Income distributional effects of CAP subsidies

Micro evidence from the EU

Pavel Ciaian, d'Artis Kancs and Sergio Gomez y Paloma

Abstract: *This paper studies the income distributional effects of three main instruments of the Common Agricultural Policy (CAP) in the EU: Coupled Direct Payments (CDP), the Rural Development Programme (RDP) and the Single Payment Scheme (SPS). The authors use a large set of cross-country farm-level panel data for the EU covering the period 1999–2007, and employ the GMM estimator, which allows important sources of endogeneity to be addressed. According to the results, farmers gain 66–72%, 77–82% and 93–109% from the CDP, SPS and RDP respectively. These findings suggest that the initiated shift in CAP expenditure from the support of farm production activities towards supporting rural development and the provision of public goods and externalities is also in line with supporting farmers' income.*

Keywords: *income distributional effects; coupled and decoupled payments; Rural Development Programme; FADN panel; CAP; GMM*

The authors are with the European Commission, DG Joint Research Centre, C/Inca Garcilaso, 3, 41092 Seville, Spain. E-mail: pavel.ciaian@ec.europa.eu. (Corresponding author: Pavel Ciaian.)

Annually, the European Union (EU) spends around 55 billion euros on the Common Agricultural Policy (CAP) with the aim of supporting farmers' income and the production of public goods and externalities, such as landscape and a clean environment (EC, 2013, 2014). The majority of CAP subsidies are disbursed in the form of decoupled direct payments, the so-called Single Payment Scheme (SPS). The other two most important CAP instruments are Coupled Direct Payments (CDP) and the Rural Development Programme (RDP). The objective of this study is to analyse the income distributional effects of the three main CAP instruments in the EU: CDP, the SPS and the RDP. The aim of the study is to provide scientific support for the policy-making decision process. Farm income support is one of the main priorities of the CAP, and thus analysing its transfer efficiency is an important element in the policy evaluation process. We econometrically estimate the income distributional effects of each of the three types of CAP subsidies. By employing a large firm-level panel dataset for the period 1995–2007, we are able to capture both the inter-temporal variation due to CAP reforms, and cross-sectional differences in the CAP implementation across EU member states (MS).

Previous theoretical literature has studied the farm income distributional effects of agricultural policy extensively. Alston and James (2002), de Gorter and Meilke (1989), Dewbre *et al* (2001), Gardner (1983) and Guyomard *et al* (2004) have analysed how income distributional effects differ between subsidy types: that is, coupled versus decoupled. Desquilbet and Guyomard (2002) and Sheldon *et al* (2001) have analysed how income distributional effects differ among the agents along the vertical chain. McCorriston and Sheldon (1991), Salhofer and Schmid (2004) and Ciaian and Swinnen (2006, 2009) examined how income distributional effects depend on input and output market imperfections. Finally, de Gorter (1992) and Munk (1994) looked at how they depend on policy implementation details. Another strand of empirical literature applies partial equilibrium (PE) and general equilibrium (CGE) models to simulate the distributional effects of agricultural subsidies (for example, Dewbre *et al*, 2001; Kancs and Weber, 2001; Gohin and Moschini, 2006; Hubbard, 1995; Salhofer and Schmid, 2004; Gocht *et al*, 2013). Although the PE and CGE simulation models can capture complex linkages present in agricultural markets, the simulated effects often depend on calibrated or arbitrary assumed parameter values, which is a common aspect for criticism.

The empirical literature tends to support the theoretical findings that not only agricultural producers, but also other market participants along the vertical chain, may benefit from agricultural subsidies. For example, according to Goodwin *et al* (2003), Weersink *et al* (1999), Lence and Mishra (2003), Roberts *et al* (2003), Kirwan (2009), Michalek *et al* (2014), Ciaian and Kancs (2012), Kilian *et al* (2012); Guastella *et al* (2013), Barnard *et al* (1997) and Patton *et al* (2008), between 20% and 100% of the coupled subsidies are leaked to landowners by increasing the land sale and/or rental prices, whereas for the decoupled subsidies the leakage rate is found to be slightly lower (between 10% and 80%). However, several studies employing EU data have found low rates of subsidy capitalization into land values, suggesting that farms may benefit from the CAP proportionally more than other agricultural market participants (Michalek *et al*, 2014; Guastella *et al*, 2013).

The main contribution of this paper to the existing literature is in providing new evidence of the income distributional effect of the CAP across the EU member states. Most of the literature on agricultural subsidies and income transfer efficiency focuses on their impact on land prices. We also assess how the income distributional effects of the decoupled CAP subsidies (SPS) compare to the coupled and RDP policy measures. To our knowledge there is no study available in the literature analysing the income distributional effects of different CAP subsidies.

Common Agricultural Policy in the EU

The CAP has undergone several major reforms since 1992, characterized by a move away from price support towards direct payments to farmers (Pillar 1). In particular, the 1992 reform introduced coupled area and animal payments. These coupled payments replaced the previous price intervention mechanism, which supported farm incomes through maintaining EU prices of agricultural commodities higher than the world prices. The 2003 reform has progressively decoupled these payments from production and introduced decoupled payments, the so-called SPS. The SPS is now by far the largest component of the CAP budget. In parallel, the CAP budget has been partially reoriented towards the RDP funded by the European Agricultural Fund for Rural Development under Pillar 2 of the CAP (EC, 2011). The latest CAP reform was adopted in 2013 (EC, 2013). This CAP reform maintained both the RDP and SPS as major policy instruments in the current financial period 2014–2020, but linked them more closely with rural development and the provision of public goods and externalities (EU, 2013).

