional market environment control - we allow it to interact with the terms of the polynomial in capital and investment.[7]

In the first stage of the estimation algorithm we identify materials and labour coefficients while the capital coefficient is identified in the second stage of the algorithm. As in the original Olley and Pakes (1996) paper, labour is treated as a variable and non-dynamic input, which is a function of the state variables and 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 fully variable and non-dynamic input on which decisions are always made after labour is chosen and given the contemporaneous realisation of productivity.[8] In the first stage we also estimate $\hat{\phi}_t$ which allows us to express ω_{jt} for use in the second stage as

$$\hat{\omega}_{jt} = \hat{\phi}_{jt} - \beta_0 - \beta_k k_{jt}. \tag{7}$$

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

[7] In addition, to control for the nature of the subsidies, we use a dummy variable capturing the effects during the period after decoupling of subsidies which was actually implemented in 2005/2006 across the EU-15. We fully interact the dummy with the polynomial in the first stage estimation equation.

[8] 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 material demands 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 (6).

not known by the farm 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 the market quickly, in the same period when the decision is made. If exit is decided in the period before actual exit occurred, then even though there is a selection *per se*, exit would be uncorrelated with ξ_{jt}. To account for endogenous selection on productivity we extend the g(.) function as in Olley and Pakes (1996):

$$\omega_{jt} = g'(\omega_{jt-1}, \hat{P}_{jt}) + \xi_{jt}, \qquad (8)$$

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 which do survive to time t likely have higher ω_{jt}s than those with higher survival probabilities. We estimate $\hat{P}_{jt}$ non-parametrically using Probit model with a polynomial approximation. Note that we extend the state variable set with information on subsidies which are important determinant of farm exit decision.[9]

[9] 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 affected by farm productivity and allocation of subsidies controlling for selection remains important. 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. Substituting equations (8) and (7) into equation (4) gives us

$$y_{jt} - \widehat{\beta}_m m_{jt} - \widehat{\beta}_l l_{jt} = \beta_k k_{jt} + g'(\hat{\phi}_{jt-1} - \beta_k k_{jt-1}, \widehat{P}_{jt}) + \varepsilon_{jt}, \qquad (9)$$

where the two β_0 terms are encompassed into the non-parametric function, *g'*(.) and ε_{jt} is a composite error term comprised of v_{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 (9) is estimated by a non-linear least squares (NLLS) search routine approximating *g'*(.) with a polynomial.[10]

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

$$tfp_{jt} = \exp(y_{jt} - \hat{\beta}_m m_{jt} - \hat{\beta}_l l_{jt} - \hat{\beta}_k k_{jt}) . \qquad (10)$$

It is clear that the modified two-stage estimation algorithm has an impact on the estimated production function coefficients. Compared to the OLS we expect materials and labour coefficients to be lower since materials and labour demands are strongly positively correlated with the productivity shock. The direction of the bias in the capital coefficient is less clear since it impacts 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 positive correlation between regional productivity and subsidy level, farms receiving higher per unit subsidies - on average – tend to be more capital intensive (FADN, 2010). Therefore in order

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

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 subsidies received by farms.[11]

4 Data and productivity estimates

We apply our estimation algorithm to the Farm Accountancy Data Network (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 the EU farms. In total there is information about 150 variables on farm structure and yield, 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; also it is representative of the commercial agricultural holdings in the whole of the EU (EU DG-AGRI, 2010). Holdings are selected to take part in the survey 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 percent of the utilised agricultural land in the EU-27.

The panel we employ in this paper covers the period 1990-2008 and includes the commercial farms defined as in Sckokai and Moro (2009) in all EU-15 Member States.[12] Our goal is to estimate unbiased total factor productivity (TFP) measures at farm level, within six

[11] More highly subsidised farms might experience faster technological change. Therefore, we checked whether technological change was affected by the level of subsidies by interacting time trend with subsidies, in addition to the fully interacted polynomial. The results were not different from the reported in the paper.
[12] For Austria, Finland and Sweden which entered the EU in 1995 the period of analysis is 1996-2008.

farm-type (FADN TF6) samples, for each country, and to document the aggregate productivity levels and changes over time and by farm type.[13] 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 TF6 samples for each country which leaves us with 83 farm-type country samples, with sufficient number of observations to apply our estimation algorithm. The estimated samples account for about 85 per cent of the FADN EU-15 farms.

