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The capitalisation of CAP subsidies into land rents and land values in the EU

An econometric analysis

Baldoni, E.

Ciaian, P.

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Contact information
Name: Edoardo Baldoni
Address: Edificio Expo. c/ Inca Garcilaso, 3. E-41092 Seville (Spain)
Email: Edoardo.BALDONI@ec.europa.eu

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Authors

Edoardo Baldoni

Pavel Ciaian

Abstract

The objective of this report is to estimate the capitalisation of different common agricultural policy subsidies into rental prices and value of land in the European Union. We use Farm Accountancy Data Network data at regional level for 1989–2016 and apply a dynamic panel approach (generalised method of moments estimator) to estimate the capitalisation effect of coupled direct payments (CDPs), decoupled direct payments (DDPs) and rural development measures at EU level. The estimated results suggest the short-run capitalisation rate of DDPs to be between 9.1 % and 46.2 % and the long-run rate to be between 11 % and 55 %. The heterogeneous DDP models appear to have a lower capitalisation rate by between 34 % and 37 % in the short run and between 41 % and 45 % in the long run than the flat-rate models. The capitalisation rate of CDPs is estimated to be around 6 % in the short run and 7 % in the long run. Rural development measures are generally found not to affect land rental prices. Regarding the capitalisation estimates for land values, they are not robust and consistent across estimated models. The estimates suggest that only DDPs may cause statistically significant capitalisation effects into land values: a capitalisation rate between 28.8 % and 32.1 % in the short run and between 154 % and 164 % in the long run.

Executive summary

The distributional effects of agricultural subsidies, including of the common agricultural policy (CAP), are the subject of intense debate and attention among policymakers and stakeholders and in academic literature. The concern is that subsidies might be indirectly gained by non-farming landowners if they are capitalised into land prices. Although farmers are the main recipients of agricultural subsidies, these subsidies might be channelled towards non-farming landowners through increasing land prices.

According to the underlying theoretical framework, in well-functioning land markets, CAP subsidies are expected to be incorporated into land prices, thus benefiting landowners. Agricultural subsidies increase marginal returns on agricultural production by raising output prices, by increasing returns on subsidised farm production activities or by reducing production costs. These effects are associated with a higher demand for input factors. As land is a scarce production factor that cannot be easily replaced by other production factors, economic theory predicts that CAP subsidies should eventually capitalise more into land rents and land values than into the price of other production factors.

However, because of their different capitalisation mechanisms, the degree to which CAP subsidies are capitalised into land prices depends critically on the type of subsidies and implementation methods. Economic theory predicts that the impact of decoupled direct payments (DDPs) on land prices may vary from zero to full capitalisation, depending on the implementation model, scarcity of entitlements and heterogeneity of payments across farms. In general, coupled direct payments (CDPs) and support granted under the rural development programme (RDP) (with the exception of less favoured area (LFA) payments) are expected to be less capitalised into land prices than DDPs. When considering the complex nature of the actual functioning of (real) land markets, several factors are present that may either impede or enhance the land capitalisation of CAP subsidies; these include the elasticity of land supply, greening and cross-compliance requirements, farmers' credit constraints, land market regulations, long-term duration of rental contracts, social capital, tradability of single payment scheme entitlements and future expectations about CAP subsidies. Moreover, because of the inherent differences in the natures of land sale markets and rental markets, the capitalisation of CAP subsidies into land values may be different from their capitalisation into land rents.

Overall, the empirical literature supports the theoretical prediction of a positive capitalisation rate of agricultural subsidies into land prices. Empirical studies show an average capitalisation rate of agricultural subsidies of 39.5 % for land rents and 25.7 % for land values. Decoupled payments seem to be capitalised into land prices more than coupled subsidies or environmental payments. That is, the average estimated capitalisation rate of decoupled subsidies into land rents (land values) is 50.4 % (39.6 %), whereas for coupled subsidies it is 39.7 % (8.6 %). In contrast, environmental payments tend to have negative capitalisation rates on average: – 8.2 % for land rents and – 9.3 % for land values. The average capitalisation rate of other payments that could not be categorised as coupled, decoupled or environmental (including aggregate payments) is around 33.3 % to 36.5 %. In general, studies based on rental prices tend to have higher average capitalisation levels than studies based on land values.

The main contribution of this report to the literature is in providing new empirical evidence of the capitalisation effects of CAP subsidies on both rental prices and land values, based on a uniquely long and detailed data set for the whole European Union. We also assess how the capitalisation of CAP subsidies compares across different subsidy types and implementation modes for the whole EU and over the last three CAP reform periods. We use the Farm Accountancy Data Network (FADN) data at the level of FADN regions, covering all Member States (MS) for 1989–2016. Additional data sources, such as Eurostat, the World Bank and the Copernicus programme, have been used to complement the FADN data.

FADN data show large differences in land markets across EU MS and across regions within MS in terms of proportion of rented land, land prices and land price development. There is wide variation in the proportion of rented land in the total utilised agricultural area (UAA) among MS. In 2016, the proportion of rented land varied between 18 % in Ireland and 91 % in Slovakia. Large disparities in terms of proportion of rented UAA also exist within MS. There have been significant changes over time across MS. The proportion of rented land increased at EU level, from approximately 50.3 % in 1995 to approximately 54.7 % in 2016.

Some patterns in the level and the evolution of rental prices can be identified. First, the level of rental prices varies considerably across MS. Particularly high rental prices have been observed in the Netherlands and Denmark for 1989–2016. Second, rental prices tend to show an upward trend across most MS over the time horizon considered, in both nominal and real terms. The highest percentage change in (real) rental prices between 2004 and 2016 can be observed in those MS that joined the EU in 2004. Rental prices also vary sizeably within MS. Relatively large variation could be found in most of the old MS (i.e. those that joined the

EU prior to 2004) and in some new MS (i.e. those that joined the EU in 2004 or later). The regional variation in rental prices is particularly large in Germany, France, Italy and Portugal. Moreover, Germany, Spain and France present some extreme values in their distributions of regional rental prices. Some new MS, such as Bulgaria, Croatia and Hungary, also show some significant internal variation in rental prices.

Generally, land values tend to increase across MS over the considered period. This upward trend seems to be less pronounced than in the case of rental prices, with several MS showing rather stable land values over the period analysed. Compared with rental prices, the increase in land values in the new MS is not so evident, but it remained rather stable in several of them over the 2004–2016 period. It is important to note that some MS show some discontinuity in land value development, which may reflect the change in methodology or sampling of FADN farms. The highest average land values were recorded in Belgium, Italy, Cyprus, Malta and the Netherlands. The lowest land values are reported in new MS. A relatively wide variation in land values could also be observed within MS, especially within old MS. High regional variability in land values within MS is particularly visible in Belgium, Germany, Croatia and Italy. Except for Croatia, new MS are associated with lower regional variation in land values. Some extreme land values have been observed in Germany, Spain and Italy.

The different evolution of rental prices and land values across regions, across MS and over time might signal different capitalisation mechanisms in land markets among some MS. Descriptive statistics show that, for old MS, the time series of rental prices and land values co-move with the time series of output value. However, the link between land prices and output value seems to be less strong than the link between rental prices and output value. New MS exhibit different relationships. For these MS, the rental prices seem to be much more closely correlated with the development of DDPs than with output value or CDPs. Unlike rental prices, land values co-move more with the output value than with CAP payments in new MS.

Both rental prices and land values are modelled econometrically following the net present value model, which accounts for potential land market rigidities that may prevent instantaneous adjustment of land prices to a changing policy environment. Moreover, following the empirical literature, it is also considered that land prices are affected by expectations of subsidies and market returns, rather than by observed subsidies and market returns. In addition, the econometric equations include a time-invariant fixed effect to account for possible omitted variables, such as land productivity, that may be linked to both higher/lower land prices and higher/lower CAP subsidies. To address the above econometric issues, the generalised method of moments framework seems the most suitable and has been adopted here. To account for differences in CAP payments, we consider DDPs, CDPs and RDP subsidies (agri-environmental-climate measures, LFA payments and investment support). Moreover, we account for different implementation methods of DDPs: the heterogeneity of DDPs between farms, scarcity of entitlements relative to total land and the implementation of the redistributive payment.

The estimated results suggest that CAP subsidies are capitalised into land rents. According to estimates, the short-run capitalisation rate of DDPs varies between 9.1 % and 46.2 %. The heterogeneous DDP models appear to have a lower capitalisation rate by between 34 % and 37 % than the flat-rate DDP models. Other implementation details of DDPs (e.g. the scarcity of entitlements and the redistributive payments) appear not to impact the capitalisation of DDPs. The long-run capitalisation rate of DDPs varies between 11 % and 55 %; the heterogeneous DDP models have a lower long-run capitalisation rate by between 41 % and 45 % than the homogenous DDPs models. The estimated results tend to show that the capitalisation of DDPs increased over 2005–2016.

The short-run capitalisation rate of CDPs is found to be lower than the capitalisation rate of DDPs, varying between 5.8 % and 6 %. The long-run capitalisation rate of CDPs is around 7 %. RDP subsidies are generally found not to affect land rental prices.

In contrast to rental prices, the estimates for land values suggest that only DDPs may cause statistically significant capitalisation effects. The results suggest a capitalisation rate between 28.8 % and 32.1 % in the short run and between 154 % and 164 % in the long run. However, estimates for land values are not robust and consistent across models and thus they need to be interpreted with care. The unstable capitalisation effects estimated for land values could be caused by (i) the fact that the land values available in the FADN database do not reflect accurately the development of the actual market (sale) value of land, (ii) the methodology used to obtain land values in the FADN database, (iii) econometric issues or (iv) the combination of these three factors.

The results of this report have several policy implications. The conceptual and empirical analyses carried out for this report suggest that the CAP contains instruments that can limit (reduce) the capitalisation of CAP subsidies. The key instruments that may limit capitalisation are those that increase heterogeneous DDPs across farms (e.g. redistributive payments, degressivity and capping), a shift from direct payment to CAP Pillar II support, environmental payments and environmental conditionality of direct payments. These effects arise because these instruments reduce land market distortions, have a smaller direct impact on (marginal) land returns (i.e. reduce the marginal subsidy value) or reduce the linkage of subsidies to land.

Despite the comprehensiveness of the analysis, the results in this report should be interpreted with care, as there are several factors that need to be taken into consideration. First, we have attempted to account for land market regulations and institutions in our analyses, which are often argued to impact subsidy capitalisation. However, data that would allow the measurement of their presence and dynamics across MS and over time are not available. For this reason, the role of land market regulations and institutions in impacting on capitalisation could not be identified empirically. Second, owing to data issues, the capitalisation estimates for land values are not robust and thus more accurate results could not be provided in this report in this respect. Third, the data considered in this report cover only a few years when the 2013 CAP reform had been implemented in MS (including the CAP greening measures), and thus its impact could not be identified in the estimates.

1. Introduction

The main objective of the common agricultural policy (CAP) is to support farmers' income, rural development and the production of public goods and externalities, such as landscape, biodiversity and a clean environment. The CAP subsidies are disbursed in the form of coupled direct payments (CDPs), decoupled direct payments (DDPs) and measures under the rural development programme (RDP). The importance of these three broad support types within the CAP has changed over time. CDPs dominated the CAP prior to the 2003 CAP reform. Currently, the majority of CAP subsidies are disbursed in the form of decoupled payments. DDPs were introduced by the 2003 CAP reform and they underwent a substantial reform in 2013, with changes to the implementation form and the payment level. The RDP was introduced by the Agenda 2000 reform and was reinforced by the subsequent CAP reforms (European Commission, 2013; European Union, 1999, 2003, 2013a, 2013b).

The distributional effects of agricultural subsidies, including of the CAP, are the subject of intense debate and attention among policymakers and stakeholders and in academic literature. The primary policy question in this respect is the capitalisation of agricultural subsidies into land prices ([1]). The concern is that subsidies might be indirectly gained by non-farming landowners if they are capitalised into land prices ([2]). Although farmers are the main recipients of agricultural subsidies, these subsidies might be channelled towards non-farming landowners through increasing land prices.

The capitalisation of agricultural subsidies has been extensively investigated in the empirical and theoretical literature. Both empirical and theoretical findings suggest that agricultural subsidies increase land prices and thus generate benefits for landowners. However, there is no consensus on the magnitude of the actual capitalisation effects of subsidies, as it depends on a number of factors, such as the type of support, conditionality on meeting environmental requirements, imperfections in factor markets, the competitiveness of land markets, land market regulations and transaction costs (Gardner, 1983; de Gorter and Meilke, 1989; McCorriston and Sheldon, 1991; de Gorter, 1992; Dewbre et al., 2001; Sheldon et al., 2001; Alston and James, 2002; Desquilbet and Guyomard, 2002; Guyomard et al., 2004; Salhofer and Schmid, 2004; Ciaian and Swinnen, 2006, 2009; Kirwan, 2009; Ciaian et al., 2018; Graubner, 2018; Ciaian et al., 2021).

The lack of a consensus on the magnitude of the capitalisation effects is particularly the case in empirical studies. Theoretical literature seems to be able to predict relatively consistently the ranking of the capitalisation of different types of subsidies, although often with specific or simplifying assumptions. Furthermore, there is a significant discrepancy between the empirical and theoretical findings, with estimates tending to suggest a lower level of capitalisation of agricultural subsidies than the theory. Although the theory is able to rank various types of agricultural subsidies by their capitalisation level, the empirical evidence is less conclusive in providing a more exact estimate of the capitalisation rate (Patton et al., 2008; Breustedt and Habermann, 2011; Ciaian and Kancs, 2012; Kilian et al., 2012; Van Herck et al., 2013; Guastella et al., 2014; Michalek et al., 2014; Kirwan and Roberts, 2016; O'Neill and Hanrahan, 2016; Ciaian et al., 2021).

There is a growing number of empirical studies estimating the capitalisation of European Union CAP subsidies. Studies have analysed the capitalisation of DDPs (e.g. Ciaian and Kancs, 2012; Kilian et al., 2012; Kropp and Peckham, 2012; Guastella et al., 2013, 2018; Nilsson and Johansson, 2013; Michalek et al., 2014; Feichtinger and Salhofer, 2015a; Valenti et al., 2020), CDPs (e.g. Patton et al., 2008; Guastella et al., 2013, 2018; O'Neill and Hanrahan, 2016; Valenti et al., 2020) and the aggregated subsidies (e.g. Van Herck et al., 2013; O'Neill and Hanrahan, 2016). Less investigated in the literature are RDP subsidies (e.g. Kilian et al., 2012; Nilsson and Johansson, 2013; O'Neill and Hanrahan, 2016; Valenti et al., 2020). Empirical studies estimating the subsidy capitalisation into land rents are more abundant than those into land values. This is mainly determined by the availability of data; rental prices are usually more accessible from farm-level survey data. Most of the available studies in the literature focus on a specific region or Member State (MS). There are only a few studies that cover the whole EU or a group of MS (e.g. new MS (i.e. those that joined the EU in 2004 or later)) (Ciaian and Kancs, 2012; Van Herck et al., 2013), the EU-25 (Guastella et al., 2014) and old MS (i.e. those that joined the EU prior to 2004) (Michalek et al., 2014).

([1]) In this report, we use 'land prices' to refer to both land rental prices (or rents) and land values. The land rental price represents the price of renting one hectare of land paid annually to its owner. The land value represents the price of one hectare of land, usually referring to market sale or purchase value of land; it could also represent the expected value at which land can be sold or acquired on the land market.

([2]) The capitalisation of subsidies refers to the extent that subsidies affect land prices (i.e. rents or land values). It can be described by several measures, of which the three most important are (i) the capitalisation level, which is usually expressed in monetary terms (change in land price in euro per EUR 1 of subsidy change), (ii) the capitalisation rate, which is usually expressed as a percentage representing the proportion of subsidies that are reflected in higher land prices and (iii) the elasticity form (capitalisation elasticity) expressed as percentage change in land price per 1 % change in subsidies.

The objective of this report is to contribute to the literature by empirically investigating the extent to which different CAP subsidies are capitalised into land prices in the EU. The report considers DDPs (including their different implementation models across MS), CDPs and RDP subsidies. The report attempts to estimate the CAP subsidy capitalisation in both rental prices and land values. The report employs the generalised method of moments (GMM) estimator to estimate empirically the capitalisation effects using the Farm Accountancy Data Network (FADN) regional-level panel data for 1989–2016.

The main contribution of this report to the literature is in providing new evidence of the capitalisation effects of CAP subsidies on both rental prices and land values based on a uniquely long and detailed data set for the whole EU. We also assess how the capitalisation of CAP subsidies compares across different subsidy types and implementation modes for the whole EU and over the last three CAP reform periods. None of the previous studies have analysed the EU-wide capitalisation effects of the CAP over such a long time horizon.

This capitalisation effect of subsidies into land prices is important because it may have significant distributional consequences in the EU context. The distributional effects of the CAP may be particularly relevant in regions where a large portion of agricultural area is rented. On average in the EU, around 50 % of farmland is rented. However, there are important differences among MS because of differences in the land market structure. In 2016, MS with a high proportion of rented land (more than 70 %) are Belgium, Bulgaria, Czechia, France, Cyprus, Malta and Slovakia. MS with a low proportion of rented land (less than 30 %) are Ireland, Poland and Portugal. These variations affect the extent to which farmers versus non-farming landowners capture policy rents. Although there is some farm-to-farm land renting in the EU, by far most of the rented land is owned by non-farming landowners. This is most problematic in those MS where the proportion of rented land is particularly high, implying that eventual capitalisation of CAP subsidies into rents and values might translate into a transfer of farm support outside agriculture.

The report is organised as follows. Section 2 briefly describes the CAP. Section 3 presents theoretical analyses of the impact of CAP subsidies on land prices. Section 4 presents insights from previous empirical studies concerning the capitalisation of agricultural subsidies. Section 5 explains the data used in the report. Section 6 describes the development of land markets in the EU. Section 7 explains the econometric approach employed to estimate the capitalisation effects. Section 8 describes the estimated results, whereas Section 9 concludes.

The main data source used in this report is the FADN database ([3]), which is compiled and maintained by the European Commission. The FADN database is a compilation of annual surveys carried out in each MS that has been part of the EU since 1989, and contains detailed structural and accountancy information on European farms.

([3]) The authors would like to thank Directorate-General for Agriculture and Rural Development Unit C.3, which provided the data.

2. The common agricultural policy

The beginnings of the CAP date back to the formation of the European Economic Community in 1957. The emphasis of the early CAP was on encouraging agricultural productivity, maintaining a stable supply of affordable food for consumers and ensuring a viable agricultural sector. The support for farmers was implemented predominantly through a price support system, through which farmers were guaranteed high prices. This early CAP had a major impact on agricultural markets. Most importantly, it led to a large increase in farm productivity and created large surpluses of the major farm commodities in the EU market, some of which were exported (with the help of subsidies) and others of which had to be stored or disposed of within the EU. These measures had a high budgetary cost and distorted world markets. At the same time, there were increasing concerns about the environmental sustainability of agriculture.

To circumvent these developments, some important changes to the CAP were made in the 1980s, but especially at the beginning of the 1990s. The first substantial reform of the CAP was in 1992, known as the MacSharry reform, followed by the Agenda 2000 reform. To reduce market imbalances, domestic prices were reduced and the income loss to farmers was redressed through compensatory direct payments (CAP Pillar I). The amounts of these payments depended on historical rather than current production. These reforms thus cut the link between support for farmers and production. However, farmers were still obliged to produce certain agricultural commodities in order to obtain the direct payments. At the same time, a ceiling was put on subsidy expenditures to keep the costs of the CAP under control. The Agenda 2000 reform also introduced the RDP as the second pillar (Pillar II) of the CAP, by bringing together different pre-existing structural and territorial measures under a common support system (European Union, 1999; Swinnen et al., 2008).

The 2003 reform progressively decoupled direct payments from production and introduced DDPs. As a result of this reform, the decoupled payments have become by far the largest component of the CAP budget. At the same time, MS were allowed to maintain some specific subsidies coupled to production. The direct payments under the new system were linked to compliance with environmental, food safety and animal welfare standards, as well as the requirement to keep land in good agricultural and environmental condition (i.e. cross-compliance requirements) (European Union, 2003). In parallel, the CAP budget has been partially reoriented towards the RDP funded by the European Agricultural Fund for Rural Development under Pillar II of the CAP (European Commission, 2011). The latest CAP reform was adopted in 2013 (European Commission, 2013). This CAP reform maintained both the RDP subsidies and DDPs as major policy instruments in the 2014–2020 financial period, but linked them more closely to rural development and the provision of public goods and externalities (European Union, 2013a, 2013b).