The CAP reforms changed significantly the distribution of different types of subsidies in the total CAP budget over time. The share of CDP increased from around 22% of the total CAP budget in 1992 to around 70% in 2000. In contrast, the 2003 CAP reform reduced the share of CDP; by 2007 they represented only around 10% of the CAP budget. The SPS share increased from zero in 2003 to around 58% in 2007 and is expected to stay at around 60% after 2013. Finally, the share of the RDP in the total CAP budget increased from less than 8% in 1992 to around 20%, and is expected to maintain this level under the 2013 CAP reform (European Commission, 2013).

Coupled Direct Payments

CDP were introduced by the MacSharry reform in 1992 and were further increased by Agenda 2000. The 2003 CAP reform significantly reduced CDP by introducing the decoupled payments (SPS). However, even with the SPS introduction, the member states (MS) could maintain a certain share of direct payments coupled to crop or animal production instead of disbursing them as decoupled payments. Under the 2003 CAP reform, for cereals, oilseed and protein crops 25% of direct payments could be linked to production, or alternatively 40% of supplementary durum wheat aid could be coupled. Other options of coupling direct payments to production included 50% of the sheep and goat premium, 100% of the suckler cow premium and 40% of the slaughter premium or 100% of the slaughter premium with up to 75% of the special male premium. In the dairy sector, member states could opt for decoupling either in 2005, or at the latest in 2007. According to the 2013 CAP reform, member states can allocate to CDP up to 15% of the total national direct payment budget.

CDP are available to farms in all MS, and include crop area direct payments and animal direct payments. The crop CDP includes area payments for cereals, oilseeds, protein crops, rice and set-aside. In general, they are land-based subsidies linked to the cultivation of certain crops, implying that the level of the crop CDP does not depend on production level, but on the area cultivated with eligible crops. The value of CDP per hectare is regionally differentiated. The coupled animal direct payments include various types of subsidies such as the suckler cow premium, beef premium, slaughter premium and ewe premium. These subsidies are either output (animal) type of payments (such as beef premiums, slaughter premiums) or subsidies linked to non-land input (such as the suckler cow premium or ewe premium), which may affect the stock of breeding livestock.

Single Payment Scheme

Under the World Trade Organization (WTO) rules, the decoupled subsidies (referred to as 'Green Box' measures) which do not distort production, or at most cause minimal distortion, are allowed without limits, whereas the coupled subsidies which are production-distorting (referred to as 'Amber Box' measures) are subject to displacement (WTO, 2003). In response to pressure from the WTO that the EU was providing an unfair competitive advantage by supporting its agricultural sector, the CAP was significantly reformed in 2003. The previous CAP subsidy system (Agenda 2000), based on coupled area and animal payments, was to a large extent replaced by the decoupled SPS starting in 2005. The aim was to shift agricultural support towards non-distortive polices. The SPS is allocated as a fixed set of payments per farm, independent of production level. Farms are entitled to yearly payments, depending on the amount of the SPS entitlements and the eligible area of land. Whereas the entitlements give the right for a farm to receive a per hectare payment, the SPS is linked to land because, in the absence of land, farms cannot activate (cash in) the SPS entitlements. An entitlement can be activated only if it is accompanied by one hectare of eligible land, which can be rented on or owned by the farm claiming the payment. However, the SPS is not linked to a specific land area – the SPS entitlements can be activated by any eligible farmland in the region. Farms can expand or decrease their stock of entitlements by buying or selling entitlements on the market from other farms.

Farm eligibility for the SPS is subject to cross-compliance. The 2013 CAP reform introduced further environmental requirements, the so-called 'greening measure' aimed at improving the environmental performance of farms. Each farm that receives the SPS must comply with the Statutory Management Requirements (SMR) and maintain the agricultural land in Good Agricultural and Environmental Condition (GAEC). The SMR are based on pre-existing EU Directives and Regulations in the fields of environment, public, animal and plant health and animal welfare. The aim of the GAEC is to prevent the abandonment and severe undermanagement of agricultural land. The 'greening' includes three measures: crop diversification, maintenance of permanent grassland and ecological focus area (set-aside).

The SPS is supplemented by an additional 'greening' payment taking up to 30% of the SPS funds, if farms respect the 'greening' requirements or measures mentioned above. Under crop diversification, cultivation of the arable land needs to include at least two different crops on farms cultivating between 10 and 30 hectares of arable land and at least three crops on farms with a larger arable area. The main crop should not exceed 75% of arable land, and the two main crops should not exceed 95% of the arable area. Under the maintenance of permanent grassland, farms are required not to convert and plough permanent grassland. The ecological focus area requires farms larger than 15 hectares to set aside at least 5% of the farm's eligible area (excluding areas under grassland), with the possibility of increasing this percentage to 7%, subject to an evaluation review in 2017. The area that qualifies as ecological focus area includes land left fallow, terraces, landscape features and buffer strips. In order to avoid penalizing those farms that already address environmental and sustainability issues, the 'Greening Equivalency' system is applied, whereby the application of environmentally beneficial practices already in place is considered to replace these three basic greening requirements (EU, 2013; European Commission, 2013). The aim of these measures is to impose a stronger linkage of the SPS to 'agricultural practices beneficial to the climate and environment'.