- Table 1 here -

Summary statistics for the regression variables are reported in Table 1 and detail definitions based on 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 the largest in terms of labour employed.

There is 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 north European countries average farm subsidies range roughly between 16,000 and 35,000 Euro (the highest subsidies being paid to the Finish farms) while for south European countries subsidies are around or less than 8,000 Euro per farm. This relationship holds also for subsidy per unit of labour employed. However, when subsidy per

[13] The six farm types comprise field crop farms, horticultural and vine farms, dairy farms, pasture farms, poultry and pig meat farms, and mixed farms.

unit of capital is considered the picture is quite opposite – south European farms are more heavily subsidised.

- Table 2 here -

In Table 2 the production function coefficients estimated from the 83 regressions 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 north 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.

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 north 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, north 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 south 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 the EU agriculture and the large majority of farms have received subsidies in one way or another; this means that 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 the means of regression analysis using the available FADN country samples that we also 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 effects of subsidies and thus, our productivity measures are not biased.

For verification purposes we specify an estimating equation, linking farm productivity and subsidies on the basis of the inverted investment demand $\omega_{jt} = h_t(i_{jt}, k_{jt}, s_{jt}, \vec{e}_{jt})$ formulated in Equation (2). 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 aim to only demonstrate the effect by the means of regression analysis. We estimate two specifications where 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. Given that 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 generalised method of moments (GMM). Arellano and Bond (1991) develop a GMM estimator (the 'difference GMM') that treats the model as a system of (first-difference) equations, one for each time period. The equations differ only in their instrument/moment condition sets. The predetermined and endogenous variables in first differences are instrumented with suitable lags of their own levels. Strictly exogenous regressors as well as any other instruments can enter the instrument matrix in the conventional instrumental variables fashion: in first differences, with one column per instrument. A problem with the original Arellano-Bond estimator is that lagged levels are often poor instruments for first differences, especially for variables that are close to a random walk. Arellano and Bover (1995) describe how, if the original equations in levels were added to the system, additional moment conditions could be brought in to increase efficiency. In these equations, predetermined and endogenous variables in levels are instrumented with suitable lags of their own first differences. Blundell and Bond (1998) present the necessary assumptions for this augmented estimator (the 'system GMM') more precisely and test it with Monte Carlo simulations.[14]

- Table 3 here -

[14] The Arellano-Bond GMM estimators have one- and two-step variants. But though asymptotically more efficient, the two-step estimates of the standard errors tend to be severely downward biased (Arellano and Bond 1991; Blundell and Bond 1998). To compensate, a finite-sample correction to the two-step covariance matrix derived by Windmeijer (2005) is applied.

Table 3 reports the system GMM (with two-step robust covariance matrix) regression results 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 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 3.7% if subsidy is doubled). Overall, for all countries, except Portugal and Finland, subsidy coefficients both in the level and in the growth equations have negative signs. In terms of productivity level we find 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 decoupling of subsidies only in four of the EU-15 countries no significant negative effect is found and in no country a positive effect is evident. These results are consistent with findings by previous productivity studies which employ two-stage approach to identify the CAP decoupled subsidy impact on farm efficiency (e.g., Latruffe et al., 2009; Lakner, 2009; Zhu and Oude Lansink, 2010).

For the period after decoupled subsidies were 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 only for six countries in the level equation as well as in the growth equation. We find statistically significant negative effect in only two countries; about 2% (if subsidy is doubled) both in the level and in the growth equation for Greece while for the UK we find a small negative effect of 0.5% (if subsidy is doubled) only 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 north and south European Member States. Overall, after decoupling we find that subsidies have either no effect or small positive effect on productivity in the majority of the EU-15 countries.

Clearly the impact of subsidies depends on their type. Our results provide evidence that coupled subsidies indeed distort farm behaviour (production structure and input allocation) leading to productivity loss. Furthermore, due to the allocative inefficiency, monitoring costs and payment uncertainty, coupled subsidies are expected to stimulate less credit and hence also enhance less productive investment compared to decoupled payments. Further note that a significant part of coupled payments could be leaked away to other agents through changed market prices meaning that farms' benefits from subsidies are shrunk and the amount potentially available to enhance farm credit is reduced. The leakage is positively correlated with coupling because it implies stronger link of subsidies to farm activities and thus stronger impact on aggregate price level (Alston and James, 2002; Floyd, 1965).