2.1. Decoupled direct payments

DDPs were introduced by the 2003 CAP reform. They started in 2005 in the form of the single payment scheme (SPS) and the single area payment system (SAPS). Under the SPS, each farm was allocated a certain amount of SPS entitlements. The SPS was linked to land because, in the absence of eligible land, farms could not activate (cash in) SPS entitlements. However, the SPS was not linked to a specific land area – SPS entitlements could be activated by any eligible farmland in the region. Farms could expand or decrease their stock of entitlements by buying or selling entitlements ([4]) (European Commission, 2011).

When implementing the SPS, MS could choose between three different SPS models: the **historical** model, the **regional** (flat-rate) model and the **hybrid** model. Under the historical model, the SPS was farm specific and equalled the support level the farm had received in the 'reference' period (i.e. when coupled subsidies were disbursed). Under the regional model, an equal per hectare payment was granted to all farms in a given region. The hybrid model was a combination of historical and regional models. The key difference between the three was the unit value of entitlements: under the historical and hybrid models, the value of entitlement varied across farms (higher in the former than in the latter), whereas under the regional SPS model all farms within a region had entitlements with the same unit value (European Commission, 2011).

The SAPS could be implemented only in new MS. A key difference between the SAPS and the SPS was the area eligible for the decoupled payment. Under the SAPS, the entire eligible area could receive a per hectare payment; there were no entitlements, as in the case of the SPS. Another key difference between the SAPS and the SPS was in the value of the per hectare payment. Under the SAPS, all farms in a MS (or region within a MS) could receive an equal per hectare payment (i.e. flat-rate payment), whereas under the SPS the payment

([4]) Note that entitlement trade is allowed only within MS, not between them, implying that a given entitlement can be activated only on the land in a given MS.

value could differ depending on the SPS model. Table 1 reports the implementation of the SPS and the SAPS by MS.

The 2013 CAP reform introduced various changes that modified the value of DDPs and the way in which they were allocated across farms. The main elements introduced by the 2013 CAP reform include the following (European Union, 2013a; European Commission, 2015, 2019b).

- **Internal convergence of decoupled payments.** The 2013 CAP reform aims to eliminate or reduce the heterogeneity of the per hectare DDP ([5]) in a given region or MS. MS can apply either (i) full convergence (i.e. introduction of a flat rate) or (ii) partial convergence. Under the full convergence, an equal per hectare payment is granted to all farms in a given region or MS. Under the partial convergence, the payment heterogeneity across farms is reduced but is not completely eliminated. All MS that previously implemented the SAPS, which is a flat-rate area payment scheme, continue to implement it (Table 1).
- **Redistributive payment.** This payment aims to increase support to small and medium-sized farms by granting a higher payment for the first hectares than for the remaining farm area. Overall, 10 MS apply the redistributive payment (Table 1).
- **Degressivity / capping payments.** Degressivity and capping of DDPs aim to reduce total payments for the largest farms. Similar to the redistributive payment, capping aims to generate a more equal distribution of direct payments between farms. Degressivity means that MS are required to reduce DDPs, by at least 5 % for payments above EUR 150 000 per farm (with the possibility of deducting salaries from the payments before applying the reduction). Overall, 10 MS have introduced capping, ranging between EUR 150 000 and EUR 600 000, whereas 14 MS apply only the minimum reduction of 5 % to amounts of DDPs above EUR 150 000 (Table 1).
- **CAP greening.** The reformed CAP provides for a stronger linkage of the direct payments to agricultural practices beneficial to the climate and environment through three greening measures: crop diversification, maintenance of permanent grasslands and ecological focus areas ([6]). CAP greening is linked to 30 % of the total direct payments.

([5]) The 2013 CAP reform replaced the SPS with the basic payment scheme. Similar to the SPS, the basic payment scheme is also based on payment entitlements that can be activated only if accompanied by eligible land. The key difference between the SPS and the basic payment scheme is that the latter grants a basic layer of support to farmers, which is topped up by other payments targeting specific issues, such as the greening payments, redistributive payments, payments for areas facing natural constraints and the young farmer scheme (European Commission, 2016). Thus, the total value of decoupled payments a farm receives is equal to the basic payment scheme plus other top-up payment elements. To simplify the terminology and keep it consistent over the whole report, we refer to these payments as the SPS (i.e. the combined value of basic payment scheme, greening payments and redistributive payments).

([6]) Under the crop diversification, the cultivation of the arable land needs to include at least two different crops in farms cultivating between 10 ha and 30 ha of the arable land and at least three crops in farms with a larger arable area. The main crop should not exceed 75 % of the arable land, and the two main crops should not exceed 95 % of the arable area. Under the maintenance of the permanent grassland, farms are required not to convert or plough the permanent grassland. The ecological focus area measure requires farms larger than 15 ha to allocate at least 5 % of their eligible area (excluding grassland) to the ecological focus area. The areas that qualify as an ecological focus area include fallow land, terraces, landscape features, buffer strips and green cover (European Union, 2013a).

Table 1. The implementation of decoupled payments, by MS

MS/region	2003 CAP reform	2013 CAP reform				
		Internal convergence	Redistributive payment (maximum area per farm)	Capping/degressivity		
				Capping (EUR 1 000)	Rate (%)	Subtraction of salaries
Belgium: Wallonia	SPS historical	PC	Yes (30 ha)			
Belgium: Flanders	SPS historical	PC		150	100	
Denmark	SPS dynamic hybrid	PC		150	5	
Germany	SPS dynamic hybrid	National FR in 2019	Yes (46 ha)			
Ireland	SPS historical	PC		150	100	
Greece	SPS historical	Regional PC		150	100	Yes
Spain	SPS historical	Regional PC		150	5	Yes
France	SPS historical	PC (*)	Yes (52 ha)			
Italy	SPS historical	PC		150/500	50/100	Yes
Luxembourg	SPS static hybrid	PC		150	5	Yes
Netherlands	SPS historical	National FR by 2019		150	5	
Austria	SPS historical	National FR by 2019			100/100	Yes
Portugal	SPS historical	PC	Yes (5 ha)	150/300	5/100	Yes
Finland	SPS dynamic hybrid	Regional FR by 2019		150	5	
Sweden	SPS static hybrid	PC		150	5	
United Kingdom: England	SPS dynamic hybrid	Regional FR in 2015		150	5	
United Kingdom: Scotland	SPS historical	Regional FR by 2019		150/600	5/100	
United Kingdom: Wales	SPS historical	National FR by 2019	Yes (54 ha)	150/200/250/300	15/30/55/100	
United Kingdom: Northern Ireland	SPS static hybrid	PC		150	100	
Bulgaria	SAPS	SAPS	Yes (30 ha)	150/300	5/100	Yes
Czechia	SAPS	SAPS		150	5	
Estonia	SAPS	SAPS		150	5	Yes
Croatia	—	PC	Yes (20 ha)			
Cyprus	SAPS	SAPS		150	5	
Latvia	SAPS	SAPS		150	5	Yes
Lithuania	SAPS	SAPS	Yes (30 ha)			
Hungary	SAPS	SAPS		150/176	5/100	
Malta	SPS regional	National FR in 2015		150	5	
Poland	SAPS	SAPS	Yes (30 ha)	150	100	
Romania	SAPS	SAPS	Yes (30 ha)			
Slovenia	SPS regional	PC		150	5	Yes
Slovakia	SAPS	SAPS		150	5	

(*) Except for Corsica, France, which applies a flat rate from 2015 onwards.

NB: Those MS implementing the dynamic hybrid model gradually move to a fully regional model. In MS implementing the static hybrid model, the regional and historical proportions do not change over time. FR, flat rate; PC, partial convergence by 2019.

Source: European Commission (2011, 2015, 2019b).

2.2. Coupled direct payments

CDPs were introduced by the MacSharry reform in 1992 and were increased by Agenda 2000. The 2003 CAP reform significantly reduced CDPs by introducing decoupled payments. However, even with the introduction of DDPs, MS could maintain a certain proportion of direct payments coupled to crop or animal production instead of disbursing them as decoupled payments. The 2013 CAP reform maintained the CDPs (i.e. voluntary coupled support). MS could grant CDPs for the purpose of maintaining the current production level in regions or sectors that face certain difficulties and are perceived to be important for economic, social or environmental reasons. MS could allocate up to 15 % of the national direct payment ceiling to CDPs (European Commission, 2019a).

The specific CDPs vary across MS and across time, as determined by CAP reforms and Member States' choices. CDPs include crop area direct payments and animal direct payments. The crop CDPs could include area payments for cereals, oilseeds, protein crops, fruits and vegetables, sugar beet, rice and set-aside. In general, they are land-based subsidies linked to the cultivation of certain crops. The coupled animal direct payments include various types of subsidies usually paid per animal head, such as for suckler cows, dairy cows, beef cattle, and sheep and goats. For example, in 2019, around 10 % of the direct payment budget was allocated to CDPs in the EU. The highest proportion of CDPs in the EU was granted to beef and veal sectors (40 % of total CDPs), followed by milk and dairy sectors (21 %), sheep and goat sectors (13 %) and protein crops (11 %). Other supported sectors were fruits and vegetables, sugar beet and other sectors (European Commission, 2019a).

2.3. Rural development programme

The RDP aims to promote the development of rural areas of the EU in order to address a wide range of economic, environmental and social challenges. RDP support includes different policy measures, each focusing on a specific area, such as 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 and climate (Dwyer, 2005; Copus et al., 2007; European Network for Rural Development, 2015, 2019; European Commission, 2019c).

RDP support for 2007–2013 was focused on four thematic axes: improvement of the competitiveness of the agricultural and forestry sectors (axis 1), improvement of the environment and countryside (axis 2), improvement of the quality of life in rural areas and diversification of the rural economy (axis 3), and the 'leader approach', which involves implementation of local development strategies (axis 4). For the 2007–2013 financial period, the total allocated RDP support represented around EUR 151 billion (including the contribution from the national budget) (European Network for Rural Development, 2015).

The 2014–2020 RDP support is split into six priority areas, and each priority area consists of several focus areas. The six priority areas are knowledge transfer and innovation (priority 1), farm viability and competitiveness (priority 2), food chain organisation and risk management (priority 3), restoring, preserving and enhancing ecosystems (priority 4), resource-efficient, climate-resilient economy (priority 5), and social inclusion and economic development (priority 6). Overall, the total RDP support for the 2014–2020 programming period represents around EUR 161 billion (including the contribution from the national budget) (European Network for Rural Development, 2019; European Commission, 2019c).

RDP support targets either the farming sector (e.g. investment support and agri-environmental-climate support), the non-farming sector (e.g. forestry and the food-processing sector) or the rural community (e.g. infrastructural investments). The main focus of this report is the RDP support targeting the farming sector: less favoured area (LFA) payments (currently known as payments to areas facing natural constraints), agri-environmental-climate measure (AEM) payments and the on-farm investment support.

LFA and AEM payments are a compensatory type of aid (Dwyer, 2005) granted as annual payments to farmers under multiannual contracts. LFA payments are granted to farmers located in mountainous areas and areas facing natural or other constraints in order to compensate fully or partially for the additional costs and income forgone from conducting agricultural production in less productive regions. They aim to prevent land abandonment in regions where natural conditions for land cultivation are less economically attractive. AEM payments are offered for the provision of environmental- and climate-related management services. They are granted for a range of farm activities aimed at making a positive contribution to the environment and climate. These payments should cover additional costs and farm income forgone resulting from the adoption of such on-farm practices (European Commission, 2005; European Union, 2013b).

The investment support usually covers only a proportion 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). The main objective of the investment support is to improve the economic performance of farms by promoting investments in farm capital and technology, adding value to agricultural production and improving the quality of agricultural products. 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 (e.g. farm shops, processing and marketing activities, and tourist accommodation).

3. Land capitalisation of common agricultural policy subsidies: conceptual analyses

Economic theory predicts that, by introducing incentives for farmers in the form of subsidies, the incentives will influence farmers' production choices and, in turn, influence agricultural output and input markets, including the land market. In general, agricultural subsidies increase marginal returns on agricultural production by raising output prices, by increasing returns on subsidised farm production activities or by reducing production costs. These effects are associated with a higher demand for input factors ([7]). Given a limited supply of inputs, an increasing demand translates into higher factor prices, especially for those input factors that are relatively scarce and that cannot be easily replaced in production by other ones (Floyd, 1965; Gardner, 1983; Alston and James, 2002).

As land is a scarce production factor with the lowest elasticity of supply (compared with other production factors) and cannot be easily replaced by other inputs, economic theory predicts that CAP subsidies should eventually capitalise more into land rents and land values than into the price of other production factors. The magnitude of these effects is expected to differ between type of subsidies and contexts (Floyd, 1965; Gardner, 1983; Alston and James, 2002).

Sections 3.1, 3.2 and 3.3 present the expected capitalisation effect of DDPs, CDPs and RDP subsidies. As shown in these sections, all types of subsidies are predicted to be capitalised to a certain extent into land prices. However, the actual degree of capitalisation of different types of subsidies is not straightforward and depends on, among other factors, implementation details and the elasticity of land supply. We consider the CAP capitalisation in rental prices, but analogous analyses could be easily adopted for the land values (sale prices) if we assume that land rents and land sale price are linked by the present value formula. The net present value (NPV) model is a main theoretical basis used to investigate the formation of land values; it assumes that land value can be modelled as a discounted stream of expected future returns from land (Weersink et al., 1999; Kropp and Peckham, 2012).

3.1. Capitalisation of decoupled payments

There is relatively abundant theoretical literature investigating the impact of the EU decoupled payments on land prices for both the 2003 and the 2013 CAP reforms. However, the results are not straightforward and the capitalisation level depends on many factors, particularly the implementation details of DDPs. The LFA payment is a per hectare payment and it is expected to generate similar incentives on the land market to the SAPS or the SPS; as a result, it will be analysed here. The theoretical literature shows that the following implementation aspects of DDPs are key determinants of the DDPs' capitalisation into land prices (e.g. Ciaian and Swinnen, 2006; Ciaian et al., 2008, 2010, 2014, 2017b, 2018; Courleux et al., 2008; Kilian and Salhofer, 2008; Kilian et al., 2012; Feichtinger and Salhofer, 2013; Viaggi et al., 2013).

- The DDP model: the SPS and the SAPS (and LFA payments).
- The ratio of the eligible area to the total number of entitlements in the case of the SPS.
- Heterogeneity of the per hectare DDPs between farms: under the 2003 CAP reform, the SPS implementation model determined whether farms in a given MS/region received the same or different values of entitlement. That is, under the historical and hybrid models the value of entitlement varied between farms, as opposed to the regional model or the SAPS. In the 2013 CAP reform, the value of entitlement varies between farms in MS that implemented the partial convergence of DDPs. Under the full convergence, all farms are granted an equal per hectare payment in a given MS/region. Furthermore, the redistributive payment and degressivity/capping of DDPs increase the differentiation of the per hectare payment between farms for both the SPS and the SAPS.

To show the impact of these implementation aspects of DDPs on their capitalisation, we use a graphical illustration based on a stylised land rental model of Ciaian et al. (2014) (Figure 1). For the sake of graphical tractability, we assume that (i) the entire land is owned by 'landowners' who rent the land to 'farms', (ii) there are two identical regions except for the land supply, and (iii) entitlements are allocated to farms (in accordance with EU rules).

(7) The exception are AEM payments (see section 3.2).

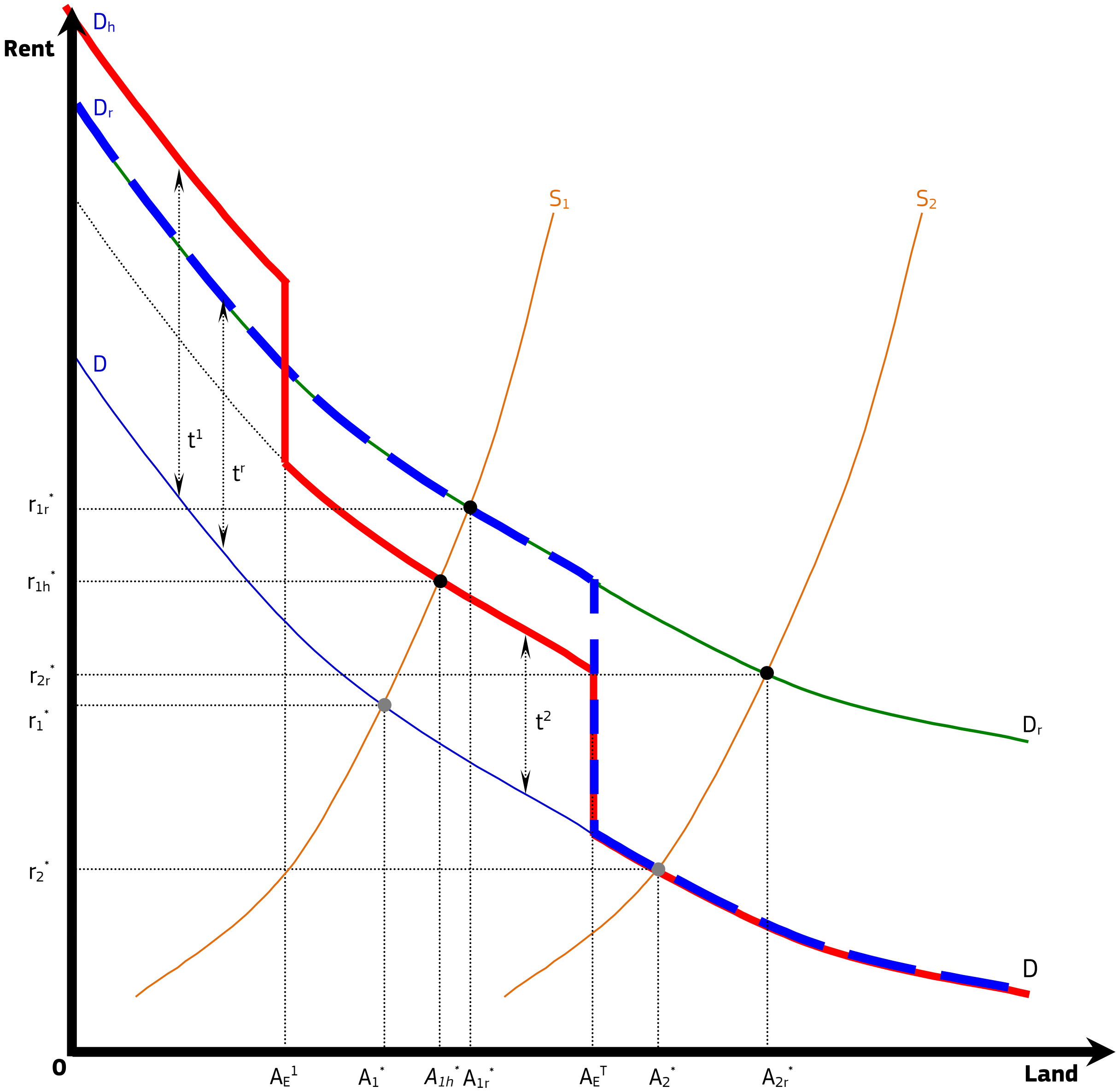
The horizontal axis shows the quantity of land, A, and the vertical axis measures the rental price, r, and the SAPS/SPS subsidy, t. The aggregate land demand without subsidies is given by the downward sloping curve DD. Land supply in region 1 is given by curve S_1, and land supply in region 2 is given by curve S_2. The land market equilibriums in the zero-support regime are (A_1^*, r_1^*) and (A_2^*, r_2^*) in region 1 and region 2, respectively. Although the productivity is the same for all farms (i.e. land demand is the same in region 1 and region 2), there is less land used in equilibrium in region 1 than in region 2 because of lower land supply. Although the model is a simplified version of reality, it shows the main insights into the pressures that DDPs generate on land markets.

As a starting point, we consider the SAPS. Under the SAPS, the entire land is eligible for support, and payment value is uniform across all farms. We denote the hectare value of the SAPS by t^r. The SAPS shifts land demand upwards from DD to D_rD_r. Farms' willingness to pay for land increases by the SAPS value, t^r. The land market equilibrium shifts from (A_1, r_1) to (A_{1r}, r_{1r}) in region 1 and from (A_2, r_2) to (A_{2r}, r_{2r}) in region 2. Land use and land rent increase by $A_{1r}^* - A_1^*$ ($A_{2r}^* - A_2^*$) and by $r_{1r}^* - r_1^*$ ($r_{2r}^* - r_2^*$), respectively, in region 1 (region 2). **The use of SAPS payments in competition for land drives up land rental prices and thus the SAPS gets capitalised into land rents.** The capitalisation level is equivalent in both regions. The capitalisation is higher when the supply of land is less elastic. In the extreme case, with perfectly inelastic (fixed) land supply (not shown in Figure 1), the SAPS may become fully capitalised into land rental prices; that is, all subsidies will go to landowners because land rents increase proportionally to the SAPS (Ciaian and Kancs, 2012).