Rural Development Programme

RDP support includes different policy measures each focusing on a specific area of rural development. In general, the RDP measures can be regrouped into eight socioeconomic areas of rural development: farm restructuring and competitiveness; improvement of human capital; innovation; provision of basic rural services and related infrastructure; improving the quality of agricultural products; support for sustainable use of agricultural land; diversification of the rural economy; and support for improvement of the environment (Copus *et al*, 2007; Dwyer, 2005). A further regrouping can be done based on targeting the RDP measures, which can be targeted either at the farm level (for example, investment support, agri-environmental support, Less Favoured Area (LFA) payments) or at the rural community level (for example, infrastructural investments). In this paper we focus on the RDP allocated to farms: LFA payments, agri-environmental payments and investment support.

LFA and agri-environmental payments are a compensatory type of aid (Dwyer, 2005) granted as annual payments to farmers in less productive areas under multi-annual contracts. Agri-environmental payments are offered for the provision of environmental management services. They are granted for a range of farm activities aimed at improving the environment on the farm. These payments should cover additional costs and farm income foregone resulting from adoption of environmental management practices on-farm. The environmental payments particularly affect farm input use, because they are conditional on the adoption of environmentally friendly production practices, such as fertilizer reduction, organic farming, intensification of livestock, conversion of arable land to grassland, rotation measures and support of biodiversity (EC, 2005).

Investment aids usually cover only a share of the total cost of a one-off or short-term programme of investment activity and farm practices on a farm (capital items) or for a farmer (training courses and other qualifications). These may be designed to improve the efficiency of an agricultural aspect of the business, or they may be intended to enable a farm to diversify into non-farming activities (farm shops, processing and marketing activities, tourist accommodation). Investment support measures enable the application of more efficient technology, knowledge spillovers and more efficient practices to farmers. They also cover output-related support in terms of marketing costs and market access transaction costs.

Theoretical hypothesis

As noted in the introduction, there is an extensive theoretical literature assessing the income distributional effects of agricultural subsidies. These studies find that although farms are the direct recipients of subsidies, they usually do not fully absorb them. According to previous literature, a farm's profits may be affected by subsidies through several channels. First, subsidies may increase input prices (for example, fertilizers, land and capital), thus channelling policy benefit to input suppliers. Second, subsidies may lead to lower output prices, thus generating policy gains for consumers. Third, subsidies may interact with other markets (as in credit constraint) or may alter farm behaviour (substitute private farm activities), which may enhance or reduce farm profits depending on the type of induced effect. The overall subsidy effect on farm profits depends on the magnitudes of these multiple factors.

According to theoretical studies, CDP and RDP are expected to have the strongest impact on input and output prices, and hence a significant share of policy rents may be leaked to other market participants (such as consumers and input suppliers) (for example, Floyd, 1965;

Alston and James, 2002; de Gorter and Meilke, 1989; Gardner, 1983; Guyomard *et al*, 2004; Salhofer, 1996; Ciaian and Swinnen, 2006, 2009). The reason is that both CDP and RDP are linked to a specific input use (for example, land) or output produced, and thus stimulate farms' demand on input markets and higher supply of production on output markets. Both effects have a detrimental impact on farm income, as stronger input demand increases input prices, while higher availability of supply on the output market reduces their prices. The actual market price change depends on the input supply and output demand elasticities. These elasticities determine price adjustments resulting from subsidy-induced input supply and output demand changes. Inelastic demand and supply lead to large adjustments in prices, implying that subsidies may be leaked from farms to other market participants by reducing the prices paid by consumers or/and increasing prices received by input suppliers. In the reverse case of an elastic output demand and input supply, the price response to subsidies is small and farmers will probably be the main subsidy beneficiaries.

The income distributional effect of the SPS is expected to be lower, because it is fully decoupled from production and only partially coupled to input (land) use. Courleux *et al* (2008), Kilian and Salhofer (2008) and Ciaian *et al* (2008) show that the income distributional effect of the SPS largely depends on the ratio of the eligible area to the total number of entitlements. If the allocated entitlements are in deficit relative to the eligible area of land, then the SPS benefits farmers. However, if the allocated entitlements are in surplus, then the SPS gets capitalized into higher land values, generating positive gains to landowners, but lower (or zero) benefits to farmers. The main intuition behind these results is that, in the presence of surplus entitlements, farmers will not be able to activate all their entitlements with the available area of land. Profit-maximizing farmers will compete for additional land in order to activate their unused entitlements. Competing farmers will overbid the market price for land until it equals marginal economic profitability and the value of entitlement. As a result, the SPS will be capitalized into land prices and will mainly benefit landowners. The effect of competitive pressure in the case of deficit entitlement is reversed. If land is in surplus relative to entitlements, farmers will compete for entitlements to benefit from the SPS. The SPS will be captured by the entitlement owners (that is, farms) and will not be reflected in higher land prices.