Compared to coupled subsidies, the results indicate that in countries where positive effects are observed, decupled subsidies likely impact farm productivity through the "credit channel". Subsidies allow farms to improve their credit position and/or reduce cost of borrowing for investments thus boosting their productivity. Further, the observed positive effect could be also due to subsidies decreasing 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 due to either insignificant market imperfections (credit problem, risk attitudes) in the agricultural sector (e.g., Germany, UK, Sweden) or partial decoupling[15] (e.g., Greece) or the 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 SPS in 2005/2006 which may lead to efficiency losses

[15] With the introduction of the decoupled payments, countries could still allocate part of the total subsidy envelope to coupled payments such as arable crop payments, sheep and goat payments, suckle cow premium, etc. (EUR-Lex, 2003). Examples of countries which maintained a significant level of coupled payments include Austria, Greece, Italy, and Portugal.

due to persistence of production distortions which may offset partially or fully the gain from the alleviation of market imperfections.

6 Summary and conclusion

The focus of the paper is on evaluating the impact of CAP subsidies on productivity (technical efficiency) of the 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 incorporating directly 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, for the period 1990/1996 – 2008. We control for differences in the economic environment across narrowly defined spatial units and model productivity as a non-parametric function of farm subsidies, investment and state variables which greatly enhances our ability to obtain consistent estimates of the production function parameters and thus, back out unbiased TFP measures at farm level.

We aggregate the farm productivity by country and farm type and find some evidence that aggregate productivity level and growth systematically differ between the north and south European country sets. Our farm-level regression analysis, for each of the EU-15 countries, clearly demonstrates the impact of CAP subsidies on farm total factor productivity. We find that subsidies impact negatively farm productivity in the period before the decoupling reform was implemented; after decoupling, in 2005/2006, the effect of subsidies on productivity is more nuanced as in several countries it turned positive. Theoretically the impact of subsidies on productivity is a net effect of allocative and technical efficiency loss and the investment-induced productivity gain caused by the interaction of market imperfections with 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 the EU-15 sample which consists of the more developed economies in Europe where market failures are less pronounced; the results might be different for the 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 for decoupling of CAP subsidies. The results suggest that the decoupled payments are less distortive and enhance productivity which is consistent with the WTO priorities. From the food security perspective the evidence indicates possible improvement in future food availability through increasing productive capacity of EU 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 rationing and risk attitudes. However, one should be careful in drawing conclusions regarding general welfare implications from this, since the analysis if to be considered comprehensive should include the distortion costs of taxation of the subsidy as well as a comparison with other policy instruments that could address market imperfections and the agricultural productivity directly.

References

Abel, A. and J. Eberly. 1994. A unified model of investment under uncertainty. American Economic Review, 84(5), 1369-1384.

Ackerberg, D., L. Benkard, S. Berry, and A. Pakes. 2007. Econometric tools for analyzing market outcomes. In Handbook of Econometrics, Eds. J.J. Heckman and E.E. Leamer, Vol. 6A, pp. 4171-4276, Elsevier: North Holland.

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 Handbook of Agricultural Economics, Eds. B.L. Gardner and G.C. Rausser, Volume 2B, pp. 1689-1749, Elsevier: North Holland.

Arellano, M., and S. Bond. 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. Review of Economic Studies, 58, 277-297.

Arellano, M., and O. Bover. 1995. Another look at the instrumental variables estimation of error-components models. Journal of Econometrics, 68, 29-51.

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

Beason, R. and D. E. Weinstein, 1996, Growth, Economies of Scale, and Targeting in Japan (1955-1990). The Review of Economics and Statistics, 78(2), May, 286–295.

Bergstrom, F. 2000. Capital subsidies and the performance of firms, Small Business Economics, 14, 283-293.

Bhaskar, A. and Beghin, J. C. 2010. Decoupled Farm Payments and the Role of Base Updating Under Uncertainty. American Journal of Agricultural Economics, 92(3): 849–858.

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), 351-364.

Blomström, M., R. E. Lipsey and M. Zejan, 1996, Is Fixed Investment the Key to Economic Growth?, Quarterly Journal of Economics. 111, February, 267–276.

Blundell, R., and S. Bond. 1998. Initial conditions and moment restrictions in dynamic panel data models. Journal of Econometrics 87: 115-143.