Being a per hectare subsidy and without entitlements, LFA payments are expected to exercise an impact on the land market similar to that of the SAPS, except that they are expected to be capitalised into land rents at a lower rate. The key difference is that the LFA payments are expected to affect land markets only in regions where natural conditions for land cultivation are less economically attractive, which is determined by its implementation rules, whereas the SAPS is applied in all regions. A second difference between LFA payments and the SAPS is that, by design, LFA payments compensate fully or partially for the additional costs and income forgone by farmers for cultivating land in less profitable regions. As a result, LFA payments are expected to stimulate land use and to reduce land abandonment. At the margin, some farms may cultivate unprofitable land that would otherwise be left unused without LFA payments. This implies that farmers may use part of LFA payments to cover the costs of maintaining marginal land in use, and only the rest of the payment will be used to compete for land on the land market. This will result in a partial capitalisation of LFA payments into land rents, which is expected to be lower than in the case of the SAPS with all other things being equal. Other things being equal, the capitalisation rate of the SAPS and LFA scheme will be the same for both payments only when they have an equivalent impact on marginal land ([8]).

([8]) Note that farmers may also use a part of SAPS payments to cover the costs of maintaining marginal land in cultivation. However, this is expected to be less likely than for LFA payments, because the SAPS is implemented in all (less and more productive) regions, whereas the LFA scheme is applied only in less productive regions.

Figure 1. The effect of the decoupled payments on land rents



The capitalisation effect of the SPS is more complex. **The capitalisation of the SPS depends strongly on the ratio of the eligible area to the total number of entitlements. If there are more entitlements than the eligible area ('surplus'), then the SPS is expected to lead to a land rental price increase. However, if there are fewer entitlements than the eligible area ('deficit'), then the SPS is expected not to increase land rents.** This is shown in Figure 1 for the regional SPS (flat-rate) model. For comparison, we assume an SPS rate of t^r; that is, the same value as in the case of the SAPS. However, under the SPS, the stock of entitlements determines the maximum amount of land that can receive payments. We assume a total amount of entitlements, A_E^T, in both regions. The land demand with the regional SPS model is given by the bold (kinked) line D_rD_r. Given that farms need land to activate their entitlements and cash in the SPS, farms' willingness to pay for land increases with the value of the entitlement, t^r. This holds until all entitlements are exhausted; that is, up to A_E^T. After this point, land demand is the same with and without the SPS, as there are no unused entitlements available.

The effects of the SPS on the land market are very different in the two regions. In region 1, where entitlements are in surplus compared with the total land area ($A_1^* < A_E^T$), the SPS gets capitalised into land rents. That is, the equilibrium changes from (A_1, r_1) without support to (A_{1r}, r_{1r}) with the regional SPS model.

The effect is the same as in the case of the SAPS. However, the effect is different in region 2, where entitlements are in deficit relative to land ($A_2^* > A_E^T$). The equilibrium (A_2, r_2) is not altered by the SPS. The SPS has a zero-distortive marginal effect on farm rental decisions. This implies zero capitalisation of the SPS in region 2.

The main intuition behind these results is that, in the presence of surplus entitlements, farms will not be able to activate all their entitlements with the current area of land. Profit-maximising farms will compete for additional land, seeking to activate their unused entitlements. Competing farms will overbid the market rental price for land until it equals the marginal profitability and the entitlement value. As a result, the SPS will be capitalised into land rents. The effect of competitive pressure in the case of deficit entitlement is the reverse. If land is in surplus relative to entitlements, farmers will compete for entitlements to benefit from the SPS. The SPS will benefit the entitlement owners, but will not be reflected in higher land rental prices (Ciaian et al., 2008, 2010, 2014; Kilian et al., 2012).

When the DDP is capitalised into land values, the proportion of payments that are capitalised into land rents decreases in the payment heterogeneity. We illustrate this effect in Figure 1 by comparing a regional (flat-rate) SPS model and a model with heterogeneous payments. For the heterogeneous payment model, we consider two types of entitlement. The stock of type 1 entitlements, A_E^1, has unit face value t^1, and the stock of type 2 entitlements, A_E^2, has face value t^2. The aggregate stock of entitlements, A_E^T, is the sum of the two types; that is, $A_E^1 + A_E^2 = A_E^T$ where $t^1 > t^2$. This implies a land demand function such as is represented by the (double-kinked) curve D_hD. Relative to a no-support regime, the heterogeneous-payment SPS model shifts land demand by t^1 up to A_E^1, where all high-value entitlements are activated. In the interval from A_E^1 to A_E^T (where $A_E^T - A_E^1 = A_E^2$), it is higher by t^2, and it is the same after all entitlements are activated at A_E^T ($= A_E^1 + A_E^2$).

To compare the effects of the homogenous versus heterogeneous DDP models, we keep the total amount (value) of DDPs constant. We have shown above that, under the homogenous payment model (regional SPS or SAPS), the equilibrium was (A_{1r}^*, r_{1r}^*) in region 1. Under the heterogeneous SPS model, the equilibrium in region 1 is (A_{1h}^*, r_{1h}^*). Hence, land use increases and land rents go up in both models, although less under the heterogeneous payment model than under the homogenous payment model. This implies lower capitalisation under the heterogeneous payment model than under the homogenous payment model.

The intuition behind these results is that, as farms with high-value payments compete with farms with low-value payments, farms owning high-value payments can afford to pay higher rents but will bid up the rent only to the maximum that those with low-value payments can (no longer) afford. Therefore, the low-value payments will determine the DDP capitalisation at the margin. This implies that the DDP capitalisation decreases in the heterogeneity of the DDPs.

In region 2, there is no effect of the SPS with both homogenous and heterogeneous payment SPS models because of the deficit of entitlements relative to the total area. The SPS had no impact on the land market – the equilibrium remains unchanged at (A_2^*, r_2^*). Hence, the SPS does not lead to capitalisation of subsidies in region 2, irrespective of the SPS model.

Following these theoretical analyses under the assumption of well-functioning land markets, **the capitalisation of the SAPS is expected to be equal to the capitalisation of the flat-rate (regional) SPS model with surplus entitlements** ([9]) **and higher than the capitalisation of LFA payments and the heterogeneous payment models** (e.g. for the historical and hybrid SPS models for the 2003 CAP reform, or in the case of partial convergence of DDPs or if redistributive payment is applied under the 2013 CAP reform) ([10]). **The lowest capitalisation is expected for the SPS model with deficit entitlements.**

3.2. Capitalisation of coupled payments and rural development programme support

The main difference between DDPs and CDPs is that the former are linked to land and do not require production, whereas the latter are linked to specific crop or animal activities of farmers and affect production. The crop CDPs are land-based subsidies linked to the cultivation of specific crops. The animal CDPs are either an output (animal) type of payments (e.g. beef premiums or slaughter premiums) or subsidies linked to non-land input (e.g. the suckler/dairy cow premium or ewe premium), which may affect the stock of breeding

([9]) Conceptually, the SAPS corresponds to the regional (flat-rate) SPS model with surplus stock of entitlements.
([10]) Note that DDPs in MS that apply the SAPS can become heterogeneous if the SAPS is combined with the redistributive payment.

livestock. It is similar for the RDP support. The RDP support affects specific farm activities. For example, the AEM payments particularly affect farm input use and adoption of new farm practices, because they are conditional on the adoption of environmentally friendly production practices. These practices are expected to alter, among other aspects, fertiliser and pesticide use, organic farming choice, intensification of livestock activities, conversion of arable land to grassland, rotation measures and support of biodiversity. The farm investment support targets, in particular, the farm capital that incentivises the application of more efficient technology, knowledge spillovers and more efficient farm practices. Overall, the CDPs and RDP (except for LFA payments) ([11]) affect primarily production processes of supported farmers, which are expected to be translated into changed demand for land and consequently also into changed land rental prices.

We illustrate the impact of the CDPs and RDP on land rents by extending the above land rental model (see Figure 1) by including output market. This is shown in Figure 2. The right panel shows the land market. To simplify the presentation, we consider only one region (region 2) because the capitalisation effect will be the same in both regions. The left panel shows the output market. The horizontal axis shows the quantity of output, Q, and the vertical axis measures the output price, p. For the sake of graphical tractability, we assume a closed economy with no international trade ([12]). The aggregate output demand without subsidies is given by the downward sloping curve D_0. The output supply is given by the upward sloping curve S_0. The output market equilibrium in the zero-support regime is (Q^*, p^*).

CDPs or RDP subsidies impact farm production activities either directly by increasing returns on a specific activity (e.g. beef production in the case of beef and veal payments) or indirectly by altering input use (e.g. fertiliser use in the case of AEM payments and capital in the case of investment support). In the case of coupled support to a specific production activity, a rational farmer will tend to increase the output of the subsidised production activities because of greater return obtained from these activities. Similarly, the support linked to input factors (e.g. investment support) will reduce production costs and stimulate an increase in farm production levels. This output increase induced by CDPs or RDP subsidies is represented in the left panel of Figure 2 by the shift in the supply curve from S_0 to S_{s1}. The output market equilibrium shifts from (Q^*, p^*) to (Q_{s1}^*, p_{s1}^*). The output quantity increases by $Q_{s1}^* - Q^*$ and its price decreases by $p^* - p_{s1}^*$.

However, such an output increase will be possible for the farmers only by increasing their demand for land ([13]). This increase in demand for land is represented in the right panel in Figure 2 by the shift in the land demand curves from D to D_{s1}. As a result, the land market equilibrium shifts from (A^*, r^*) to (A_{s1}^*, r_{s1}^*). Land use and land rent increase by $A^* - A_{s1}^*$ and by $r_{s1}^* - r^*$, respectively. **Competition for land drives up land rental prices and thus CDPs and RDP subsidies get partially capitalised into land rents** ([14]). **The capitalisation of CDPs or RDP subsidies is expected to be smaller than the capitalisation of DDPs (i.e. SAPS or the flat-rate SPS model with surplus entitlements).** The main reason for this is because part of CDPs or RDP subsidies benefit market players on the market targeted by the subsidy (e.g. consumers through lower output prices in the case of CDP linked to output). The CDP or RDP subsidies' capitalisation is higher when the supply of land is less elastic. CDPs or RDP subsidies are fully capitalised into land values only in specific situations when there is a perfectly inelastic (fixed) land supply, when either non-land input supply or output demand are perfectly elastic, or when the factor proportions are fixed. In other situations, the benefits from coupled subsidies are shared between landowners, suppliers of other production factors and consumers (Floyd, 1965; Gardner, 1983; Alston and James, 2002).

The capitalisation effect of the AEM payments is not straightforward. AEM payments are expected to cover additional costs in return for the adoption of environmental and climate-conscious farm practices. The AEM payments affect farm input use and the adoption of new farm management practices (e.g. Pufahl and Weiss, 2009; Kuhfuss and Subervie, 2018). The changes in input use and farm practices are expected to alter farm productivity. Empirical studies find mixed results: they estimate negative effects (e.g. Lakner, 2009; Arata and Sckokai, 2016), positive effects (e.g. Sauer and Park, 2009) or insignificant effects on productivity of the AEMs (e.g. Mary, 2013).

In terms of market impacts, because AEMs affect farm productivity they are expected to shift the output supply curve downwards or upwards depending on the trend in the productivity change. If AEM payments

([11]) In this section, RDP refers only to AEM payments and the investment support. LFA payments were analysed in the previous section.

([12]) The inclusion of trade would affect the magnitude of the CDPs' impact on output price by making the demand more elastic, implying a smaller output price response to the introduction of CDPs.

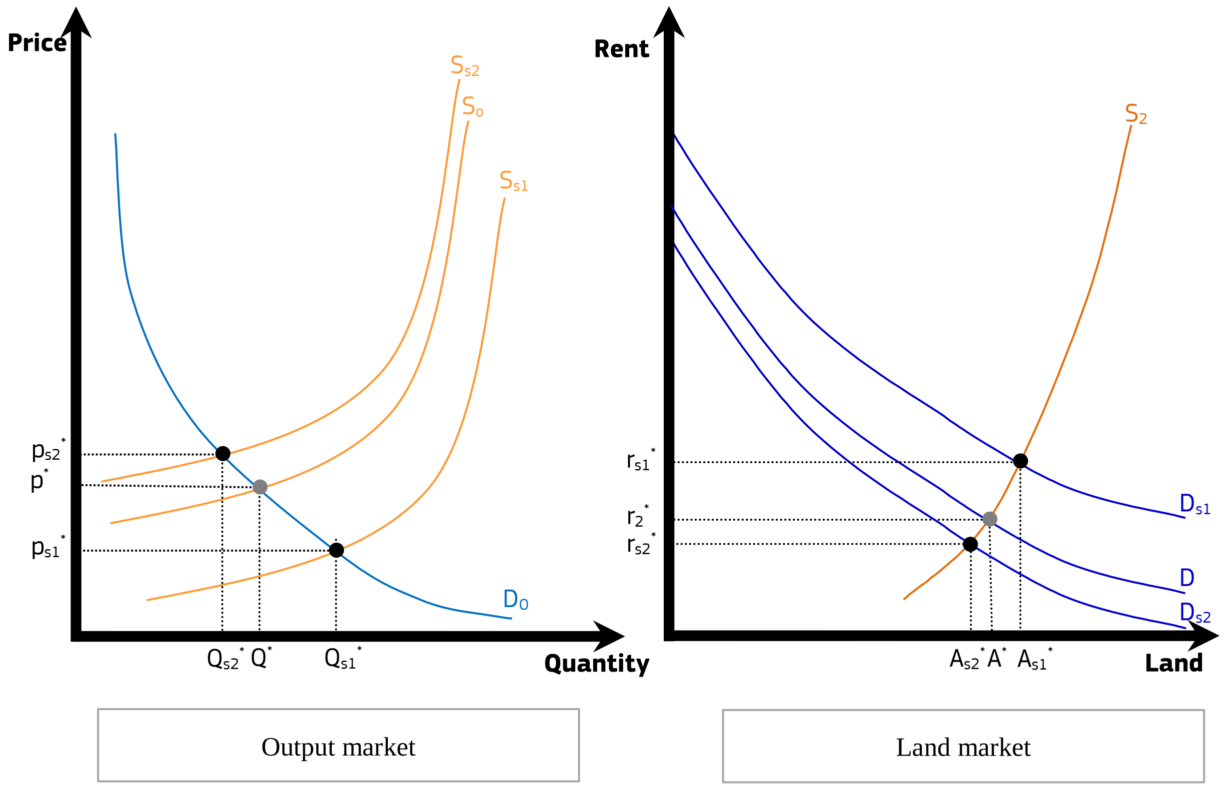
([13]) Note that the land demand change depends on the magnitude of the price change. If price decrease is substantial relative to the increase in farm productivity, then actually the net impact on land use could be negative.

([14]) Under certain situations, the capitalisation of CDPs might actually be negative; this could be the case for non-land input subsidies if land and non-land inputs are gross substitutes in production.

increase the farm productivity, their capitalisation effect is analogous, as shown in Figure 2. If instead AEM payments reduce the farm productivity, the capitalisation effect changes. Lower farm productivity shifts the supply curve upwards from S_0 to S_{s2} and the output market equilibrium shifts from (Q^*, p^*) to (Q_{s2}^*, p_{s2}^*) (left panel of Figure 2). Now the output quantity decreases and its price increases by $Q^* - Q_{s2}^*$ and by $p_{s2}^* - p^*$, respectively. This also has implications for the land market. Lower farm productivity is expected to reduce demand for land ([15]), represented in the right panel in Figure 2, by shifting it downwards from D to D_{s2}. The land market equilibrium changes from (A^*, r^*) to (A_{s2}^*, r_{s2}^*). Land use and land rent decrease by $A^* - A_{s2}^*$ and by $r_{s2}^* - r^*$, respectively. In the case shown in Figure 2, **the AEM payments lead to negative capitalisation of subsidies into land rents. However, if the productivity effect of AEM payments is positive then they may get partially capitalised into land rents** (analogous to the case shown above). The production effect of the AEMs is expected to be lower than in the case of CDPs or the investment support, because they are designed to motivate farmers to take costly actions that have a positive impact on environmental and climate-related public goods but might have a negative impact on their production. This implies that the AEM payments' capitalisation into land rents is expected to be lower than in the case of CDPs or the investment support.

Overall, CDPs and the investment support are expected to be partially capitalised into land rents but in general less than DDPs (less than the SAPS or the flat-rate SPS model with surplus entitlements). The capitalisation of AEM payments into land rents is expected to be lower and in certain situations may lead to a negative capitalisation effect.

Figure 2. The effect of CDPs and RDP support on land rents



([15]) Note that the land demand change depends on the magnitude of the price change. If price increase is substantial relative to the decrease in farm productivity, then actually the net impact on land use could be positive.

3.3. Other determinants of the capitalisation of common agricultural policy subsidies

Although the above model (see Figure 2) is a simplified version of the reality, it shows the main pressures that CAP subsidies generate on land markets and their expected capitalisation rate when land markets function relatively well. In reality, however, the actual CAP subsidies will be determined by additional factors that may either impede or enhance the land capitalisation of CAP subsidies. At the same time, because of the inherent differences between rental and sale markets, the responses of rents and land values to CAP subsidies may differ. The literature shows that the following factors may affect the actual land capitalisation of DDPs, CDPs and RDP subsidies in both land rents and land values and differences between the two (Ciaian et al., 2010, 2014; Swinnen et al., 2013; Michalek et al., 2014).

- **As discussed above, the capitalisation of CAP subsidies into land prices is expected to be higher when the supply of land is less elastic.** In empirical studies, land supply elasticity is usually found to be rather low, mostly owing to natural constraints. For example, based on an extensive literature review, Salhofer (2001) concludes that a plausible range of land supply elasticity for the EU is between 0.1 and 0.4, which implies relatively low responsiveness of total quantity of land to any change in the profitability of land cultivation. That is, most of the adjustment induced by any demand shock (e.g. including subsidies) will be absorbed by land prices rather than land quantity.

- **The capitalisation of CAP subsidies into land prices might be lower with CAP greening and cross-compliance.** CAP greening and cross-compliance requirements imply additional costs to land users, which may reduce the demand for land, and thus the (positive) effects of CAP subsidies on land rents will be smaller. However, the impact of CAP greening and cross-compliance on the CAP subsidies' capitalisation is expected to be rather small because of their small expected impact on farm costs or performance (e.g. for the impact of CAP greening on farm performance, see Solazzo et al., 2014; Cimino et al., 2015; Gocht et al., 2017; Louhichi et al., 2017, 2018).

- **The capitalisation of CAP subsidies into land prices is expected to be higher when subsidies reduce credit constraints on farmers (Ciaian and Swinnen, 2009).** Many farms, particularly those in the poorer rural regions of the EU, face credit market constraints. However, access to cash payments (CAP subsidies) may reduce these credit market constraints, either directly by increasing farms' cash flow or indirectly through easier access to bank loans. This will increase the capitalisation of CAP subsidies, because it increases farm productivity and hence the demand for land.

- **The capitalisation of CAP subsidies into land prices is expected to be lower when land markets are regulated.** Land regulations may affect CAP subsidies' capitalisation, because they may make land transactions more costly, induce lower competition on the land market and restrict land price adjustments. This is particularly related to increased administrative requirements when land is transacted (e.g. fees and notary charges, and costs of fulfilling administrative requirements), maximum price regulations and asymmetric land access rights among different types of buyers/tenants (i.e. between those with pre-emption rights and those without). Land market regulations in the EU vary significantly among MS, and hence their impact on CAP subsidies' capitalisation may differ between MS (Swinnen and Vranken, 2009, 2010; Ciaian et al., 2010, 2017a; Swinnen et al., 2014a, 2014b).

- **Changes in capitalisation of CAP subsidies into land rents is expected to be more gradual with long-term rental contracts.** The length of the rental contracts can vary greatly and, often because of regulations, varies greatly among MS ([16]). With short-run contracts, average rental price adjustments can occur quickly; with long-term contracts, average rental price adjustments will occur more slowly. This may also affect land values (sale price), as it reduces the return of land for non-farming landowners.

([16]) According to Ciaian et al. (2010), the key determinants of rental contract durations in the EU are social norms (e.g. in Greece), governmental regulations (e.g. there is a minimum of 9 years in Belgium and France, 6 years in the Netherlands and 5 years in Spain) and market institutions (e.g. Germany, Italy and Sweden). Moreover, in several countries (e.g. France), even the renewal of rental contracts is regulated.

- **Social capital may imply a more sluggish adjustment of land prices and thus reduced capitalisation of subsidies.** Studies show that social capital is a pivotal factor for the rural land market, influencing the type of transactions (e.g. Patterson et al., 1998; Rainey et al., 2005), the price of the land (Robison et al., 2002) and the partners involved in the transaction (Siles et al., 2000). In many regions, land transactions depend on the relationship between the parties involved (e.g. between landlord and tenants) and tend to occur more often between relatives or neighbours (Patterson et al., 1998; Siles et al., 2000). According to Robison et al. (2002) and Tsoodle et al. (2006), this group of land market participants may receive a rebate on the land price of between 10 % and 43 %.