Other important factors that may affect the actual income distributional effects of subsidies (valid for CDP, RDP and SPS) include various market rigidities, farm behavioural effects and region-specific aspects such as credit market imperfections (Ciaian *et al*, 2010; Brandsma *et al*, 2013). The exact impact depends on the particularities of these factors and on how they interact with subsidies in particular. For example, subsidies may induce productivity gains if farmers are credit-constrained. Subsidies may be substituted for missing finance if farms are credit-constrained, leading to higher input use and hence higher farm productivity and farm income (Ciaian and Swinnen, 2009). Another effect of subsidies (in competitive markets) could be that subsidies may induce farm behavioural changes which may cancel out (or crowd out) private farm activities. For example, Brandsma *et al* (2013) have shown that the RDP investment support may fully crowd out (substitute) private investments of farms in competitive markets, implying that farm investment would also be undertaken without the support. In this case, the RDP investment support has no impact on farm productivity but represents a full income transfer to farms.

Econometric strategy

Econometric model

As mentioned above, theoretical studies have shown that subsidies affect farm profits both directly (by altering the subsidy amount received and farm behaviour) and indirectly (by affecting output and input prices). They further found that the magnitude of the income distributional effects depends on the type of subsidies. Following the theoretical studies and assuming a profit-maximizing farm, the optimal farm profit depends on input and output prices, subsidies and farm characteristics (Floyd, 1965; Alston and James, 2002; de Gorter and Meilke, 1989; Gardner, 1983; Guyomard *et al*, 2004; Salhofer, 1996; Ciaian and Swinnen, 2006, 2009):

$$\Pi = \Pi[p(CDP, RDP, SPS), r(CDP, RDP, SPS), w(CDP, RDP, SPS), CDP, RDP, SPS, X] + \varepsilon \quad (1)$$

where p is the price of the final product, r is the rental price of land, and w is the price of non-land inputs, CDP are crop coupled subsidies, RDP are rural development payments, SPS are decoupled payments, X is a vector of observable covariates and ε is the residual.

The profit equation (1) accounts for both the direct and indirect effect of subsidies on farm profits. Totally differentiating equation (1) yields the following relationship between profits and subsidies:

$$\begin{aligned} d\Pi = & \left[\frac{\partial \Pi}{\partial p}\frac{\partial p}{\partial CDP} + \frac{\partial \Pi}{\partial r}\frac{\partial r}{\partial CDP} + \frac{\partial \Pi}{\partial w}\frac{\partial w}{\partial CDP} + \frac{\partial \Pi}{\partial CDP}\right] dCDP \\ & + \left[\frac{\partial \Pi}{\partial p}\frac{\partial p}{\partial RDP} + \frac{\partial \Pi}{\partial r}\frac{\partial r}{\partial RDP} + \frac{\partial \Pi}{\partial w}\frac{\partial w}{\partial RDP} + \frac{\partial \Pi}{\partial RDP}\right] dRDP \\ & + \left[\frac{\partial \Pi}{\partial p}\frac{\partial p}{\partial SPS} + \frac{\partial \Pi}{\partial r}\frac{\partial r}{\partial SPS} + \frac{\partial \Pi}{\partial w}\frac{\partial w}{\partial SPS} + \frac{\partial \Pi}{\partial SPS}\right] dSPS \\ & + \frac{\partial \Pi}{\partial X} dX + \varepsilon \end{aligned} \quad (2)$$

where $\partial\Pi/\partial p \; \partial p/\partial s$, $\partial\Pi/\partial r \; \partial r/\partial s$ and $\partial\Pi/\partial w \; \partial w/\partial s$ are parameters representing the indirect impact of subsidies on profits (that is, through subsidy impact on input and output prices) and $\partial\Pi/\partial s$ is the direct effect of subsidies on profits, for $s = CDP, RDP, SPS$.

Equation (2) can be rewritten as:

$$d\Pi = \delta_0 + \delta_{CDP} dCDP + \delta_{RDP} dRDP + \delta_{SPS} dSPS + \delta_X dX + \varepsilon \quad (3)$$

where

$\delta_X = \partial\Pi/\partial X$, $\delta_{CDP} = \partial\Pi/\partial p \; \partial p/\partial CDP + \partial\Pi/\partial r \; \partial r/\partial CDP + \partial\Pi/\partial w \; \partial w/\partial CDP + \partial\Pi/\partial CDP$, $\delta_{RDP} = \partial\Pi/\partial p \; \partial p/\partial RDP + \partial\Pi/\partial r \; \partial r/\partial RDP + \partial\Pi/\partial RDP$

and $\delta_{SPS} = \partial\Pi/\partial p \; \partial p/\partial SPS + \partial\Pi/\partial r \; \partial r/\partial SPS + \partial\Pi/\partial w \; \partial w/\partial SPS + \partial\Pi/\partial SPS$

Parameters δ_s (for $s = CDP, RDP, SPS$) measure the net impact of subsidies on farm profits by accounting for both direct and indirect subsidy effects. In other words, they indicate the income effects of subsidies in terms of policy rents, which farmers receive for each additional euro of CAP subsidies.

Estimation issues

The estimation of equation (3) is subject to individual heterogeneity and endogeneity issues. Addressing these issues is crucial for obtaining consistent estimates of the incidence of agricultural subsidies on farm income.