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

Ciaian, P. and J.F.M. Swinnen. 2009. Credit market imperfections and the distribution of policy rents. American Journal of Agricultural Economics 91(4): 1124-1139.

De Long, J. B. and L. H. Summers, 1991. Equipment Investment and economic growth, Quarterly Journal of Economics 106, May, 445–502.

Ericson, R. and Pakes, A. 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, Accessed at http://www.euklems.net.

EU DG-AGRI. 2010. EU Farm Economics Overview: FADN 2007, EU Commission, Brussels, September.

European Commission, 2010. The CAP Towards 2020: Meeting the Food, Natural Resources And Territorial Challenges Of The Future. Brussels, 18 November 2010.

European Commission, 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, European Commission: Brussels, 19 October 2011.
EUR-Lex. 2003. Council Regulation (EC) No 1782/2003. Official Journal of the European Union L 270, 29 September 2003.
FADN. 2010. Farm Accounting Data Network: An A to Z of Methodology. Accessed of line http://ec.europa.eu/agriculture/rica//pdf/site_en.pdf
FAO. 2011. State of Food Insecurity in the World 2009, Food and Agriculture Organization of The United Nations: Rome
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, 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, 1151–57.
Floyd, J.E. 1965. The Effects of Farm Price Supports on the Return to Land Labour in Agriculture. Journal of Political Economy, 73, 148-158.
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), 135-152.
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), 1200-1210.
Goodwin, B. K. and A. K. Mishra. 2006. Are 'Decoupled' Farm Payments Really Decoupled? An Empirical Evaluation. American Journal of Agricultural Economics, 88(1), 73-89.
Hennessy, D. A. 1998. The production effects of agricultural income support polices under uncertainty. American Journal of Agricultural Economics, 80, 46–57.
Hüttel, S., O. Muβhoff and M. Odening. 2010. Investment reluctance: Irreversibility or imperfect capital markets? European Review of Agricultural Economics, 37(1), 51-76.
Hyytinen, A. and O. Toivanen. 2005. Do financial constraints hold back innovation and growth? Evidence on the role of public policy, Research Policy, 34, 1385-1403.
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), 343-367.
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, August 16-22, 2009, Beijing, China.
Latruffe, L., Bravo-Ureta, B.E., Moreira, V.H. ,Desjeux, Y. and Dupraz, Pi. 2011. Productivity and Subsidies in European Union Countries: An Analysis for Dairy Farms Using Input Distance Frontiers. EAAE 2011 International Congress, August 30-September 2, 2011, Zurich, Switzerland.

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, Rennes, France.

Lee, J.-W. 1996. Government Interventions and Productivity Growth, Journal of Economic Growth, 1, 391–414.

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

Maskin, E. and Tirole, J. 1988. A theory of dynamic oligopoly: I&II, Econometrica, 56, 549-600.

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

Nickell, S. J., 1996, 'Competition and Corporate Performance', Journal of Political Economy, 104(4), 724–746.

Olley, S. and A. Pakes. 1996. The dynamics of productivity in the telecommunications equipment industry. Econometrica, 64(6), 1263-1297.

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

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

Rajan, R.G. and Zingales, L., 1998. Financial dependence and growth. American Economic Review, 88, 559–587.

Ridier, A. and Jacquet, F. 2002. Decoupling direct payments and the dynamic of decisions under price risk in cattle farms. Journal of Agricultural Economics, 53(3), 549-565.

Rizov, M. and P. Walsh. 2009. Productivity and trade orientation of UK manufacturing, Oxford Bulletin of Economics and Statistics, 71(6), 821-849.

Rizov, M. and P. Walsh. 2011. Is there a rural-urban divide? Location and productivity of UK manufacturing, Regional Studies, 45(5), 641-656.

Roche, M. and K. McQuinn, 2004. Riskier product portfolio under direct payments. European Review of Agricultural Economics, 31, 111–123.

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), 269-288.

Van Biesebroeck, J. 2008. The sensitivity of productivity estimates: Revisiting three important debates. Journal of Business and Economics Statistics, 26(3), 311-328.

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), 569–580

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, 112-114.
Yee, J., Ahearn, M. and Huffman, W. 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.