- **In the case of the SPS, the more difficult it is to trade SPS entitlements, the more the SPS may become capitalised into land values.** With low tradability, farms are more likely to keep their entitlements (instead of selling them) and to use them to compete for land, which exerts an upward pressure on land prices. In other words, entitlements indirectly become farm specific or practically attached to the farmer's land if trade is constrained. In contrast, facilitating entitlement trade may actually play a role in reducing potential SPS capitalisation, because it will reduce SPS pressure on land markets. In principle, full tradability cuts the link between entitlements and a specific land area or a specific farmer, thus leading to a lower SPS impact on the land market. The impact of the tradability on SPS capitalisation is more significant in the case of deficit entitlements. With surplus entitlements, the SPS is expected to be capitalised anyway (see Figure 1), so tradability is less important. In this case, low tradability also leads to higher SPS capitalisation, but its effect is rather small.

- **Future expectations about CAP subsidies may affect the capitalisation of subsidies into land prices.** The current farm behaviour may be subject to uncertainties about future policy changes (Organisation for Economic Co-operation and Development, 2001; Shaik et al., 2005). When land market participants make their decisions, they take into consideration the policy risk related to uncertainty about future subsidies. The CAP subsidies are subject to reforms largely following the budgetary planning of the EU as part of the multiannual financial framework (i.e. a 7-year framework regulating the annual EU budget). Any CAP reform can change the level of payments, eligibility conditions and type of payments. For example, the 2003 CAP reform decoupled most of the direct payments, the 2013 CAP reform made direct payments conditional on meeting greening requirements, and the proposal for the post-2020 CAP reform aims to further strengthen the environmental conditionality of direct payments (European Union, 2003, 2013a; European Commission, 2013, 2018).

  The actual impact of the future expectations on the current land capitalisation depends on what land market participants expect regarding the future CAP subsidies. If market participants' expectations are that CAP subsidies will continue or increase in the future, the expectations will not affect or may actually increase the current capitalisation rate, respectively. In contrast, if market participants expect a decrease (or introduction of more stringent eligibility requirements and/or stronger environmental conditionality) in the future CAP subsidies, the current capitalisation rate may reduce. The future expectations are expected to be more relevant to land values than to land rents, because, according to the economic theory, the former should reflect the present value of the future expected land returns, whereas the latter is an annual price determined more by short-term than by long-term drivers.

- **If land values are only partially determined by the discounted stream of expected agricultural returns from land (i.e. by the present value model), then the CAP subsidies' capitalisation into land values will be lower than the capitalisation into land rents.** Economic theory suggests that farmland values should be determined by the discounted stream of expected agricultural returns. However, the literature suggests that agricultural land values are often driven by a complex set of factors, not necessarily by those related to agriculture (including subsidies). Agricultural land values might be driven by different non-agricultural factors, such as population and urban influence, recreational and natural amenities, and locational characteristics (e.g. Borchers et al., 2014; Delbecq et al., 2014; Czyżewski et al., 2019). When land values are driven by non-agricultural factors, they are expected to be less responsive to CAP subsidies than land rents, implying a lower capitalisation of CAP subsidies into land values than into rents.

- **Owing to the inherent differences between planning horizons involved in renting and in owning the land, subsidy capitalisation into land rents cannot be directly used in predicting the capitalisation effect of subsidies into land values.** In fact, rental rates are expected to be more flexible in adjusting to the changing policy environment than land values (Alston, 2007; Kirwan, 2009; Kropp and Peckham, 2012). In a longer-term investment horizon such as land ownership, economic agents may discount returns differently from land rents according to their expectations with regard to future policy changes. As argued above, other non-agricultural factors may be more important in explaining the value of the land rather than in explaining rental rates (Swinnen et al., 2013). Because of these differences, rental prices may be more responsive to CAP subsidies than land values.

4. Land capitalisation of subsidies: empirical evidence

There is a large body of literature, dating back to the 1960s and 1970s, dedicated to empirically estimating the impact of agricultural subsidies on land prices. Early studies (Herdt and Cochrane, 1966; Tweeten and Martin, 1966; Reynolds and Timmons, 1969; Cowling et al., 1970; Klinefelter, 1973) mostly focused on the analysis and prediction of agricultural land values. More recently, especially for the EU, most of the studies on capitalisation effects have analysed rental prices. Usually the choice between the two options is determined by the data availability: the availability of either land values (from regional data sets or sale transaction data) or rental data (from farm-level surveys or regional data sets) generally determines the choice of the estimated model.

Following the theoretical analyses, land rents may be empirically superior for investigating the effects of domestic support on land value for several reasons. As explained in the previous section, one of the main advantages of using the land rental model is that rents are less affected by farmers' expectations about the future effects of subsidies and market returns. Hence, land rents may more accurately reflect the incidence of the contemporaneous marginal subsidy euro and returns (Alston, 2007; Kirwan, 2009; Kropp and Peckham, 2012; Ciaian et al., 2021). In contrast, land prices are based on expectations about the long-run stream of net returns on production and subsidies tied to land (Kirwan, 2009). Second, rental rates are observed in the market, whereas land value is often stated by the owner and therefore subjective (Whitaker, 2006). Finally, rental prices are less affected by urban pressures and other non-agricultural factors if contracts are for short periods of time, and may therefore more accurately reflect the value of agricultural activity on the land (Whitaker, 2006; Swinnen et al., 2013; Borchers et al., 2014; Delbecq et al., 2014; Czyżewski et al., 2019).

Typically, the empirical literature on capitalisation of agricultural subsidies into land rents estimates a reduced-form model specification whereby rental rate is defined as a function of agricultural subsidies and other exogenous variables (e.g. market returns from agriculture and production characteristics). This literature usually estimates the capitalisation level of subsidies expressed in monetary terms, indicating how much EUR 1 of subsidy is reflected in land rents ([17]). A value equal to EUR 1 indicates full capitalisation, whereas a value smaller than EUR 1 indicates a partial capitalisation of subsidies into land rents.

The most common empirical specification used in empirical studies to estimate the subsidy capitalisation in land values is derived based on the NPV model. Early studies (Herdt and Cochrane, 1966; Tweeten and Martin, 1966; Cowling el al., 1970) have used a supply and demand framework, but they have been criticised on theoretical and empirical grounds (Latruffe and Le Mouël, 2009). A third approach applied for land price modelling in empirical studies is the hedonic pricing approach, which assumes land value as a function of its quality components (Shonkwiler and Reynolds, 1986), including the ability to generate returns from agricultural subsidies. This literature usually estimates the change in land value in euro resulting from EUR 1 of subsidy change. In contrast to the capitalisation level estimated for rents, its interpretation is not straightforward and it needs to be converted using the NPV formula to derive the capitalisation level (rate). Another (less frequently) estimated parameter in the literature is the capitalisation elasticity, expressed as percentage change in land value per 1 % change in subsidies. The capitalisation elasticity is not directly comparable with the capitalisation level (rate); it only indicates responsiveness of land values to subsidies.

Most of the existing empirical studies on agricultural subsidy capitalisation focus mainly on the EU and the United States. Overall, this literature provides evidence that agricultural subsidies are capitalised into land prices. However, empirical estimates typically find less than full capitalisation of subsidies (less than 100 %) and often lower capitalisation than predicted by theoretical studies, although the variation is relatively wide across studies. The main reasons for these findings could be land market institutions and regulations (Ciaian and Swinnen, 2006; Michalek et al., 2014), spatial effects and local market power in land markets (Graubner, 2018), and the nature of subsidies and their implementation details (Alston and James, 2002; Kilian and Salhofer, 2008; Ciaian and Kancs, 2012; Kilian et al., 2012; Nilsson and Johansson, 2013; Van Herck et al., 2013).

The variability of the empirical estimates on capitalisation effects on land prices can be also explained by the different methodologies adopted and the different data used by different studies (Sumner et al., 2010; Feichtinger and Salhofer, 2013; Ciaian et al., 2021). Many studies used farm-level survey data, whereas others have used data aggregated at county, municipality, region or country level ([18]). The choice of the

([17]) Note that the capitalisation level can be easily converted to the capitalisation rate, which is expressed as a percentage representing the proportion of subsidies that are reflected in higher land rents. We use capitalisation rate to report empirical estimates from the literature.

([18]) Less common data used for the estimation of subsidy capitalisation effects are based on field-level data (e.g. Kirwan and Roberts, aggregation level may be an important factor impacting the estimated capitalisation rate. According to the meta-analyses of Feichtinger and Salhofer (2013), the estimates based on aggregated data lead to higher capitalisation elasticities of subsidies in land sale values than those using farm-level data. In addition, several econometric identification issues can affect estimates. The main issues identified in the literature on land capitalisation are unobserved heterogeneity, measurement errors in the dependent and independent variables, simultaneity between land prices and subsidies (endogeneity), selection bias and inertia in land markets. Empirical studies have individually addressed some of these issues and have done so differently. In studies based on longitudinal data, unobserved heterogeneity has been addressed by including individual fixed effects among the set of explanatory variables in regression equations. Measurement errors and simultaneity between land prices and subsidies have been generally addressed by accounting for unobserved heterogeneity (or proxies for productivity) by resorting to instrumental variable estimators (Kropp and Peckham, 2012) or by using proxy variables for subsidies to reduce measurement errors (Goodwin et al., 2004). In farm-level studies, selection bias in rental price estimates has been addressed by adopting the two-stage Heckman correction approach (Ciaian and Kancs, 2012; Michalek et al., 2014; Guastella et al., 2018), whereas other studies have not found any significant selection bias (Kirwan, 2009). Inertia and dynamic adjustments in land markets have been modelled by including autoregressive terms in land price equations (Hendricks et al., 2012; O'Neill and Hanrahan, 2016), even though a limited number of studies have done so. Moreover, some authors have assumed that either land prices or unobserved factors involved in the capitalisation mechanisms were geographically correlated (Barnard et al., 1997; Lance and Mishra, 2003; Guastella et al., 2014) and augmented their econometric specification with appropriate strategies.

Table 2 and Figure 3 ([19]) present summary statistics of the estimated capitalisation levels in the empirical literature for the full samples (average across all subsidy types) and for different subsidy types for both rental prices and land values ([20]). The empirical studies imply an average capitalisation rate of agricultural subsidies of 39.5 % for land rents and 25.7 % for land values. Decoupled payments seem to be capitalised into land prices more than coupled subsidies or environmental payments. That is, the average estimated capitalisation rate of decoupled subsidies into land rents (values) is 50.4 % (39.6 %), whereas for coupled subsidies it is 39.7 % (8.6 %). In contrast, environmental payments tend to have negative capitalisation rates on average: – 8.2 % for land rents and – 9.3 % for land values. The average capitalisation rate of other payments that could not be categorised as coupled, decoupled or environmental (including aggregate payments) is around 33.3 % to 36.5 %. The mixed nature of these subsidies makes it difficult to draw comparisons with other types of subsidies. In general, studies based on rental prices tend to have higher average capitalisation levels than studies based on land values. However, the capitalisation levels estimated in the empirical literature vary widely across studies, although more for land rents than for land values. Overall, the estimates vary between – 0.79 and 5.58. Large standard deviations are present for all subsidy types, with the coefficient of variation (the ratio of the standard deviation to the mean) being greater than 1 for most subsidy types (except for the capitalisation of decoupled payments in land rents).

2016).

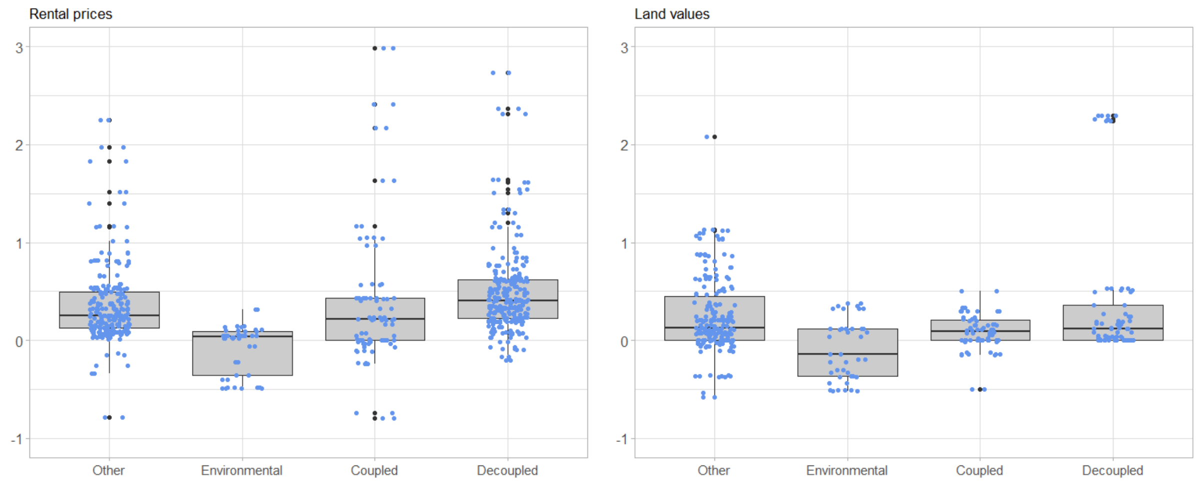
([19]) A few extreme values have been excluded in Figure 3 to improve visual comparability of distributions.

([20]) The estimates are based on 20 studies yielding 306 and 192 observations for the capitalisation level for land rents and land values, respectively. For a review of estimated capitalisation effects in the literature, see Ciaian et al. (2021).

Table 2. Estimated subsidy capitalisation levels into land rents and land values across empirical studies

Type of subsidies	N	Mean	Minimum	Maximum	Standard deviation	Coefficient of variation
Land rents						
Full sample	306	0.395	– 0.796	2.986	0.511	1.294
Other payments	114	0.365	– 0.784	2.251	0.425	1.164
Environmental payments	22	– 0.082	– 0.494	0.312	0.252	– 3.073
Coupled payments	42	0.397	– 0.796	2.986	0.757	1.907
Decoupled payments	128	0.504	– 0.209	2.734	0.467	0.927
Land values						
Full sample	192	0.257	– 0.578	5.583	0.642	2.498
Other payments	105	0.333	– 0.578	5.583	0.721	2.165
Environmental payments	21	– 0.093	– 0.515	0.378	0.311	– 3.344
Coupled payments	32	0.086	– 0.500	0.505	0.187	2.174
Decoupled payments	34	0.396	0.000	2.296	0.715	1.806

Figure 3. Distribution of the subsidy capitalisation levels by type of subsidies for rental prices (left) and land values (right) across empirical studies



Sections 4.1, 4.2 and 4.3 provide a more detailed analysis of the findings on the capitalisation effects of decoupled, coupled and other types of payments into both land rental prices and land values in the empirical literature.

4.1. Impact of decoupled subsidies

Table 3 and Table 4 present a summary of the estimated impacts of decoupled agricultural subsidies into rental prices and land values, respectively, found in major land capitalisation studies. All studies refer to subsidies in the EU and the United States, and, overall, they span the period between 1992 and 2013. Disaggregate data are most commonly used to investigate the impacts of decoupled payments. For the United States, most studies have employed farm- or field-level data. Lance and Mishra (2003) is the only study to use county-level data for the United States. For the EU, both farm-level and aggregate data have been used. Among those studies that have used aggregate data, Kilian et al. (2012) and Nilsson and Johansson (2013) have carried out their investigation at municipality level, and Valenti et al. (2020) have carried out their investigation at Nomenclature of Territorial Units for Statistics (NUTS) 3 level, whereas Guastella et al. (2014) have used data at NUTS 2 level. The main source of information used in studies focusing on multiple MS has been the FADN.

As for the United States, major decoupled subsidies considered are production flexibility contracts, market loss assistance, counter-cyclical payments and direct payments. Production flexibility contracts and direct payments have been based on historical yields and acreage (Kropp and Peckham, 2012), and, therefore, they are typically classified as decoupled subsidies. Counter-cyclical payments are tied to market prices but not to current production levels, and, therefore, they are considered as partially decoupled (Kropp and Peckham, 2012). Despite market loss assistance payments being instituted to compensate farmers for low market prices, they are considered decoupled because their eligibility is linked to other decoupled payments, such as production flexibility contracts and direct payments, and does not depend on the current production (Goodwin et al., 2004; Westcott and Young, 2005).

The impact of the decoupled subsidies on land prices reported in the literature has been almost always found to be statistically significant and positive, but estimates vary widely (Ciaian et al., 2021). The exceptions are Guastella et al. (2013) and Valenti et al. (2020), who estimate an insignificant capitalisation effect of decoupled subsidies. The proportion of decoupled subsidy capitalised into land prices has been typically found to be smaller than 100 %. Most estimates vary between around 5 % (Feichtinger and Salohfer, 2016) and 60 %. A limited number of studies have found estimates lower than 0 (e.g. Goodwin et al., 2011; Feichtinger and Salhofer, 2016) or exceeding 100 % (e.g. Lance and Mishra, 2003; Roberts et al., 2003; Patton et al., 2008; Kirwan and Roberts, 2016).

Regarding the EU, results are available for the EU-25 (Guastella et al., 2014), for old MS (Michalek et al., 2014), for new MS (Ciaian and Kancs, 2012), for Italy (Guastella et al., 2013; Guastella et al., 2018; Valenti et al., 2020), for Northern Ireland (Patton et al., 2008) and for Bavaria in Germany (Kilian et al., 2012; Feichtinger and Salhofer, 2016). These studies typically span the period before and after the 2003 CAP reform and have estimated the impact of the SPS and SAPS on land prices. In addition, impacts of decoupled payments for LFAs have been analysed (Patton et al., 2008; Kilian et al., 2012). To date, no study has investigated the impacts of the 2013 CAP reform.

In general, estimated impacts of decoupled payments in the EU seem to be smaller than those in the United States. Except Kilian et al. (2012), whose maximum impact of the regional part of the SPS has been estimated at 94 %, studies have found that the capitalisation rate into rental prices varies between 0 % (Guastella et al., 2013) and 61 % (Kilian et al., 2012). Estimates of the capitalisation of LFA payments into rental prices range between 19 % (Kilian et al., 2012) and 119 % (Patton et al., 2008). Regarding the impact of CAP subsidies on land values, the small number of studies and different methodologies make it hard to find patterns in the literature. Valenti et al. (2020), using a rather novel estimation approach, have found no significant capitalisation effect of decoupled payments at NUTS 3 level in Italy.

Comparing the SPS and the SAPS, the estimates of the capitalisation rates for the SPS vary more across studies. This could be because of different regional coverage by the studies, which captures different SPS implementation models (Ciaian et al., 2018). Michalek et al. (2014) estimate the capitalisation of the SPS into land rents using farm-level data across old MS for the early period of the SPS implementation (2004–2007). They find a relatively low capitalisation rate of only 6 % to 10 %. However, Michalek et al. (2014) also show that there is significant variation in the SPS capitalisation rate across old MS, among regions and among farms. Moreover, their estimates confirm the theoretical predictions that the heterogeneity of SPS payments reduces the capitalisation rate (i.e. they find a lower capitalisation rate in the historical model than in the hybrid model). Guastella et al. (2013) and Guastella et al. (2018) find a relatively low capitalisation effect of the SPS on land rents in Italy (between 0 % and 40 %), where the historical SPS model is implemented and entitlements are less abundant, which, according to theoretical predictions, should result in a low capitalisation rate when markets work relatively well.

Regarding the SAPS, Ciaian and Kancs (2012) used a farm-level panel data set of more than 10 000 farms in seven new MS in 2004 and 2005 and found that between 18 % and 20 % per additional EUR 1 of the SAPS was capitalised into higher land rental prices. These estimates appear somewhat low given that theory suggests a considerably higher capitalisation rate of the SAPS (see Figure 1).

In general, with some exceptions, the estimated capitalisation of the SPS appears to be more in line with the theoretical predictions than in the case of the SAPS, although the patterns cannot be fully identified because of the relatively small number of available studies. However, the estimated capitalisation rates for both types of payments could be underestimated because of the presence of various land market regulations. In particular, long-duration rental contacts and rules regulating land transactions in several countries may prevent full price adjustments or cause sluggish adjustment of land prices to subsidies, meaning that the effect may not be full and immediate. For example, Kilian et al. (2012) find that the SPS capitalisation effect is significantly higher for newly signed rental contracts in Bavaria (Germany). Furthermore, Latruffe et al. (2013) find that land regulations linked to intervention of the public authority (i.e. Sociétés d'aménagement foncier et d'établissement rural (SAFER)) in land markets reduces land sale prices in Brittany (France). This is because of the pre-emptive rights of SAFER, which enable the maintenance of lower market prices by purchasing land if the price is perceived to be too high and selling it back at a lower price.