Individual heterogeneity. According to the underlying theoretical model, equation (3) contains the key variables determining the incidence of agricultural subsidies. However, in addition to these included explanatory variables, there are also unobservable farm characteristics (such as farmer ability, which affects farm income), which at the same time are correlated with explanatory variables in equation (3). The positive correlation between CAP payments and the time-invariant unobserved factors that influence productivity will upwardly bias the estimated effect of subsidies on farm income. In addition, transient shocks, such as drought or pests, may also affect income and CAP subsidies. Ignoring the time-varying region fixed effects would yield biased estimates.

Endogeneity. If subsidies were assigned to farms randomly, then parameter δ_s (for $s = CDP, RDP, SPS$) in equation (3) would correctly measure the farm income increase per additional euro of subsidy. In reality, however, CAP subsidies are not assigned randomly. For example, the value of CDP available to farms in each MS is based on regional productivities (such as reference yield in the region). Farms located in more productive regions receive higher CDP than farms in less productive regions. Further, the amount of CDP received by farms depends on the farms' crop choice. Farms producing supported outputs have higher subsidies than farms producing non-supported outputs. The value of the SPS depends on coupled payments in the past, and on the average country/regional productivities. The RDP are allocated based on project proposals of farms and are subject to fulfilling certain criteria (for example, farm size, location, specialization). Hence, the RDP are also non-random, because farms self-select to participate, and only those with the best projects (likely to be the more productive farms), and those that fulfil predefined criteria, are granted RDP support. This allocation of coupled and decoupled CAP subsidies implies that in the econometric model they are endogenous variables reflecting the characteristics of countries'/regions' land and farmer's behaviour. If subsidies are not assigned randomly, then subsidy payments are correlated with the error term, implying that the resulting Ordinary Least Squares (OLS) estimates of δ_s will be biased.

In addition, market prices and subsidy payments are probably subject to an expectation error. The difference between the actual and the expected market prices/subsidies is the expectation error, which is part of the composite error term potentially biasing the estimates. Farm decisions are based on a combination of the current and pre-harvesting information. The expectation error is less problematic for subsidies in the short–medium run, because they are set beforehand, and hence are known to farmers. However, some uncertainty may exist, particularly with respect to coupled subsidies (for example, crop payments), because they are subject to downward correction at the farm level, if the sum of all farm applications for subsidies exceeds the national ceilings. A further source of expectation error is uncertainty about the future CAP reforms. However, this error is likely to be less problematic for profit function estimation, because profits tend to be determined on a yearly basis reflecting the given market conditions (as opposed to land prices, which incorporate the present value of future land rents).

Econometric specification

In order to reduce the individual heterogeneity bias, we exploit the panel structure of the farm-level data available from the Farm Accountancy Data Network (FADN). To address these sources of bias, we include farm fixed effects and regional control variables in the estimable equations, $\delta_f f_j$ and $\delta_r R_r$ respectively. In order to absorb farm-specific time-invariant unobserved factors, we first difference the series. The resulting farm income model in the first differences eliminates the unobserved heterogeneity component that remains fixed over time.

To address the issue of endogeneity, we employ the Arellano and Bond (1991) robust two-step generalized method of moment (GMM) estimator. Arellano and Bond (1991) have shown that lagged endogenous variables can be a valid instrument in panel data setting. The GMM estimator is particularly suitable for datasets with a large number of cross-sections and few periods and it requires that there is no autocorrelation (Arellano and Bond, 1991; Kielyte, 2008). To correct for the intrinsic downward bias of the robust two-step GMM standard errors, we use the Windmeijer (2005) bias-corrected robust variances. The final econometric specification which we estimate is:

$$\Delta\Pi_{jt} = \delta_0 + \delta_{CDP}\Delta CDP_{jt} + \delta_{RDP}\Delta RDP_{jt} + \delta_{SPS}\Delta SPS_{jt} + \delta_X \Delta X_{jt} + \delta_r R_r + \varepsilon_{jt} \quad (4)$$

where Π_{jt} is the profit of farm j in period t and R_r is a vector of regional variables.

Data and variable construction

The main source of the data used in the empirical analysis is the FADN, which is compiled and maintained by the European Commission. The FADN is a European-wide system of sample surveys that take place every year and collect structural and accountancy data about farms. In total, there is information about 150 variables on farm structure, yield, output, costs, subsidies and taxes, income, balance sheet and financial indicators. Sample sizes vary from country to country (between 500 and 20,000 observations, while most countries have about 1,500–10,000), representing a population of around 5,000,000 farms, covering approximately 90% of the total utilized agricultural area and accounting for more than 90% of the total agricultural production. The aggregate FADN data are publicly available. However, farm-level FADN data, which we employ in this study, are confidential and, for the purposes of this study, accessed under a special agreement.

To our knowledge, the FADN is the only source of micro-economic data that is harmonized (the bookkeeping principles are the same across all EU MS) and is representative of the commercial agricultural holdings in the whole EU. Farms are selected to take part in the survey on the basis of a sampling scheme established at the level of every region in the EU. The survey does not, however, cover all the agricultural holdings in the EU, but only those which are of a size allowing them to rank as commercial holdings. The FADN data constitute a panel dataset, which means that farms that stay in the sample over consecutive years can be traced over time using a unique identifier. In this study we use a balanced panel for 1999–2007 covering the EU-15: Austria, Belgium, Germany, Denmark, Spain, France, Finland, Greece, Italy, Ireland, Luxembourg, the Netherlands, Portugal, Sweden and the UK.