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	43679	881935	5131	76323	140971	22919	0.14
	(282519)	(686788)	(2618)	(67454)	(106314)	(14784)	(14482)
Denmark	112820	1429519	4932	201566	327328	26956	0.26
	(526561)	(1763689)	(4713)	(208165)	(332105)	(28473)	(17543)
Germany	84099	1841140	5336	113431	172399	31257	0.12
	(2497164)	(5461136)	(7990)	(199692)	(285913)	(78321)	(74777)
Greece	3011	173873	4301	14839	38177	7095	0.20
	(43950)	(115452)	(2518)	(12987)	(22392)	(10461)	(17883)
Spain	32793	304669	3399	29284	60333	8167	0.15
	(1251647)	(2188137)	(1776)	(39483)	(57893)	(11860)	(58502)
France	58531	658768	3821	67690	117234	21490	0.13
	(587110)	(1220771)	(2533)	(52899)	(91397)	(21959)	(93420)
Ireland	49564	817596	3711	42958	73092	16210	0.16
	(240331)	(649796)	(1361)	(25267)	(46347)	(14933)	(8230)
Italy	57020	901081	4701	30868	73105	7870	0.29
	(950727)	(1735947)	(2805)	(41684)	(84248)	(53745)	(99433)
Luxembourg	26721	1047658	3697	69548	117041	31755	0.08
	(145642)	(471116)	(1260)	(36794)	(56326)	(22688)	(4807)
Netherlands	111121	1588701	6358	182174	314895	16669	0.17
	(765337)	(1700511)	(6191)	(206852)	(326502)	(24221)	(17290)
Austria	16080	370652	4178	33577	63626	19628	0.06
	(63608)	(190470)	(1499)	(19601)	(32720)	(11903)	(17248)
Portugal	3599	152441	5176	30136	49175	8280	0.21
	(56179)	(119936)	(2826)	(27466)	(37274)	(17099)	(12343)
Finland	13427	322369	4577	67044	83005	34699	0.10
	(64504)	(219101)	(2450)	(50103)	(70080)	(24801)	(7176)
Sweden	55069	818385	3725	98106	132079	28293	0.11
	(424276)	(832441)	(1750)	(75022)	(111042)	(26768)	(6645)
UK	33549	990267	5488	95061	142365	31585	0.17
	(299587)	(781154)	(3687)	(82161)	(132278)	(32108)	(38405)

Notes: All monetary variables are in 2000 Euros. The average annual exits (Exits) capture farms exiting the sample both because of exiting production and because of the sampling rules. The total number of observations (No. obs.) is reported.

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.

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)
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)

Table 3 continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)
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). Diagnostics reported are the p-values for the AR(2) test and for the Hansen J test (in parentheses). In all estimated equations year and farm type controls are included. Coefficients of the subsidy variable (pre and after decoupling) when significant at 5 percent or better are denoted in bold.

Appendix 1
Definitions of regression variables

All monetary variables are transformed to real values using 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 farming overheads contain also machinery and buildings current cost as well as contractor costs 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 contactor labour costs. Therefore we add all these to our variable cost measure.

Subsidies include all payments to farms, excluding payments on 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 the year 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 the 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 and second, we estimate the rate of return on land and buildings at narrowly defined spatial units and eight farm types (NUTS3 by FADN TF8). Finally, we discount the rental payments using the rate of return as discount rate.

To calculate the rental payment per hectare we divide the rent paid (SE375) for farm land and buildings by the U.A.A. rented (SE030). The value of land and buildings owned is calculated using the balance sheet value of land, permanent crops and quotas (SE446) and of buildings (SE450). To calculate the land and buildings price per hectare we divide this value by the difference of total U.A.A (SE025) and the U.A.A. 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 at narrowly defined special units - for each NUTS3 region by FADN TF8 farm type. We note that using regional median rather than farm-specific rate of return circumvents inconsistencies in data such as coexistence of positive values of rent paid and zero values of U.A.A. 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 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 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 capital stock (K) using the perpetual inventory method: $I_t = K_{t+1} - (1-\delta)\, K_t$, where t is time period and, δ is depreciation rate. Thus, our investment measure captures investment in total fixed capital, both owned and rented.

Appendix 2
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 of 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)

Table A1 Continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)
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)
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)

Table A1 Continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)
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)
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 crops 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 sector for the period 1991-2008 (1996-2008 for Austria, Finland and Sweden).