Table 3. Estimated capitalisation of decoupled payments into rental prices in the empirical literature

Paper	Region	Period of analysis	Type of subsidy	Capitalisation level		
				Minimum	Mean	Maximum
Lance and Mishra (2003)	United States (Iowa)	1997–2000	Market loss assistance	0.270	0.635	0.900
			Production flexibility contracts	0.710	1.040	1.340
Roberts et al. (2003)	United States	1992	Production flexibility contracts	0.211	0.698	2.314
	United States	1992–1997	Production flexibility contracts	0.336	0.528	0.768
	United States	1997	Production flexibility contracts	0.329	0.784	1.545
Goodwin et al. (2004)	United States	1998–2001	Agricultural Market Transition Act	0.070	0.416	0.658
Patton et al. (2008)	EU (Northern Ireland)	1994–2002	LFA	1.199	1.199	1.199
Kirwan (2009)	United States	1997–1999	Land subsidy	0.265	0.306	0.347
Goodwin et al. (2011)	United States	1998–2005	Direct payments	– 0.171	0.375	0.730
Ciaian and Kancs (2012)	EU (new MS)	2004–2005	SAPS	0.183	0.190	0.196
Kilian et al. (2012)	EU (Bavaria)	2005	Direct payments – historical	0.280	0.405	0.547
			Direct payments – regional	0.413	0.685	0.941
			LFA	0.191	0.242	0.292
Kropp and Peckham (2012)	United States	1998–2008	Decoupled payments	0.609	0.615	0.619
Guastella et al. (2013)	EU (Italy)	1994–2008	SPS	– 0.017	0.198	0.412
Guastella et al. (2014)	EU (EU-25)	2006–2008	SAPS/SPS	0.224	0.226	0.229
Michalek et al. (2014)	EU (EU-15)	2004–2007	SPS	0.060	0.083	0.100
Feichtinger and Salhofer (2016)	EU (Bavaria)	2005–2011	LFA	– 0.209	0.319	0.683
			Single farm payments	0.141	0.340	0.432
Kirwan and Roberts (2016)	United States	2006–2007	Counter-cyclical payments	2.370	2.552	2.734
			Direct payments	– 0.098	0.299	0.765
Guastella et al. (2018)	EU (Italy)	2005–2008	SPS	0.024	0.082	0.160

Table 4. Estimated capitalisation of decoupled payments into land values in the empirical literature

Paper	Region	Period of analysis	Type of subsidy	Capitalisation level		
				Minimum	Mean	Maximum
Goodwin et al. (2003)	United States	1998	Agricultural Market Transition Act	0.197	0.197	0.197
	United States (Heartland)	1998	Agricultural Market Transition Act	0.017	0.017	0.017
	United States (Northern Great Plains)	1998	Agricultural Market Transition Act	0.272	0.272	0.272
	United States	1998–2001	Agricultural Market Transition Act	0.118	0.118	0.118
	United States	1999	Agricultural Market Transition Act	0.040	0.040	0.040
	United States (Heartland)	1999	Agricultural Market Transition Act	0.118	0.118	0.118
	United States (Northern Great Plains)	1999	Agricultural Market Transition Act	0.245	0.245	0.245
	United States	2000	Agricultural Market Transition Act	0.174	0.174	0.174
	United States (Heartland)	2000	Agricultural Market Transition Act	0.160	0.160	0.160
	United States (Northern Great Plains)	2000	Agricultural Market Transition Act	0.024	0.024	0.024
	United States	2001	Agricultural Market Transition Act	0.080	0.080	0.080
	United States (Heartland)	2001	Agricultural Market Transition Act	0.189	0.189	0.189
	United States (Northern Great Plains)	2001	Agricultural Market Transition Act	0.362	0.362	0.362
Goodwin et al. (2004)	United States	1998–2001	Agricultural Market Transition Act	0.032	0.058	0.083
Goodwin et al. (2011)	United States	1998–2005	Direct payments	0.048	0.088	0.128
Kropp and Peckham (2012)	United States	1998–2008	Decoupled payments	0.496	1.395	2.296
Valenti et al. (2020)	EU (Italy)	2006–2013	Decoupled subsidy	0.000	0.000	0.001

NB: The capitalisation rates are calculated following the NPV model by dividing the estimated level of capitalisation into land values by the present value of subsidies. As a proxy for the interest rate in the NPV model, we use the average 10 years' maturity US government bond yield between 2010 and 2019 (i.e. 2.396 %) from Eurostat.

4.2. Impact of coupled subsidies

Table 5 and Table 6 present findings from the literature on the impact of coupled subsidies on rental prices and land values. Similar to the case of decoupled subsidies, most studies provide estimates for the EU and the United States. One study is available for China ([21]).

In general, capitalisation estimates vary widely for coupled subsidies across the studies. However, they seem to be smaller than those for decoupled payments. Several studies estimate the capitalisation rate for coupled subsidies between 0 % and 50 %. Other studies find either a relatively high positive capitalisation rate (greater than 100 %) or a negative rate (see Table 5 and Table 6; Ciaian et al., 2021). A high variation in the estimated capitalisation effects is particularly observed across US studies. For example, coupled payments have been associated with both relatively large negative impacts (Lance and Mishra, 2003; Kropp and Peckham, 2012) and relatively large positive impacts (Kirwan, 2009).

As for the EU, the capitalisation of coupled payments seems to be positive but rather small for most studies using rental prices. Excluding Patton et al. (2008), the estimated capitalisation rates range between – 11 % (Guastella et al., 2013) and 24 % (Guastella et al., 2018). Patton et al. (2008) have analysed a wide range of livestock-related coupled payments and found greater capitalisation rates varying between – 2 % and 105 %. Only Valenti et al. (2020) have analysed the effects of coupled payments on land values and have estimated insignificant capitalisation rates (around 0 %).

Table 5. Estimated capitalisation of coupled payments into rental prices in the empirical literature

Paper	Region	Period of analysis	Type of subsidy	Capitalisation level		
				Minimum	Mean	Maximum
Lance and Mishra (2003)	United States (Iowa)	1997–2000	Loan deficiency payments	– 0.240	– 0.165	– 0.070
Goodwin et al. (2004)	United States	1998–2001	Loan deficiency payments	0.321	0.445	0.568
Patton et al. (2008)	EU (Northern Ireland)	1994–2002	2002 sheep annual premium	1.038	1.038	1.038
			Beef special premium	0.408	0.408	0.408
			Hill livestock compensation allowance	0.575	0.575	0.575
			Other beef	– 0.020	– 0.020	– 0.020
			Pre-2002 sheep annual premium	1.053	1.053	1.053
			Suckler cow premium	0.422	0.422	0.422
Kirwan (2009)	United States	1997–2006	Production subsidy	1.162	1.162	1.162
Goodwin et al. (2011)	United States	1998–2005	Loan deficiency payments	0.001	1.695	2.986
Kropp and Peckham (2012)	United States	1998–2008	Loan deficiency payments	– 0.796	0.104	0.435
Guastella et al. (2013)	EU (Italy)	1994–2008	Coupled	– 0.109	0.063	0.235
Van Herck et al. (2013)	EU (new MS)	1994–2009	Market price support	0.050	0.050	0.050
Guastella et al. (2014)	EU (EU-25)	2006–2008	Payments for energy crops	– 0.002	0.000	0.002
Guastella et al. (2018)	EU (Italy)	2000–2004	Coupled payments	– 0.035	0.052	0.237
Zhang et al. (2020)	China	2012	Grain subsidies	0.160	0.160	0.160

([21]) For the United States, loan deficiency payments were considered in the literature. These are direct payments that allow producers to receive support equal to the difference between the market price and the support price. Loan deficiency payments are typically considered coupled payments, because they are linked to both current production and current market prices (Kropp and Peckham, 2012). For China, Zhang et al. (2020) consider grain subsidies, which include direct grain subsidy, quality seed subsidy, comprehensive input subsidy (to cover costs of materials such as fertilisers and pesticides) and agricultural machinery subsidy.

Table 6. Estimated capitalisation of coupled payments into land values in the empirical literature

Paper	Region	Period of analysis	Type of subsidy	Capitalisation level		
				Minimum	Mean	Maximum
Goodwin et al. (2003)	United States	1998	Loan deficiency payments	0.106	0.106	0.106
	United States (Heartland)	1998	Loan deficiency payments	– 0.020	– 0.020	– 0.020
	United States (Northern Great Plains)	1998	Loan deficiency payments	0.084	0.084	0.084
	United States	1998–2001	Loan deficiency payments	0.157	0.157	0.157
	United States	1999	Loan deficiency payments	0.150	0.150	0.150
	United States (Heartland)	1999	Loan deficiency payments	0.237	0.237	0.237
	United States (Northern Great Plains)	1999	Loan deficiency payments	0.018	0.018	0.018
	United States	2000	Loan deficiency payments	0.215	0.215	0.215
	United States (Heartland)	2000	Loan deficiency payments	0.125	0.125	0.125
	United States (Northern Great Plains)	2000	Loan deficiency payments	0.199	0.199	0.199
	United States	2001	Loan deficiency payments	0.105	0.105	0.105
	United States (Heartland)	2001	Loan deficiency payments	0.159	0.159	0.159
	United States (Northern Great Plains)	2001	Loan deficiency payments	0.069	0.069	0.069
Goodwin et al. (2004)	United States	1998–2001	Loan deficiency payments	0.099	0.214	0.329
Goodwin et al. (2011)	United States	1998–2005	Loan deficiency payments	0.057	0.281	0.505
Kropp and Peckham (2012)	United States	1998–2008	Loan deficiency payments	– 0.500	0.015	0.301
Valenti et al. (2020)	EU (Italy)	2006–2013	Coupled subsidy	0.000	0.002	0.003

NB: The capitalisation rates are calculated following the NPV model by dividing the estimated level of capitalisation into land values by the present value of subsidies. As a proxy for the interest rate in the NPV model, we use the average 10 years' maturity US government bond yield between 2010 and 2019 (i.e. 2.396 %) extracted from Eurostat.

4.3. Impact of the rural development programme and other agricultural subsidies

Some types of agricultural subsidies considered in the literature do not clearly fit the decoupled/coupled distinction, and, therefore, they are evaluated separately. These subsidies include aggregate payments, aggregate direct payments (CAP Pillar I) (i.e. coupled and decoupled payments combined), aggregate RDP payments (CAP Pillar II), specific environmental and disaster payments and other subsidies. Theoretically, it is not straightforward to predict their expected capitalisation level. However, as they could include a combination of coupled payments, decoupled payments and/or RDP subsidies, their estimated capitalisation level is expected to be a combined effect of subsidy types actually represented in estimates. Table 7 and Table 8 present the summary results of the empirical literature on the capitalisation effects of these subsidies on rental prices and land values, respectively. Overall the estimates reported in the tables vary widely, from relatively highly negative capitalisation rates (Goodwin et al., 2004; Goodwin et al., 2011) to highly positive capitalisation rates (Goodwin et al., 2004; Kropp and Peckham, 2012).

The majority of the studies find a significant positive capitalisation rate of aggregate payments into rental rates for both the EU and the United States. The estimates for rental rates vary between – 34 % (Kirwan, 2009) and 116 % (Goodwin et al., 2004; Goodwin et al., 2011). The capitalisation rates of aggregate payments into land values seem to be higher in magnitude and variation across studies than estimates for rental prices. They range between – 10 % (Shaik et al., 2005) and 558 % (Kropp and Peckham, 2012). Note that, for the EU, aggregate subsidies could include both CAP Pillar I and CAP Pillar II types of payments. Regarding the aggregate Pillar I payments, Hendricks et al. (2012) estimate their capitalisation rate into rental prices to range between 0 % and 48 %, whereas the estimates of O'Neill and Hanrahan (2016) are between 9 % and 77 %.

The aggregate CAP Pillar II payments are an aggregation of various types of payments that span from AEM payments, LFA payments and investment support to other types of RDP payments. The capitalisation rates of the Pillar II payments into both rental prices and land values have been found to vary between small or negative values and 89 % (O'Neill and Hanrahan, 2016; Valenti et al., 2020).

An important type of agricultural subsidy studied in the literature is payments for the conservation of the environment and the adoption of environmentally friendly farm practices. In the United States these payments include Conservation Reserve Program payments, whereas in the EU they cover agri-environmental payments (as part of CAP Pillar II). Environmental payments seem to be largely associated with a negative or small positive capitalisation effect for both rental prices and land values. For both the EU and the United States, most estimates vary between (strongly) negative (– 40 %) and relatively small positive effects (15 %) (e.g. Goodwin et al., 2003, 2004; Lance and Mishra, 2003; Kilian et al., 2012; Feichtinger and Salhofer, 2016).

Other types of subsidies studied in the literature include the disaster payments that are part of US agricultural policy. There seem to be large uncertainties around their capitalisation effects, as estimates were found to range between largely negative (Goodwin et al., 2011; Kropp and Peckham, 2012) and largely positive rates (Kropp and Peckham, 2012).

Finally, for other payments covered in the empirical literature, no clear pattern can be detected for their capitalisation effects across studies. The estimates range from small and negative capitalisation rates (Goodwin et al., 2003; Goodwin et al., 2011) to positive capitalisation rates (Goodwin et al., 2003; Goodwin et al., 2011; Kropp and Peckham, 2012).

Table 7. Estimated capitalisation of other types of payments into rental prices in the empirical literature

Paper	**Region**	**Period of analysis**	**Type of subsidy**	**Capitalisation level**		
				Minimum	**Mean**	**Maximum**
Lance and Mishra (2003)	United States (Iowa)	1997–2000	Conservation Reserve Program	0.048	0.095	0.144
Goodwin et al. (2004)	United States	1998–2001	Conservation Reserve Program	– 0.401	– 0.382	– 0.362
			Ad hoc assistance	1.161	1.161	1.161
Patton et al. (2008)	EU (Northern Ireland)	1994–2002	General subsidies	0.790	0.790	0.790
Kirwan (2009)	United States	1992–1997	Aggregate excluding Conservation Reserve Program	– 0.342	0.203	0.658
		1998–1999	Aggregate excluding Conservation Reserve Program	0.061	0.172	0.318
Kirwan and Roberts (2010)	United States	2006	Aggregate payments	0.079	0.238	0.476
Goodwin et al. (2011)	United States	1998–2005	Aggregate payments	0.321	0.749	1.164
			Disaster payments	– 0.784	– 0.521	– 0.258
			Other payments	– 0.133	1.006	2.251
Ciaian and Kancs (2012)	EU (new MS)	2004–2005	Other	0.078	0.081	0.086
Hendricks et al. (2012)	United States (Kansas)	1990–2008	Aggregate subsidies	0.060	0.178	0.480
Kilian et al. (2012)	EU (Bavaria)	2005	Agri-environmental payments	– 0.220	– 0.142	– 0.063
Kropp and Peckham (2012)	United States	1998–2008	Conservation Reserve Program	– 0.494	– 0.231	0.044
			Aggregate payments	0.317	0.566	0.817
			Disaster payments	0.520	0.919	1.972
			Other	0.026	0.217	0.374
Van Herck et al. (2013)	EU (new MS)	1994–2009	Aggregate	0.120	0.227	0.480
Feichtinger and Salhofer (2016)	EU (Bavaria)	2005–2011	Agri-environmental payments	0.049	0.118	0.312
O'Neill and Hanrahan (2016)	EU (Ireland)	2000–2004	CAP Pillar I	0.145	0.459	0.767
		2005–2009	CAP Pillar I	0.092	0.242	0.407
		2000–2004	CAP Pillar II	0.061	0.451	0.893
		2005–2009	CAP Pillar II	0.074	0.265	0.527

Table 8. Estimated capitalisation of other payments into land values in the empirical literature

Paper	Region	Period of analysis	Type of subsidy	Capitalisation level		
				Minimum	Mean	Maximum
Barnard et al. (1997)	United States	1994–1996	Aggregate payments	0.000	0.234	0.500
Goodwin et al. (2003)	United States	1998	Conservation Reserve Program	– 0.379	– 0.379	– 0.379
	United States (Northern Great Plains)	1998	Conservation Reserve Program	0.086	0.086	0.086
	United States	1998–2001	Conservation Reserve Program	– 0.363	– 0.363	– 0.363
	United States	1999	Conservation Reserve Program	– 0.510	– 0.510	– 0.510
	United States (Heartland)	1999	Conservation Reserve Program	– 0.335	– 0.335	– 0.335
	United States (Northern Great Plains)	1999	Conservation Reserve Program	– 0.196	– 0.196	– 0.196
	United States	2000	Conservation Reserve Program	– 0.138	– 0.138	– 0.138
	United States (Heartland)	2000	Conservation Reserve Program	0.040	0.040	0.040
	United States (Northern Great Plains)	2000	Conservation Reserve Program	– 0.226	– 0.226	– 0.226
	United States	2001	Conservation Reserve Program	– 0.305	– 0.305	– 0.305
	United States (Northern Great Plains)	2001	Conservation Reserve Program	– 0.441	– 0.441	– 0.441
	United States	1998–2001	Aggregate payments	0.112	0.115	0.118
	United States	1998	Disaster payments	– 0.003	– 0.003	– 0.003
	United States (Heartland)	1998	Disaster payments	– 0.115	– 0.115	– 0.115
	United States (Northern Great Plains)	1998	Disaster payments	0.367	0.367	0.367
	United States	1998–2001	Disaster payments	0.112	0.112	0.112
	United States	1999	Disaster payments	0.156	0.156	0.156
	United States (Heartland)	1999	Disaster payments	0.238	0.238	0.238
	United States (Northern Great Plains)	1999	Disaster payments	0.033	0.033	0.033
	United States	2000	Disaster payments	0.074	0.074	0.074
	United States (Heartland)	2000	Disaster payments	– 0.060	– 0.060	– 0.060
	United States (Northern Great Plains)	2000	Disaster payments	– 0.019	– 0.019	– 0.019
	United States	2001	Disaster payments	0.096	0.096	0.096
	United States (Heartland)	2001	Disaster payments	0.071	0.071	0.071
	United States (Northern Great Plains)	2001	Disaster payments	– 0.031	– 0.031	– 0.031
	United States	1998	Other	0.067	0.067	0.067
	United States (Heartland)	1998	Other	– 0.029	– 0.029	– 0.029
	United States (Northern Great Plains)	1998	Other	– 0.069	– 0.069	– 0.069
	United States	1998–2001	Other	0.065	0.065	0.065
	United States	1999	Other	0.117	0.117	0.117
	United States (Heartland)	1999	Other	– 0.040	– 0.040	– 0.040
	United States (Northern Great Plains)	1999	Other	0.014	0.014	0.014
	United States	2000	Other	0.031	0.031	0.031
	United States (Heartland)	2000	Other	– 0.058	– 0.058	– 0.058
	United States (Northern Great Plains)	2000	Other	0.204	0.204	0.204
	United States	2001	Other	0.059	0.059	0.059
	United States (Heartland)	2001	Other	0.287	0.287	0.287
	United States (Northern Great Plains)	2001	Other	0.513	0.513	0.513
Goodwin et al. (2004)	United States	1998–2001	Conservation Reserve Program	– 0.515	– 0.512	– 0.508
			Ad hoc assistance	0.130	0.164	0.197
			Aggregate payments	0.080	0.160	0.239
Shaik et al. (2005)	United States	1940–2002	Aggregate subsidies	– 0.109	0.888	3.398
Devadoss and Manchu (2007)	United States (Idaho)	1983–1997	Aggregate	0.000	0.000	0.000
Goodwin et al. (2011)	United States	1998–2005	Aggregate payments	0.070	0.192	0.315
			Disaster payments	0.120	0.433	0.745
			Other payments	– 0.022	0.016	0.076
Kropp and Peckham (2012)	United States	1998–2008	Conservation Reserve Program	0.108	0.231	0.378
			Aggregate payments	0.067	1.039	5.583
			Disaster payments	– 0.578	– 0.431	– 0.362
			Other	0.208	0.650	1.127
Vyn et al. (2012)	Canada	1959–2009	Aggregate subsidies	0.112	0.182	0.240
Valenti et al. (2020)	EU (Italy)	2006–2013	CAP Pillar II	0.000	0.000	0.000

NB: The capitalisation rates are calculated following the NPV model by dividing the estimated level of capitalisation into land values by the present value of subsidies. As a proxy for the interest rate in the NPV model, we use the average 10 years' maturity US government bond yield between 2010 and 2019 (i.e. 2.396 %) extracted from Eurostat.