The description of constructed variables is presented in Table 1. The dependent variable in equation (4) ($\Delta\Pi_{jt}$) is calculated as the change in *net farm income*. The net farm income is obtained by subtracting taxes, variable expenses (intermediate, land, labour) and fixed costs (depreciation and interest payments) from the total farm revenues (output and subsidies). We estimate equation (4) per hectare, which means that we divide the obtained net farm income by the utilized agricultural area. The advantage of using per hectare values instead of totals per farm is the reduction of the potential problem of heteroskedasticity. The farm size varies strongly in countries covered by this study, implying that the value of farm income, as with the other variables described below (output, subsidies), will also vary significantly in the cross-sectional dimension. The FADN data contain three main groups of subsidies: CDP (crop area payments, animal payments); the RDP (investment support, environmental payments, LFA and other rural development payments); and the SPS. To account for taxes and other types of subsidies, we construct a variable known as 'other subsidies' by subtracting taxes from the rest of the farm payments not included in the above categories.

The covariates matrix, X, includes a set of explanatory variables, which contribute to explaining the variation in profits among farms (Table 2). The aim of covariates is to identify more effectively the true relationship between

Table 1. Description of variables used in the study.

Variable name	Unit	Description
Dependent variable (π)		
Net farm income	EUR/ha	Total farm revenues (output and subsidies) minus taxes, variable expenses (intermediate, land, labour), depreciation, and interest payments. The value obtained is divided by UAA to obtain the hectare value of farm income.
Subsidies (s)		
Coupled payments (CDP)	EUR/ha	Hectare value of all farm subsidies on livestock and crops, including compensatory payments/area payments and set-aside premiums.
Decoupled payments (RDP)	EUR/ha	Hectare value of SPS.
RDP	EUR/ha	Hectare value of RDP subsidies.
Other subsidies (OS)	EUR/ha	Hectare value of other coupled and RDP not included in the above subsidy categories minus taxes.
Covariates (X)		
Output	EUR/ha	Hectare value of total output of crops and crop products, livestock and livestock products and of other output.
Rented land ratio	%	Ratio of rented area to UAA.
Own labour ratio	%	Ratio of unpaid input to total labour.
Sharecropped land	%	Ratio of sharecropped land to UAA.
Farm size	ha	Economic size of holding expressed in European size units (ESU).
Land per capita	ha per capita	Ratio of total agricultural area to total population at MS level.
GDP growth	Index	Index of GDP growth at MS level.
Irrigated land ratio	%	Ratio of irrigated land to UAA.
Glass land ratio	%	Ratio of the area under glass or plastic to UAA.
Fallow land ratio	%	Ratio of fallow and set-aside land to UAA.
Woodland ratio	%	Ratio of woodland area to UAA.
Output livestock ratio	%	Ratio of total livestock output to total farm output.
Own consumption ratio	%	Ratio of farmhouse consumption and farm use to total output.
Liabilities-to-assets ratio	%	Ratio of total liabilities to total farm assets.
Farm product stock	EUR/ha	Stock of agricultural products divided by UAA.
Investment	EUR/ha	Gross investment divided by UAA.
Building machinery per ha	EUR/ha	Value of buildings and machinery divided by UAA.
LU	Number of head	Total livestock units.
Sectoral and regional dummy variables (R)		
Variables in *R*	[0; 1]	Year, sector, country, LFA region and their interaction terms.

Notes: All variables are calculated from FADN data, except for *land per capita* and *GDP growth*, which use agricultural land from FAOSTAT, the total population from the UN National Accounts Main Aggregates Database and GDP growth rate from Eurostat. UAA = utilized agricultural area.

farm profits and subsidies. We include four sets of explanatory variables: covariates linked to owned inputs, productivity, management practices and macro-economic factors. Covariates linked to farm-owned inputs include rented land ratio, own labour ratio, own consumption ratio and liabilities-to-assets ratio. The objective is to account for the effect of farm-owned inputs on farm profits because they reduce farm costs. At the same time, these variables control for potential differences in incentives of farmers in using their own versus rented/hired land/capital/labour (Pollak, 1985; Binswanger and Rosenzweig, 1986; Kancs and Ciaian, 2010). In order to account for differences in rental contracts, we follow Ciaian and Kancs (2012), and construct a variable 'sharecropped land' by dividing the sharecropped area by the total utilized agricultural area (UAA). Covariates linked to productivity include output, farm size, irrigated land ratio, glass land (area under glass) ratio, investment, and building machinery per ha. Given that productivity is an important determinant of farm profitability, if not controlling for the productivity variation between farms, it may be confounded with the estimated subsidy effect on profits. As the names of variables imply, we capture productivity differences between farms by constructing variables for output attained per hectare (output), whether irrigation and greenhouses are used on-farm (irrigated land ratio, glass land ratio), for the amount of farm investment (investment) and for capital intensity (building machinery per ha). A variable capturing farm size is also included. Studies find that farm size may be an important determinant of productivity in agriculture (Feder, 1985; Allen and Lueck, 2002; Gorton and Davidova, 2004). Similar to productivity, management practices affect the organization of farm activities, production structure and application of different farm inputs, and thus also have a direct impact on farm profitability. Covariates capturing management practices include variables linked to land management (fallow land ratio, woodland ratio), output structure (output livestock ratio, LU) and production organization (farm product stock, own consumption ratio). Finally, the fourth set of variables covers macro-economic drivers of farm profitability (land per capita, GDP growth). They account for non-agricultural pressures on agricultural technology and competition for resources (such as land).