5. Data

The main data source used in this report is the FADN database ([22]), which is compiled and maintained by the European Commission. The FADN database is a compilation of annual surveys carried out in each MS that has been part of the EU since 1989, and contains detailed structural and accountancy information on European farms. Information contained in the database includes farm structures, yields, output, input, costs, subsidies, income and other financial indicators. The FADN is the only harmonised and representative data source at the farm level in the EU, and therefore it is very valuable for monitoring and analysing the evolution of the farming sector in the EU.

In 2016, the yearly FADN sample covered approximately 80 000 farms across all MS. Every farm in the sample is associated with a specific weight that represents the number of farms in the population that are associated with that farm. In 2016, the FADN represented over 4.4 million farms and covered around 90 % of the total utilised agricultural area (UAA) of the EU ([23]).

The field of observation of the FADN is restricted to those farms defined as commercial. A farm is defined as commercial when it 'is large enough to provide a main activity for the farmer and a level of income sufficient to support his or her family' ([24]). Thus, the FADN excludes some smaller farms. Economic size is the measure used to classify farms into different size categories. Starting with Commission Regulation (EC) No 1242/2008 'Community typology for agricultural holdings', economic size is defined in the FADN as the total standard output of the farm expressed in euro (European Union, 2008) ([25]). Before 2008, economic size was expressed in terms of standard gross margin ([26]).

Farms are selected to take part in the FADN survey based on three conditions: (i) they are large enough, (ii) they have the required system of accounts, and (iii) they are willing to participate. Once they satisfy these conditions, farms are selected at random. To capture the heterogeneity of farming systems in the EU, the FADN stratifies the sample along three dimensions: FADN region, economic size and types of farming.

In this report, we use the FADN data at the level of FADN regions covering all MS for 1989–2016. Note that the period covered in the FADN differs between MS depending on their date of EU accession. For old MS, FADN data include the whole 1989–2016 period; for other MS, the period is shorter and data start from the year a particular MS joined the EU.

Additional data sources, such as Eurostat, the World Bank and the Copernicus programme, have been used to complement the information contained in the FADN database. The use of these data sources allowed the creation of a set of comparable statistics over the period covered by the analysis of this report.

5.1. Farm Accountancy Data Network data

The FADN database has been used to obtain all the agricultural-related information used in this report. In particular, information on rental prices and land values, subsidies, output values and structural characteristics of the farming sector have been extracted from it.

Regarding land rental prices, the FADN database contains information on the total value of rent paid by those farmers that rent land. This information is contained in the 'Standard Results' section of the database, and it is under the heading SE375, 'Rent Paid'. According to RI/CC 1680 v.5, March 2019, rent paid includes the rental price for land, buildings, quotas and other rights for the farm business.

Regarding land values, the 'Standard Results' section of the FADN database contains the heading SE446 'Land, permanent crops and quotas'. According to RI/CC 1680 v.5, March 2019, SE446 contains the value of land owned by the holding, which in principle is evaluated at fair value or, if this is not available, at historical value. This definition contains two main pieces of information: (i) data refer only to land owned by the holding, and (ii) the evaluation of data can be done either at fair value or at historical value. Fair value refers to the amount for which land could be exchanged less the cost estimated to be incurred in relation to the sale. Historical value refers to the nominal or original cost of the assets when acquired.

([22]) The authors would like to thank Directorate-General for Agriculture and Rural Development Unit C.3, which provided the data.

([23]) https://ec.europa.eu/agriculture/rica/methodology2_en.cfm

([24]) https://ec.europa.eu/agriculture/rica/methodology1_en.cfm

([25]) The total standard output is the sum of the average monetary values of all the agricultural crop and livestock products produced in a year by a holding and valued at farm gate prices.

([26]) The standard gross margin is a classification measure based on the difference between expected revenues and costs of specific agricultural activities.

The variables 'rent paid' and 'land values' used in the report are converted to the per hectare bases obtained by dividing their total value by the corresponding total number of hectares of land (i.e. total rented land for land rent and total owned land for land value). Table 9 describes the construction of the two land price indicators used in this report.

Table 9. Land price information

Indicator	Description (FADN database)
Rental price / hectares of land	SE375/SE030
Land value / hectares of land	SE446/(SE025–SE030)

The second main set of information extracted from the FADN database is related to CAP payments. The FADN database classifies CAP payments into several aggregate categories: decoupled payments, coupled payments and CAP Pillar II payments. In addition, CAP Pillar II payments are further disaggregated into more specific measures, such as environmental payments, investment payments, LFA payments and other RDP payments. This classification available in the FADN database allowed the construction of consistent indicators of CAP payments, on a per hectare basis, for the whole period covered in the report. Table 10 presents the construction of the subsidy variables.

Table 10. Subsidy information

CAP pillar	Measure type	Description (FADN database)
Pillar I	Decoupled	SE630/SE025
	Coupled	(SE610+SE615)/SE025
Pillar II	Environment	SE621/SE025
	LFA	SE622/SE025
	Other RDP	SE623/SE025
	Investment	SE406/SE025

The third main variable used in the report is the output value of farms. This variable captures the value of farm production (or market returns) and is extracted from the FADN database under the heading SE131, 'Total Output'. It is a sum of all crop and livestock products produced in 1 year and evaluated at farm gate prices (in euro). To be comparable with the previous land price and subsidy indicators, output values have been converted to be per hectare (Table 11).

Table 11. Output value information

Output type	Description (section of FADN database)
Total output / hectares of land	SE131/SE025

As described in Section 3, subsidies and output values are the main drivers that are expected to impact land prices. Several additional variables, such the proportion of rented land, the proportion of land dedicated to specific farming activities, the number of livestock units, the value of fixed assets, labour intensity (annual working units) and other agricultural-related characteristics of farms, have been extracted from the FADN database and used in the econometric estimation of the capitalisation effects. These variables are described in Section 7.1, together with the econometric model specification.

The FADN also provides shapefiles (27) of FADN regions (28) that represent one of the dimensions of stratification of the sampling strategy. As explained below, the analysis of the capitalisation effect is carried out at the FADN region level. The maps of FADN regions have been used to construct aggregate statistics of the empirical investigation.

5.2. Eurostat data

The following Eurostat data have been used in this report: (i) deflation to convert the FADN current (nominal) monetary values into constant (real) values; (ii) macro variables, such as population density, employment rate and real gross domestic product (GDP) growth, at regional level; and (iii) maps at NUTS 2 and NUTS 3 levels.

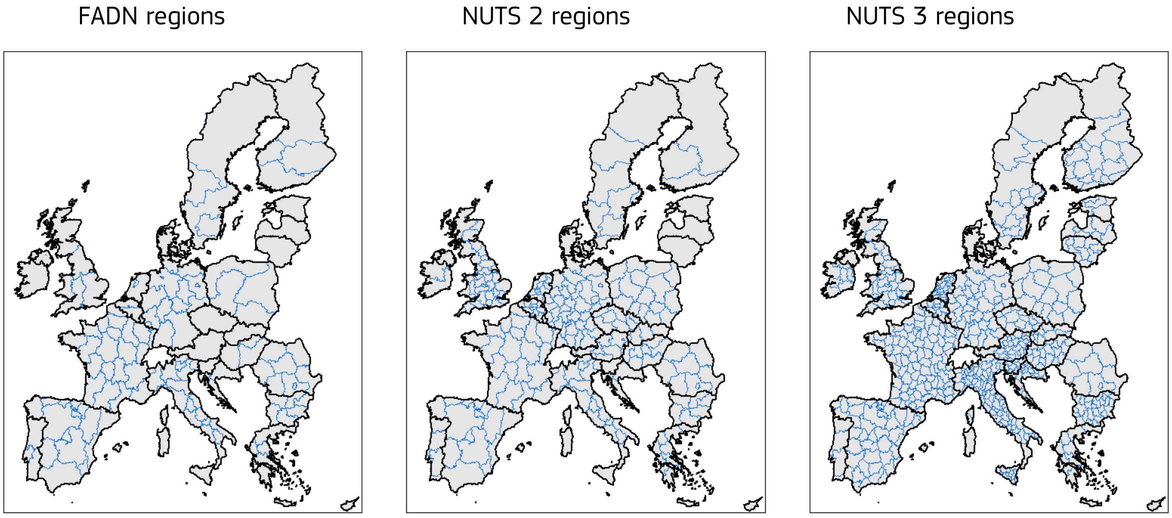
To obtain real monetary values for land values, rents, subsidies and output, the country-level GDP deflator (29) has been used to deflate FADN nominal values over the period considered. The GDP deflator is a measure of the price level of goods produced in each country. To deflate nominal land prices, the GDP deflator is considered to be more appropriate than the consumer price index, as it is more focused on the variation in the cost structures of the supply side of the economies of the MS. Country-level time series of the GDP deflators have been retrieved from the Eurostat online database. Eurostat GDP deflators are denominated in euro and therefore can be directly used to deflate the FADN monetary values (in euro). Note that the deflated monetary values are used only in Section 6 and not in econometric estimates (30).

Eurostat has been used to retrieve all regional statistics on macro variables, such as population density, GDP growth and employment rate. Eurostat statistics on macroeconomic variables were obtained at NUTS 2 level and then averaged at FADN region level to match the FADN data on land prices. Whenever NUTS 2-level data were not available, statistics at MS level have been used to fill in the data gaps. This has been particularly necessary for the first years of the panel when some Eurostat regional statistics were not available.

Eurostat also provides shapefiles (maps) of NUTS 2 and NUTS 3 regions of the EU. These maps have been particularly useful in mapping Eurostat regional statistics with FADN regions and for creating a map of FADN regions that is consistent throughout the period covered in the report. In fact, FADN regions – like any other administrative classification system – change over time. As FADN regions are aggregates of Eurostat NUTS 2 regions (31), the maps of NUTS 2 and NUTS 3 regions have been used to track the changes in FADN regions and to update the statistics of the FADN database. However, even NUTS 2 and NUTS 3 classifications have changed noticeably over time. Therefore, before being able to use them, an artificial regional classification that is consistent for 1989–2016 had to be created. Figure 4 presents these consistent maps of FADN regions and of NUTS 2 and NUTS 3 regions.

(27) A standard format to store geographical information system data.
(28) https://ec.europa.eu/agriculture/rica//othermaps_en.cfm
(29) See Eurostat's website (https://ec.europa.eu/eurostat/data/database; [nama_10_gdp]).
(30) The estimated equations include, on both (left and right) sides, monetary values, and thus they do not need to be deflated.
(31) With a few exceptions in Portugal, Finland and Sweden.

Figure 4. 1989–2016 consistent maps for EU regions (FADN, NUTS 2 and NUTS 3 regions)



Although the FADN regions are based on the existing classifications of FADN regions, the NUTS 2 and NUTS 3 final maps used in the report are based on an artificial combination of existing classifications. In general, these maps have been obtained through aggregation of those spatial units that have changed over time and are based on the Eurostat NUTS classification system. Owing to the relatively large number of changes made to the Eurostat NUTS 3 classification over time, the 1989–2016 consistent NUTS 3 map used in the report has been obtained through a mixture of NUTS 3 and NUTS 2 regions.

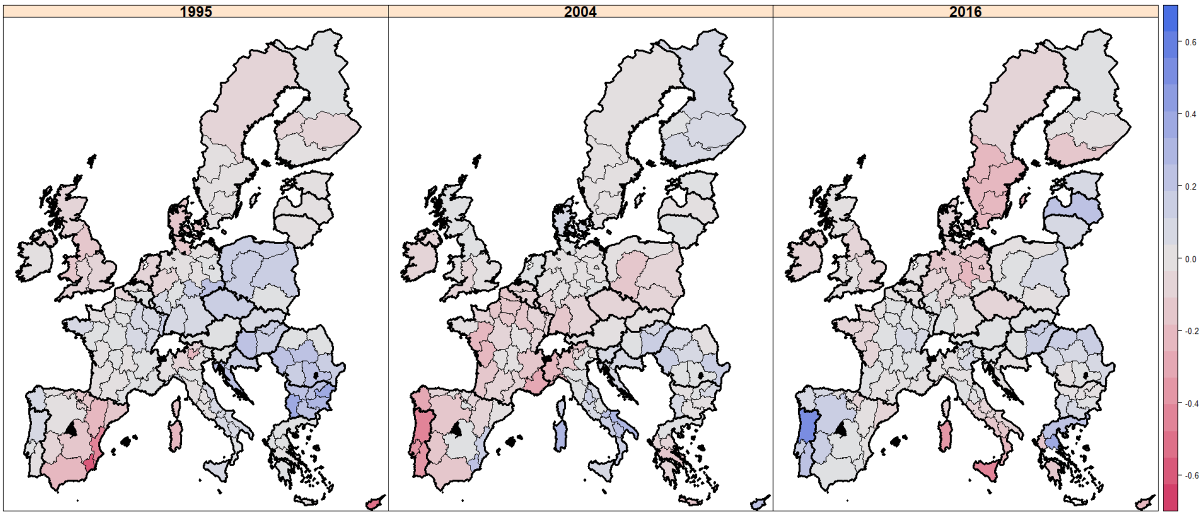
5.3. Other data sources

Two additional data sources used in the analysis are the World Bank database for inflation time series and the Copernicus programme for spatially explicit information on temperatures and rainfall. Although inflation can be an important driver of asset prices (Feldstein, 1978; Gloy et al., 2012), a changing climate could have effects on agricultural returns (Willenbockel, 2012; Powell and Reinhard, 2016) and, in turn, land prices.

Average country-level inflation rates have been retrieved from the World Bank statistical database, as they cover longer time horizons than Eurostat inflation statistics. Eurostat inflation statistics are available from 1996, whereas World Bank indicators go back as far as 1960. The World Bank inflation is used as a control variable in the econometric estimates.

Data from the Copernicus programme have been used to account for weather-related factors that may affect land prices. Data on daily average minimum and maximum temperatures, as well as cumulated rainfall, have been retrieved from the Copernicus database and used to construct indicators of climate change. In particular, three indicators have been constructed: (i) the annual deviation of average minimum temperatures from the long-term trend, (ii) the annual deviation of average maximum temperatures from the long-term trend and (iii) the annual deviation of cumulated rainfall from the long-term trend (Figure 5). The long-term trend has been defined as a moving window of 12 years prior to the current period.

Figure 5. Annual percentage deviation from rainfall 12-year trend (in 1995, 2004 and 2016)



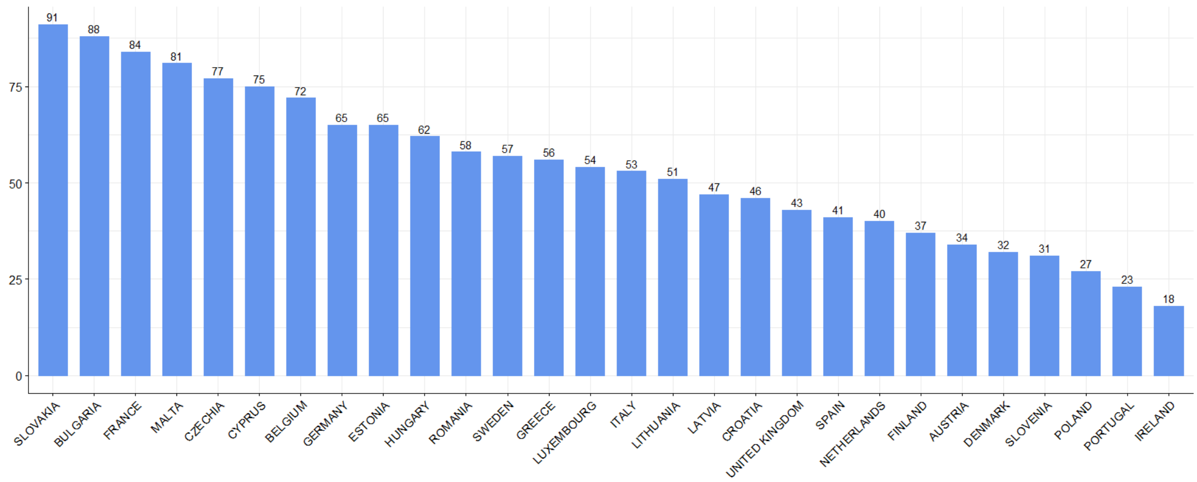
6. Development of land prices in the EU

Agricultural land prices depend on several geographical factors, such as climate, soil quality, slope and drainage, but may also depend on a number of specific local factors, such as infrastructure, regulations and proximity to networks and urban areas. In fact, there are large differences among land markets in MS with respect to the nature of land markets, local characteristics, the evolution of land prices over time, and land market regulations and institutions (Swinnen et al., 2013). The aim of this section is to give a representation of the evolution of land prices, both rental prices and land values, in the EU between 1989 and 2016.

6.1. Rental prices

There is wide variation in the proportion of rented UAA in the total UAA among MS. Figure 6 shows the proportion of rented land by MS in 2016. The proportion of rented land varies between 18 % in Ireland and 91 % in Slovakia. The average proportion of rented land in the EU is 55 %. MS with high proportions of rented land (more than 70 %) are Belgium, Bulgaria, Czechia, France, Cyprus, Malta and Slovakia. MS with the lowest proportions of the rented land (less than 30 %) are Ireland, Poland and Portugal.

Figure 6. Rented UAA as a proportion of total UAA in MS (2016) (%)



Large disparities in terms of proportion of rented UAA also exist within MS, and significant changes have taken place over time across MS. Figure 7 presents the proportion of rented UAA for FADN regions in the EU in 1995, 2004 and 2016. Over time, rented UAA as a proportion of total UAA increased at EU level from approximately 50.3 % in 1995 to approximately 54.7 % in 2016. This proportion increased both because of the accession of new MS, where more land renting takes place, and because the proportion of rented land increased in some of the old MS. The most significant changes in the old MS were observed in Greece, where land renting increased from 31.1 % in 1995 to 56.5 % in 2016, and Italy, where it increased from 33.8 % to 52.8 % over the same period. Among the new MS, a significant increase in land renting occurred in Latvia, from 39.2 % to 47.0 %, in Cyprus, from 67.7 % to 74.6 %, and in Estonia, from 60.8 % to 64.9 %, between 2004 and 2016. For a few old MS, such as Germany, the proportion of rented land decreased in the period shown in Figure 7. Large regional disparities in land renting can be found in old MS, such as Spain, Italy and the United Kingdom. Large disparities can also be found in Romania, where eastern regions in 2016 are characterised by a proportion of rented UAA larger than 60 % while western regions are characterised by significantly lower proportions.

Figure 7. Rented UAA as a proportion of total UAA in FADN regions (1995, 2004 and 2016) (%)

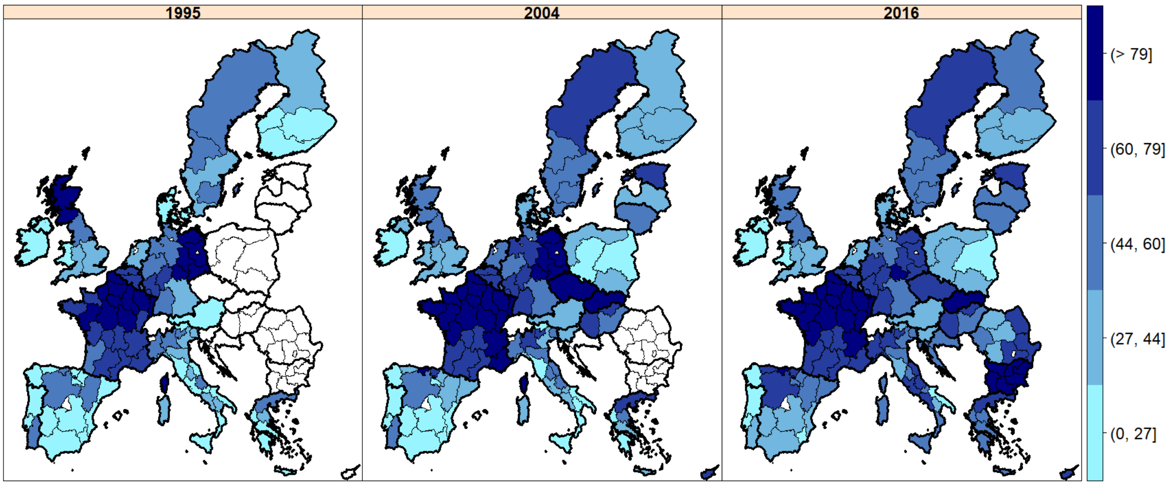


Figure 8 presents the evolution of MS-level average rental prices per hectare for MS that were part of the EU by 1989 [32]. Figure 9 shows rental prices for MS that joined the EU in 1995. Figure 10 presents rental prices for MS that joined the EU in 2004. Figure 11 presents rental prices for MS that joined the EU in 2007 or later (i.e. Bulgaria, Croatia and Romania). Both nominal values and real values [33] are presented for all MS for the available years.

Some patterns in the level and the evolution of rental prices can be identified. First, the levels of rental prices vary considerably across MS. Particularly high rental prices have been observed in Denmark and the Netherlands over the relevant period. For example, in 2016, the average rental prices were EUR 985/ha in the Netherlands and EUR 582.7/ha in Denmark (Figure 8). The lowest rental prices are in new MS, where their values are in general lower than EUR 100/ha, with the exception of Cyprus and Hungary. Particularly low rental prices could be observed in the three Baltic MS: in 2016, they were EUR 36.2/ha, EUR 44.5/ha and EUR 61.3/ha in Latvia, Estonia and Lithuania, respectively (Figure 10). In most other MS, the rental prices vary between EUR 150/ha and EUR 400/ha (Figure 8, Figure 9, Figure 10 and Figure 11).

Second, rental prices tend to show an upward trend across most MS over the time horizon considered, in both nominal and real terms. The exception to this trend is Greece, where nominal and real rental prices show decreasing values. In addition, relatively stable development is observed in Ireland, France, Italy, Austria and the United Kingdom, where real rental prices either decrease or remain stable over the time horizon considered. MS with relatively high rental price dynamics over the time horizon considered include Belgium, Denmark, the Netherlands, Finland, Sweden and new MS; in some of these the price more than doubled over the period analysed (e.g. Denmark, the Netherlands, Sweden and some new MS) (Figure 8, Figure 9, Figure 10 and Figure 11).

[32] Eastern Germany's accession date in the FADN system was in 1995. As can be seen from Figure 7, rental prices per hectare in Germany decreased in 1995 because of the accession of Eastern Germany.

[33] Real values have been obtained by deflating nominal values with the Eurostat GDP deflators denominated in euro. As the GDP deflator was not available for all MS between 1989 and 1995, real valued land prices could not be obtained for all MS in all years.

Figure 8. Evolution of average MS-level nominal and real rental prices in MS that were part of the EU in 1989 (EUR/ha, 1989–2016)

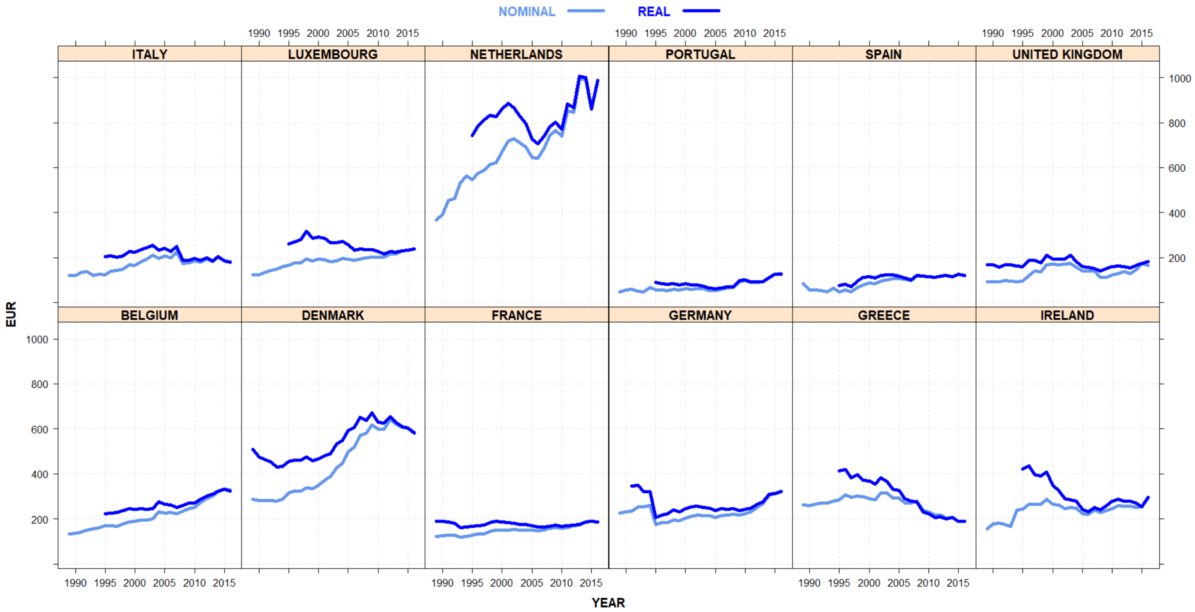


Figure 9. Evolution of average MS-level nominal and real rental prices in MS that joined the EU in 1995 (EUR/ha, 1995–2016)

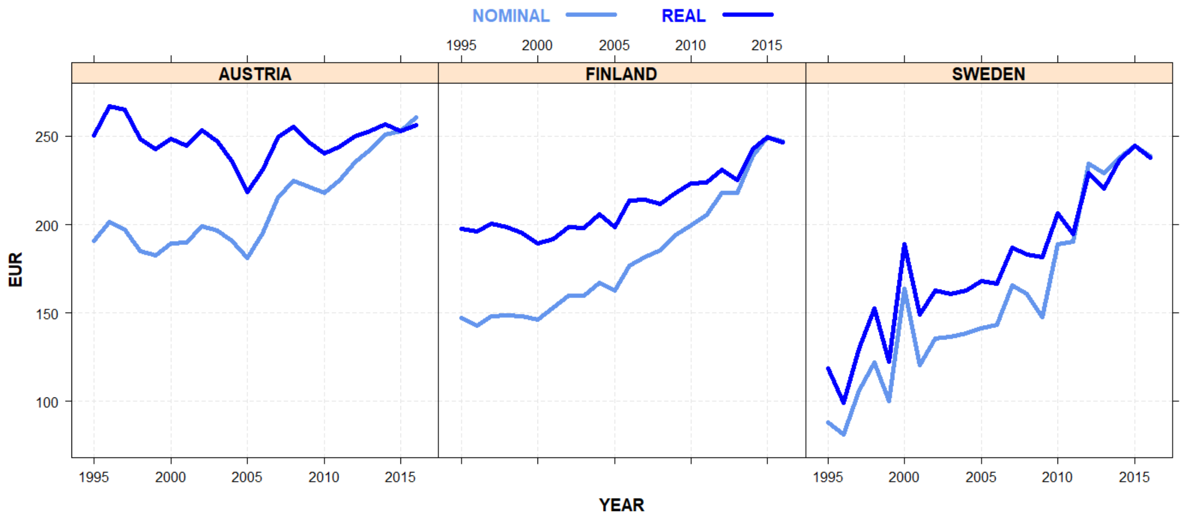


Figure 10. Evolution of average MS-level nominal and real rental prices in MS that joined the EU in 2004 (EUR/ha, 2004–2016)

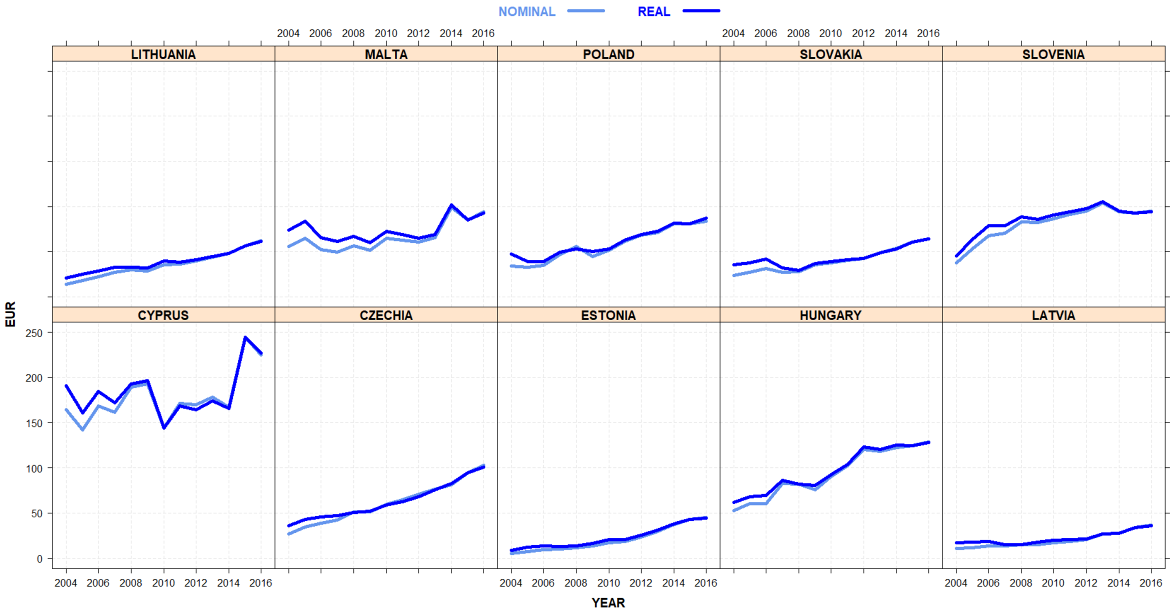
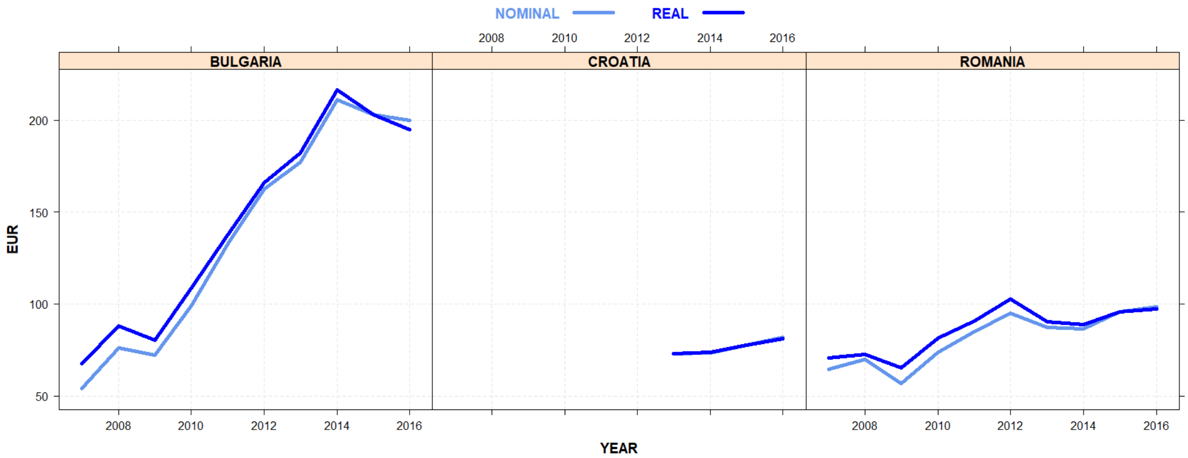
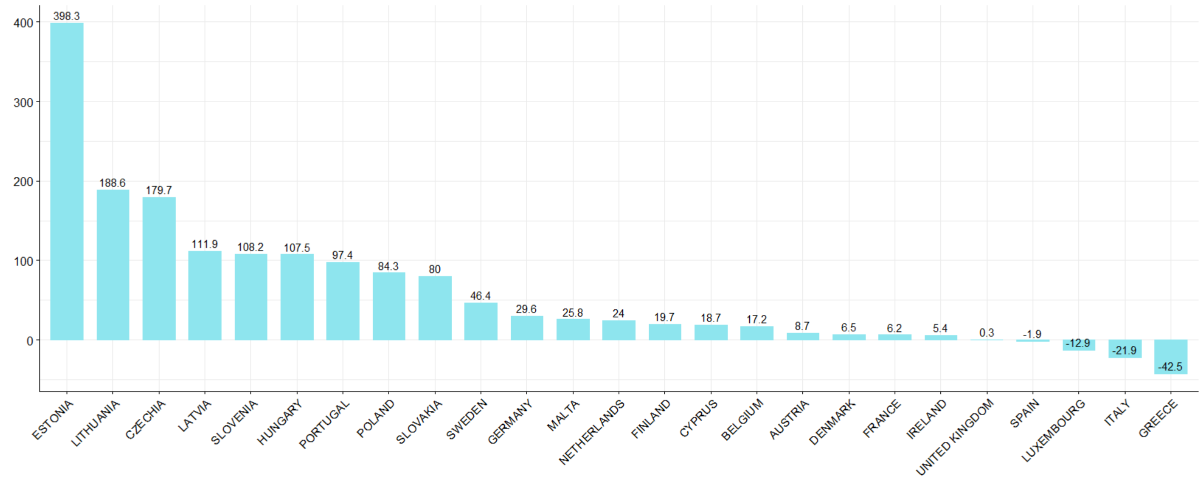


Figure 11. Evolution of average MS-level nominal and real rental prices in MS that joined the EU in 2007 or later (EUR/ha, 2007–2016)



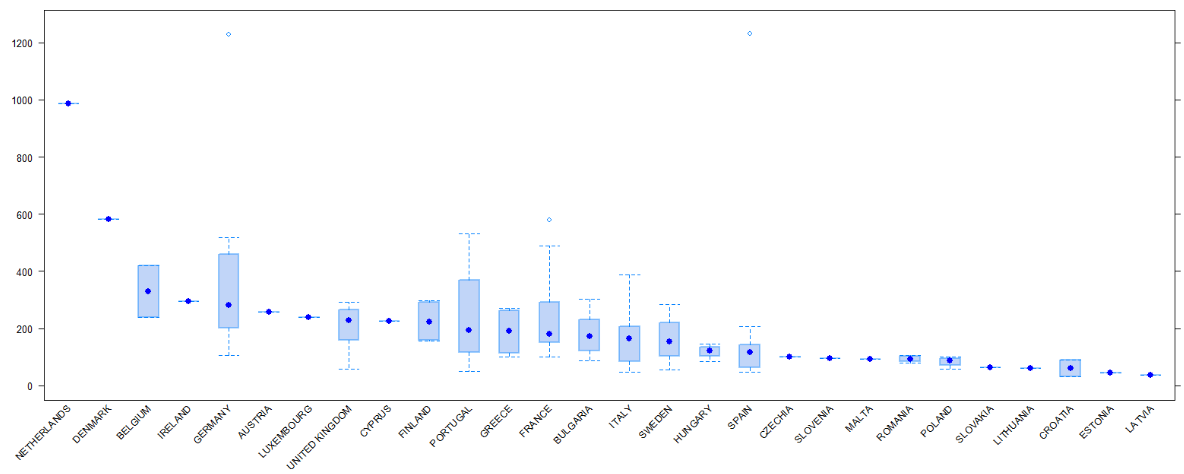
To have a comparable base for the evolution of rental prices over time across MS, Figure 12 shows the percentage change in (real) rental prices between 2004 and 2016 by MS (the figure does not include Bulgaria, Croatia and Romania). According to the figure, the MS that joined the EU in 2004 exhibit the largest growth rates among all MS. Between 2004 and 2016, rental prices grew by almost 400 % in Estonia, by 189 % in Lithuania, by 180 % in Czechia, by 112 % in Latvia, by 108 % in Slovenia and by 107 % in Hungary. Poland, Portugal, Slovakia and Sweden also exhibited sizeable growth rates of land rents, of between 45 % and 84 % in real terms, in the same period. In general, older MS exhibited smaller growth rates. In this group, Portugal reports the largest growth in rental prices (97.4 %), followed by Sweden (46.4 %) and Germany (29.6 %). Spain, Luxembourg, Italy and Greece exhibited a decline in real rental prices over this period (– 1.9 %, – 12.9 %, – 21.9 % and – 42.5 %, respectively) (Figure 12). Bulgaria, Croatia and Romania also recorded substantial increases in land rents since their accession. Between the accession date and 2016, Bulgaria, Romania and Croatia registered a growth in real rental prices of 188 %, 37 % and 11 %, respectively (not shown in Figure 12).

Figure 12. Change in the average (real) rental prices between 2004 and 2016 by MS (%)



Rental prices also vary sizeably within MS. Figure 13 shows the distributions of regional rental prices across all MS for 2016. Although the distributions are not directly comparable between countries because MS differ in size (number of regions) and the heterogeneity in agro-economic and climatic conditions, the figure shows sizeable regional variations. Relatively large variation could be found in most of the old MS and in some new MS. The regional variation in rental prices in Germany, France, Italy and Portugal seems to be particularly large. Moreover, Germany, Spain and France present some extreme values in their distributions of regional rental prices. Some new MS, such as Bulgaria, Croatia and Hungary, also show some significant internal variation in rental prices.

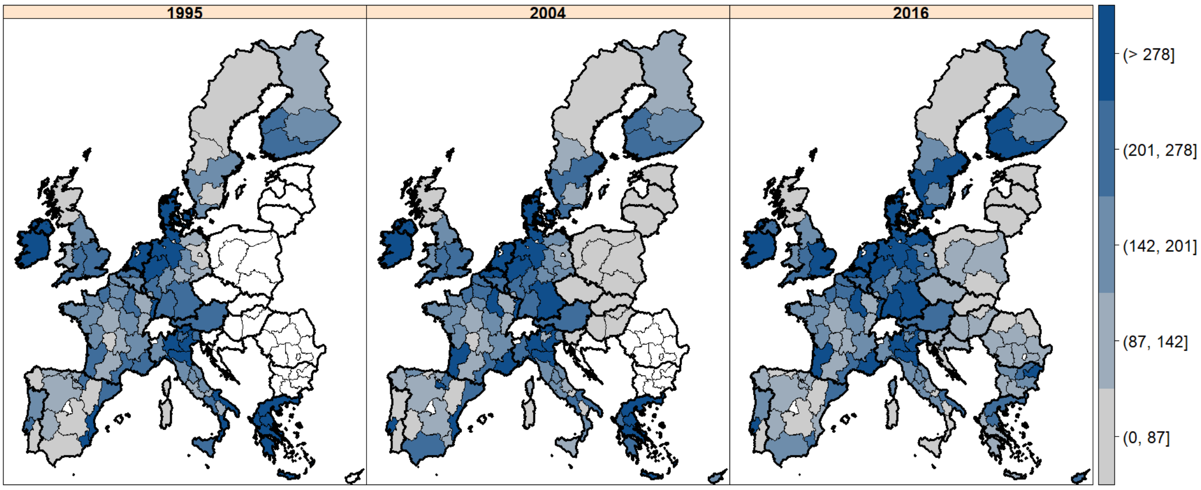
Figure 13. Distributions of regional (real) rental prices (EUR) across FADN regions by MS (2016)



NB: MS are sorted according to their median regional rental rate.

Figure 14 presents average (real) rental prices for the whole of the EU at the FADN region level in 1995, 2004 and 2016. The three maps give a summary of both the temporal and the cross-sectional variation in rental prices across regions in the EU. As discussed above, a general increasing trend in real rental prices in the EU is observed over the considered period. This increase is particularly pronounced in those new MS that joined the EU in 2004 or later. In some old MS, the real land rental prices remained rather stable over the period. Large variations within MS can be observed, especially in old MS. The central EU regions of Belgium, Denmark, Germany, France, northern Italy and the Netherlands are associated with higher rental prices. Some of the geographically peripheral regions of Portugal, Sweden, Baltic and eastern MS, and the United Kingdom are associated with lower regional rental prices.

Figure 14. Average (real) rental prices in EU FADN regions (EUR/ha, in 1995, 2004 and 2016) (*)



(*)Those FADN regions with 15 farms or fewer have been removed from the maps and represented as white polygons.

Table 12 presents the 10 FADN regions ([34]) with the highest average rental prices in 2016. Table 12 also shows their land prices in 1995 and 2004, as well as their growth rates between these years. German regions are the most represented in the top 10 ranking, with Hamburg ([35]) being the FADN region with the highest rental price reported for the considered period. These top 10 regions show relatively significant growth rates of rental prices for 1995–2016. The only exceptions are Veneto and Alsace, which exhibited a decrease in their rental rates between 2004 and 2016.

Table 12. Average rental prices (EUR) and growth rates (top 10 FADN regions)

MS	FADN region	2016	2004	1995	Δ % 2004–2016	Δ % 1995–2004
Germany	Hamburg	1 228.0	1 223.8	—	0	—
The Netherlands	Netherlands	985.9	795.2	743.4	+ 24	+ 7
Denmark	Denmark	582.8	547.0	456.0	+ 7	+ 20
Portugal	Ribatejo e Oeste	531.7	414.5	204.7	+ 28	+ 102
Germany	Nordrhein-Westfalen	517.0	434.6	381.6	+ 19	+ 14
Germany	Niedersachsen	497.9	395.5	350.4	+ 26	+ 13
Germany	Schleswig-Holstein	459.8	409.8	360.9	+ 12	+ 14
Belgium	Vlaanderen	420.7	340.3	268.6	+ 24	+ 27
Italy	Veneto	388.2	446.2	297.4	– 13	+ 50
France	Alsace	344.8	373.1	307.0	– 8	+ 22

6.2. Land values

Similar to rental prices, we show the evolution of the average per hectare land values (both nominal and real values ([36])) for the available years. Figure 15 presents the evolution of land values for MS that were part of the EU by 1989. Figure 16 shows land values for MS that joined the EU in 1995. Figure 17 and Figure 18 present land values for MS that joined the EU in 2004. Figure 19 presents land values for MS that joined the EU in 2007 or later.