To account for regional unobserved heterogeneities, we include sectoral, regional and time dummies, *R* (year, sector, country, LFA region) (Table 2). In general, these variables capture unobserved heterogeneities, which represent common characteristics for all farms, but may differ among regions and sectors (for example, informal and formal rural institutions, differences in climatic conditions, and market imperfections).

To account for the dynamic adjustment of farm income, we create lagged dependent (1 lag) and lagged explanatory (0 and 1) variables. For all endogenous variables, we first use lags as instruments along the exogenous and lagged dependent variables. The choice of lags as instruments was selected by checking the validity of different sets of instruments. Table 2 summarizes both the endogenous and exogenous variables.

Table 2. Variables used in the GMM estimation.

Variable	Lags
Dependent variable	
Net farm income	1
Endogenous variables	
RDP	0 and 1
CDP	0 and 1
SPS	0 and 1
Other subsidies (OS)	0 and 1
Output	1
Building machinery per ha	1
Farm product stock	0
Investment	1
Exogenous variables	
Land per capita; rented land ratio; sharecropped land ratio; own labour ratio; livestock output ratio; own consumption ratio; liabilities-to-assets ratio; trend, GDP growth; land per capita; and other dummies for sector, country, and their interaction terms	0

Results and policy implications

We estimate two models: model 1 with contemporaneous values of variables, and a dynamic model 2, which also includes lagged variables. Table 3 summarizes the main results. Following the standard convention, we start with

Table 3. Arellano–Bond estimates of farm income.

		Model 1	Model 2
I	SPS	0.772***	0.618***
	SPS (–1)		0.202*
	RDP	1.088***	0.930***
	RDP (–1)		0.473
	CDP	0.722***	0.663***
	CDP (–1)		0.0816
II	Other subsidies (OS)	0.784	0.883
	Other subsidies (OS) (–1)		1.120***
	Output	0.646***	0.610***
	Farm product stock	0.836***	0.428
	Investment	–0.103*	–0.0968*
	Investment (–1)	–0.0211	–0.0507
	Rented land ratio	504.9***	328.9*
	Sharecropped land ratio	584.2***	479.3***
	Farm size	0.524***	0.433**
	GDP growth	–1.063	–1.339
	Land per capita	194.5	303.7
	Own labour ratio	205.8*	265.2**
	Livestock output ratio	–67.68	–64.05
	Own consumption ratio	–669.6***	–633.7***
	Liabilities-to-assets ratio	–594.4***	–602.4***
	Constant	–8,229	–17,805
III	Observations	50,619	50,619
	Number of farms	7,553	7,553
	Sargan test (Prob > chi^2)	0.0000	0.0000
	Arellano–Bond autocorrelation test		
	AR(1) (Prob > z)	0.0000	0.0000
	AR(2) (Prob > z)	0.1273	0.3234

Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. All estimates are based on the period 1999–2007.

specification tests (empirical analysis was performed using STATA v.12.1). We employ the Arellano-Bond statistics to test for serial dependence of errors. Serial correlation of an order higher than 1 would imply a misspecification of the model. Test results are reported in panel III of Table 3. The specification tests indicate strong evidence against the null hypothesis of zero autocorrelation in the first-differenced errors at order 1, but reject autocorrelation in the differenced errors at order 2. The Sargan test statistics suggest that we cannot reject the null hypothesis that the over-identifying restrictions are valid for the income equation; otherwise, the Sargan test would imply that instruments might be correlated with residuals, and thus would fail to fulfil the exogeneity condition. To account for heteroskedasticity, we follow Windmeijer (2005) and use robust standard errors.

According to the results reported for both empirical models in panel I of Table 3, all estimated subsidy coefficients have the expected sign and most of them are statistically significant. The estimation results suggest that subsidies importantly affect farm income: the net farm income increases by between 0.66 euro and 1.09 euro per additional euro of subsidy. The estimates are relatively stable across the models. The subsidy income effect higher than one estimated for the RDP in model 1 may be caused by the interaction of subsidies with the farm credit constraint. Credit-constrained farms may substitute subsidies with credit and thus increase input use intensity, leading to productivity upgrade and hence higher farm income (Ciaian and Swinnen, 2009).

Table 3 also shows that the income effect of the CAP subsidies is different for different payment types (models 1 and 2). The RDP has the highest income effect (between 0.93 and 1.09). The estimates for the SPS are between 0.77 and 0.82. Note that the coefficient associated with lagged subsidies is significant only for the SPS, implying that its total income effect is 0.82 in model 2. As expected, the estimated income effect for CDP is the lowest in both models, between 0.66 and 0.72.

These results are consistent with the theoretical hypothesis, except for the RDP, which are estimated higher than the theory predicts. According to the theoretical predictions, a substantial share of the RDP may be capitalized into input prices (for example, land rents, capital cost) and hence benefit input suppliers (for example, landowners, capital suppliers) instead of farmers (Dewbre *et al*, 2001; Ciaian *et al*, 2008). However, due to the fact that agricultural demand is small in the overall capital demand, the RDP (for example, investment support) probably does not affect capital prices. Second, because a large share of the RDP is not linked to land, they do not directly affect rental prices. Further, the RDP may substitute (crowd out) private on-farm activities (for example, farm investments, adoption of innovative management practices) without causing additional effects on farm behaviour. In such a case, the RDP represent a pure income transfer to farms (implying a coefficient close to one consistent with the estimates reported in Table 3). This result was confirmed by the estimates of Michalek *et al* (2015) for the Schleswig-Holstein region in Germany. Their results show that the majority of investment support ends up as income transfer to farms by increasing their private off-farm spending.

The estimates of covariates are reported in panel II of Table 3. Most of the estimated coefficients have the expected sign and are statistically significant. Output has a positive and significant impact on farm income. Surprisingly, the investment variable has a statistically negative impact on farm profits. This could be due to the fact that farmers often invest during times when the profit is high; hence they incur a higher cost and thus attain lower profits. Since the effect of an investment may be visible only over a longer period, our estimates do not capture well this profit-enhancing effect over time. Farm income increases with farm size, which may reflect the presence of economies of scale. The land abundance variable (land per capita) is positive, but not statistically significant. GDP growth does not have a statistically significant impact on farm income. The shares of both rented land and sharecropped land increase farm income. This is somewhat unexpected, because the cultivation of rented and sharecropped land is usually associated with higher costs due to rental payments to landowners, as well as lower incentives compared with the cultivation of farmers' own land. However, this might be offset by other effects, which could be stronger (for instance, the extent of renting may be a proxy for more dynamic and growing farms) (Feder, 1985), leading to a positive sign.

The share of farmers' own labour increases farm profits. This is probably because of the cost-reducing effect of farmers using their own labour on-farm. The liabilities-to-assets ratio reduces farm income, which may be primarily due to higher costs associated with using external financing of farm activities. This could also be caused by lower ability to raise loans of more highly indebted farms and thus leading to lower productivity. The estimated coefficient associated with the livestock output ratio suggests that a higher rate of farmers' own consumption reduces farm income, which is possibly because of the smaller market orientation of farms producing for self-consumption. Statistically, however, it is not significant. The 'own consumption ratio' decreases farm income because on-farm consumption of outputs reduces the quantity available for off-farm sales.

These results have important policy implications for the implementation and future reforms of the CAP. In terms of farm income, the most transfer-efficient policy instrument seems to be the RDP, followed by the SPS, whereas the least effective is CDP. This suggests that the initiated shift in the CAP expenditure towards decoupled payments, rural development support and the provision of public goods and externalities is also in line with respect to supporting farmers' income. Even though the SPS is less transfer-efficient than the RDP, a substantial amount of policy gains (more than 77%) still ends up with farms. Given the current importance of the SPS (representing around two-thirds of the total CAP budget), income dependency on the SPS is substantial for many farms. According to the FADN data, the share of the SPS in the total output value varies between 5% and 40% in different MS.

Conclusions

In this paper we study the income distributional effects of CAP subsidies. According to theoretical studies, the income distributional effects depend substantially on the subsidy type. In well-functioning agricultural markets, input suppliers (such as landowners) and consumers would benefit from a large share of CAP subsidies instead of farmers. This is particularly the case with CDP and RDP, because they affect both output and input prices and thus generate leakage of policy rents to input suppliers and consumers. In particular, landowners might potentially be large beneficiaries of CDP and RDP due to relatively inelastic land supply (Goodwin *et al*, 2003; Lence and Mishra, 2003; Kilian and Salhofer, 2008; Kirwan, 2009; Breustedt and Habermann, 2011; Michalek *et al*, 2014; Ciaian and Kancs, 2012; Patton *et al*, 2008). The SPS are less prone to the leakage issue, because they are decoupled from production and only partially coupled to input (land) use. As a result, they may generate higher policy gains for farms compared to CDP and RDP. However, studies that account for market imperfections (such as credit constraints) or farm behavioural effects indicate that all types of subsidies may have other unintended effects on farms, and may reverse the above-suggested income distributional effects.

To estimate empirically the impact of agricultural subsidies on farm income in the EU, we employed the GMM estimator and used the FADN farm-level panel data for the period 1999–2007. Our results suggest that farmers benefit from a major share of CAP subsidies. According to our estimates, farmers gain more than two-thirds of the CAP payments: 66–72%, 77–82% and 93–109% from CDP, SPS and RDP respectively. Hence, our results provide evidence that farm income benefits are substantial from the CAP in the EU.

These results have important policy implications for the implementation and future reforms of the CAP. In terms of farm income, the most transfer-efficient policy instrument seems to be the RDP, followed by the SPS, whereas the least effective is CDP. This suggests that the initiated shift in CAP expenditure towards decoupled payments, rural development support and the provision of public goods and externalities is also in line with supporting farmers' income.

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