Generally, land values tend to increase across MS over the considered period. However, the upward trend is less pronounced than in the case of rental prices, and several MS show rather stable levels of evolution of land values over the period analysed. The exceptions are Germany ([37]), Italy, Malta and Portugal, which have

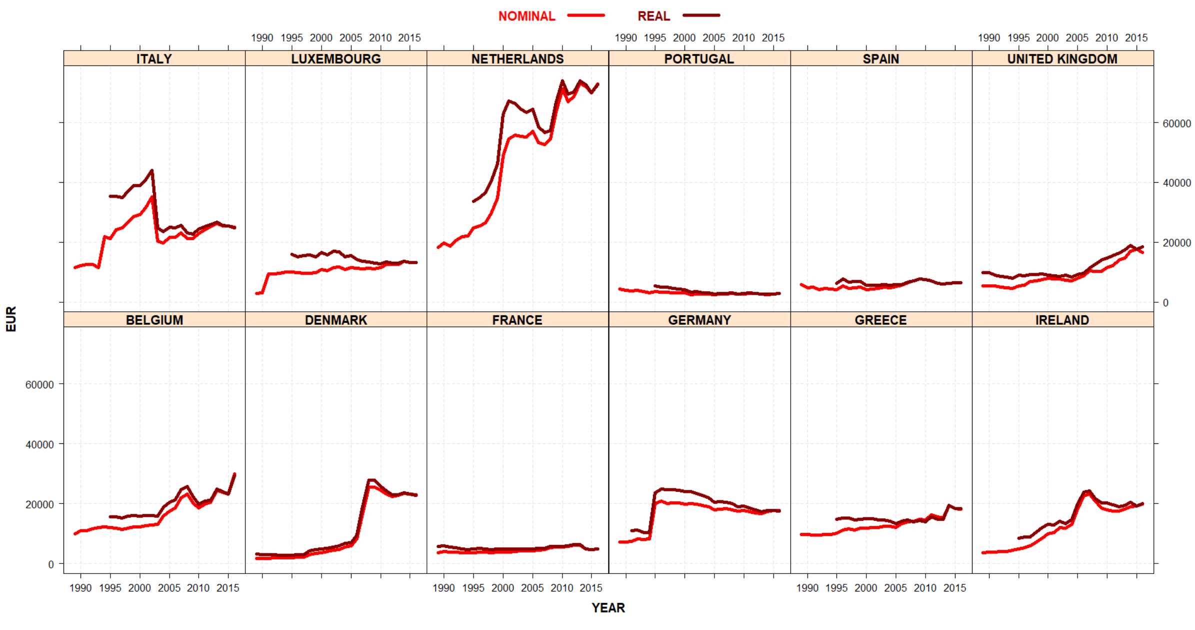
([34]) Excluding the peripheral islands of Canarias, Madeira and La Reunion, which are not presented in Figure 14.
([35]) Data for Hamburg were not available in 1995 owing to the small number of observations.
([36]) Real values could not be obtained for all MS in all years owing to data gaps in the time series of GDP deflators.
([37]) Only after Eastern Germany entered the system of FADN accounts. In fact, in 1995 there was a drastic increase in the average

experienced a decrease in land values. In Greece, Spain, France, Cyprus, Luxembourg, Slovenia and Slovakia, land values remained rather stable in real terms over the considered period. In Austria, a large decrease in land value was experienced in the first year after accession. In the following years, despite fluctuations, land prices remained rather stable in Austria. In other MS, land values increased over time (Figure 15, Figure 16, Figure 17, Figure 18 and Figure 19).

Figure 20 shows the percentage change in the average real land values between 2004 and 2016 by MS (the figure does not include Bulgaria, Croatia and Romania). Compared with rental prices, the increase in land values in the new MS is not so evident, but it remained rather stable in several of them between 2004 and 2016. The largest increases in the real land values are observed in Poland (310 %), Denmark (240 %), Sweden (164 %), the United Kingdom (122 %), Latvia (99 %), Estonia (73 %) and Belgium (56 %). The average land values increased considerably (between 15 % and 50 %) in Finland, Ireland, Greece, Cyprus and Spain. In contrast, Slovakia, Malta, Germany, Luxembourg, Portugal, France and Slovenia experienced a decrease in average land values between 2004 and 2016. In the rest of the MS, the land values increased between 5 % and 15 % (Figure 20). In addition, land values in Bulgaria, Croatia and Romania increased, compared with their values in the first year of EU accession (Figure 19).

It is important to note that some MS show some discontinuity in land value development, which may reflect the change in methodology or sampling of FADN farms. The most visible discontinuous developments in land values are in Bulgaria in 2010, Denmark in 2005, Germany in 1995 and Poland in 2008. For example, in Bulgaria, land values spiked from less than EUR 5 000/ha in 2009 to around EUR 20 000/ha in 2010 and fluctuated widely until 2013, when they returned to a level (below EUR 5 000/ha) comparable to the pre-2010 period.

Figure 15. Evolution of average MS-level nominal and real land values in MS that were part of the EU in 1989 (EUR/ha, 1989–2016)



land value in Germany.

Figure 16. Evolution of MS-level nominal and land values in MS that joined the EU in 1995 (EUR/ha, 1995–2016)

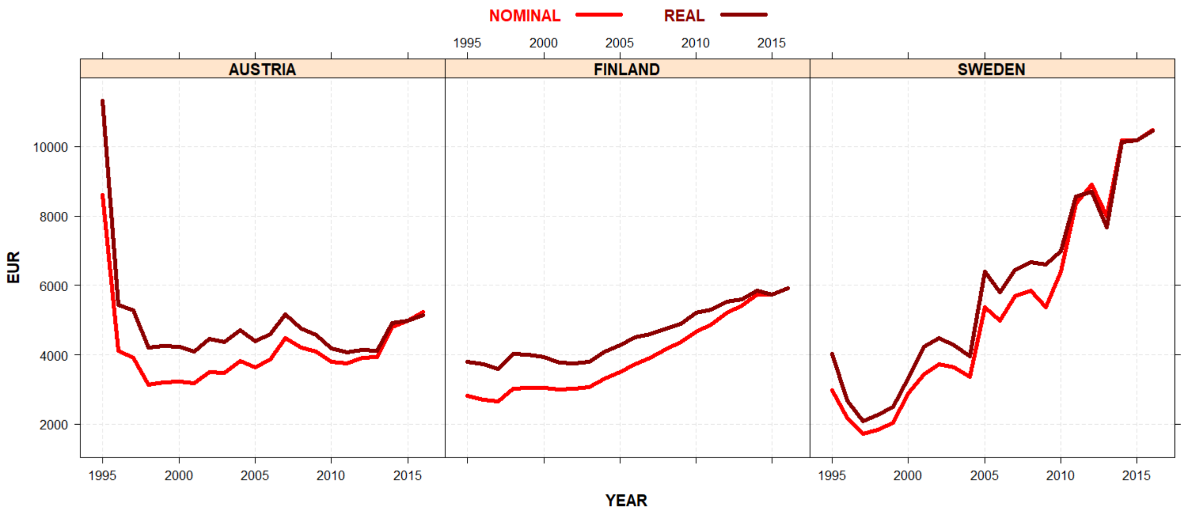


Figure 17. Evolution of MS-level nominal and land values in MS that joined the EU in 2004 (excluding Cyprus and Malta) (EUR/ha, 2004–2016)

Figure 18. Evolution of MS-level nominal and land values in Cyprus and Malta (EUR/ha, 2004–2016)

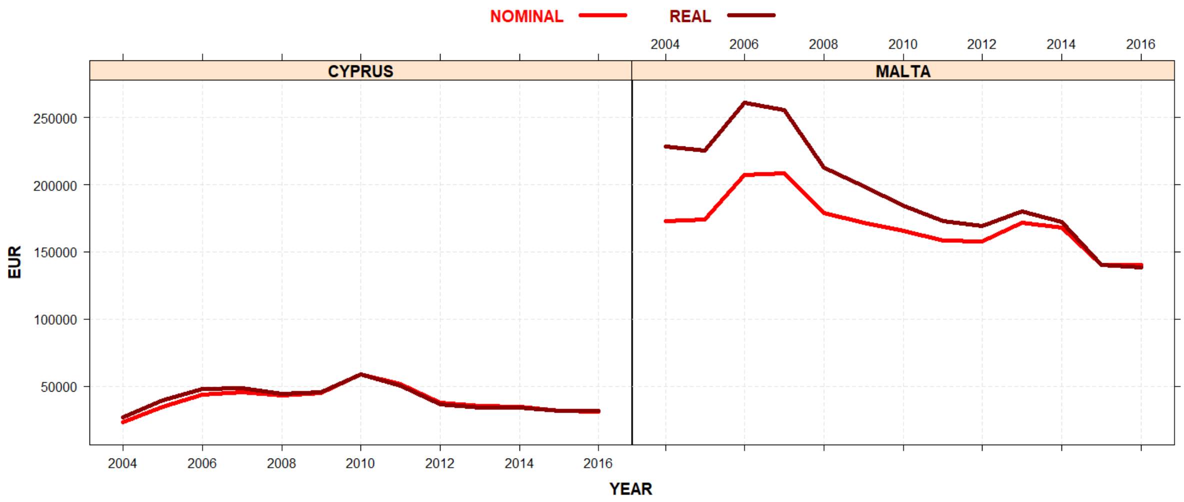


Figure 19. Evolution of MS-level nominal and land values in Bulgaria, Croatia and Romania (EUR/ha, 2007–2016)

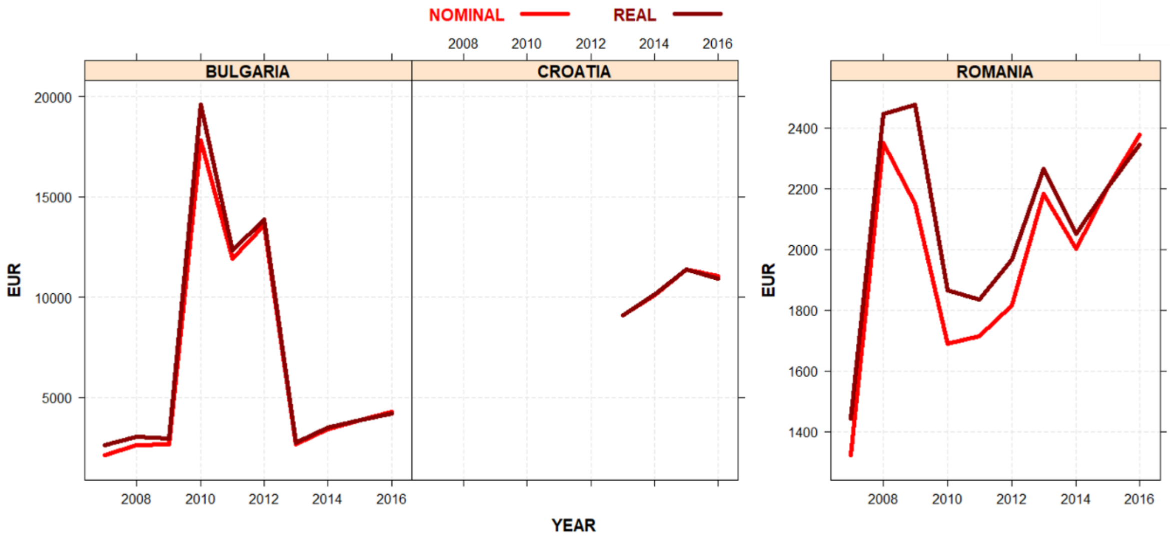
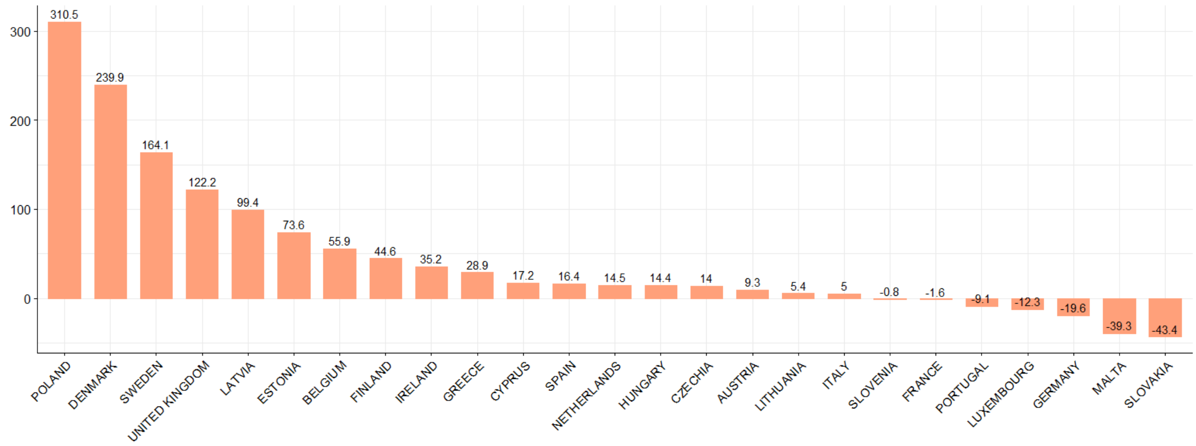


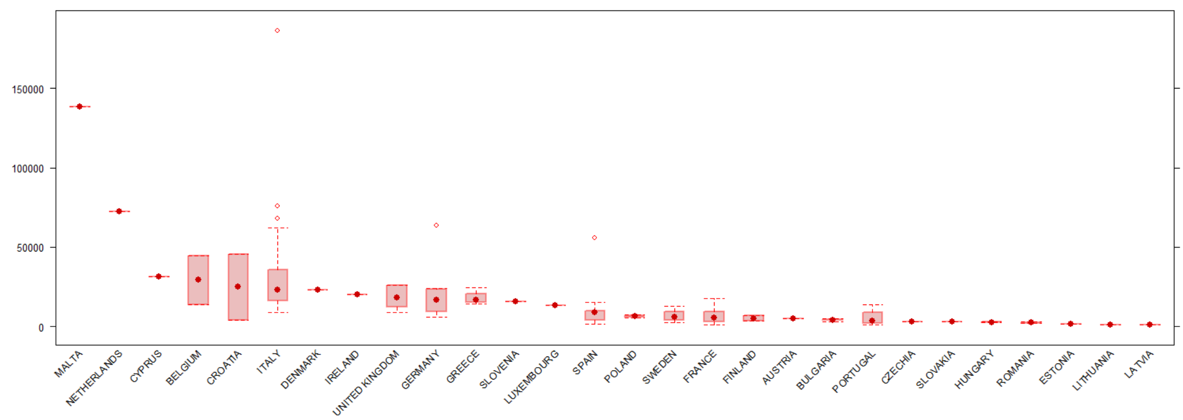
Figure 20. Change in the average (real) land values between 2004 and 2016 by MS (%)



The highest average land values are recorded in Malta, the Netherlands, Cyprus, Italy and Belgium. Malta and the Netherlands rank as the top two MS in terms of the average land value per hectare in 2016, with approximately EUR 138 000/ha and EUR 73 000/ha, respectively. Cyprus, Belgium and Italy follow in the ranking, with land values of EUR 30 000/ha, EUR 29 400/ha and EUR 24 700/ha, respectively, in 2016. Owing to a strong increase experienced in 2005, land values in Denmark were also particularly high in 2016, with an average value of EUR 22 900/ha. The lowest land values are reported in new MS. For example, the average land value was EUR 2 900/ha in Czechia, EUR 2 800/ha in Slovakia, EUR 2 700/ha in Hungary, EUR 2 400/ha in Romania, EUR 1 400/ha in Estonia, EUR 1 300/ha in Lithuania and EUR 1 200/ha in Latvia in 2016 (Figure 15, Figure 16, Figure 17, Figure 18 and Figure 19).

As shown in Figure 21 for 2016, a relatively wide variation in land values could also be observed within MS, especially within old MS. High regional variability in land values within MS is particularly visible in Belgium, Germany, Croatia, Italy and the United Kingdom. Except for Croatia, new MS are associated with lower regional variation in land values. Some extreme land values have been observed in Germany, Spain and Italy.

Figure 21. Distributions of regional land values across EU FADN regions by MS (EUR/ha, 2016)



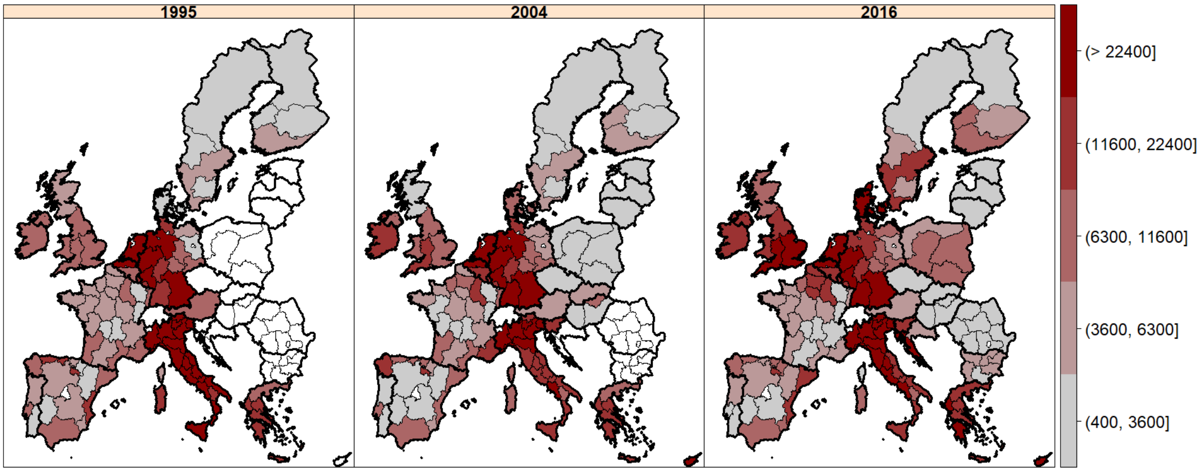
NB: The distributions are sorted by median regional land values.

Figure 22 presents a cross-regional and temporal overview of the average regional land price in the EU in 1995, 2004 and 2016. Relatively high land values have been recorded in regions in Belgium, Germany, Greece, Italy ([38]) and the Netherlands. Large regional differences in land values are especially visible in German regions (particularly between eastern and western regions), in Spain and in France. For Scandinavian MS, large differences can be observed between northern and southern regions, with the latter in general characterised by higher, and increasing, land values over time. Among eastern MS, Croatia and Slovenia were

([38]) Large variations in regional prices in Italy are masked by the classification of land prices into classes. The use of classes simplifies the visualisation when there are large differences between regions, and especially between MS, but masks differences between values in the same class.

associated with the highest land values in 2016. Relatively high values have also been registered in some Polish regions, compared with other new MS.

Figure 22. Average land values (in real terms) in EU FADN regions (in 1995, 2004 and 2016) (*)



(*) Those FADN regions with 15 farms or fewer have been removed from the maps and represented as white polygons.

Table 13 presents the top 10 FADN regions with the highest land values in the EU in 2016. Land was most valuable in Trentino (Italy) and in Malta in 2016, representing EUR 186 278/ha and EUR 138 485/ha, respectively. High land values have also been recorded in Alto-Adige (Italy), the Netherlands, Liguria (Italy), Hamburg (Germany), Veneto (Italy), Lombardia (Italy), Jadranska Hrvatska (Croatia) and Vlaanderen (Belgium). The top 10 FADN regions showed a mixed development in land values for 1995–2016. Land values in most of these regions decreased in 1995–2004 and increased in 2004–2016 (Table 13).

Table 13. Average land values (EUR) and growth rates (top 10 FADN regions)

MS	FADN region	2016	2004	1995	Δ % 2004–2016	Δ % 1995–2004
Italy	Trentino	186 278	204 469	213 778	– 9	– 4
Malta	Malta	138 485	228 326	—	– 39	—
Italy	Alto-Adige	75 985	20 952	47 214	+ 263	– 56
The Netherlands	Netherlands	72 619	63 410	33 706	+ 15	+ 88
Italy	Liguria	68 131	43 780	122 101	+ 56	– 64
Germany	Hamburg	63 854	57 236	—	+ 12	—
Italy	Veneto	62 390	56 380	63 397	+ 11	– 11
Italy	Lombardia	59 657	58 544	67 730	+ 2	– 14
Croatia	Jadranska Hrvatska	45 746	—	—	—	—
Belgium	Vlaanderen	44 810	24 196	24 362	+ 85	– 1

6.3. Comparative analyses of land prices, output value and common agricultural policy subsidies

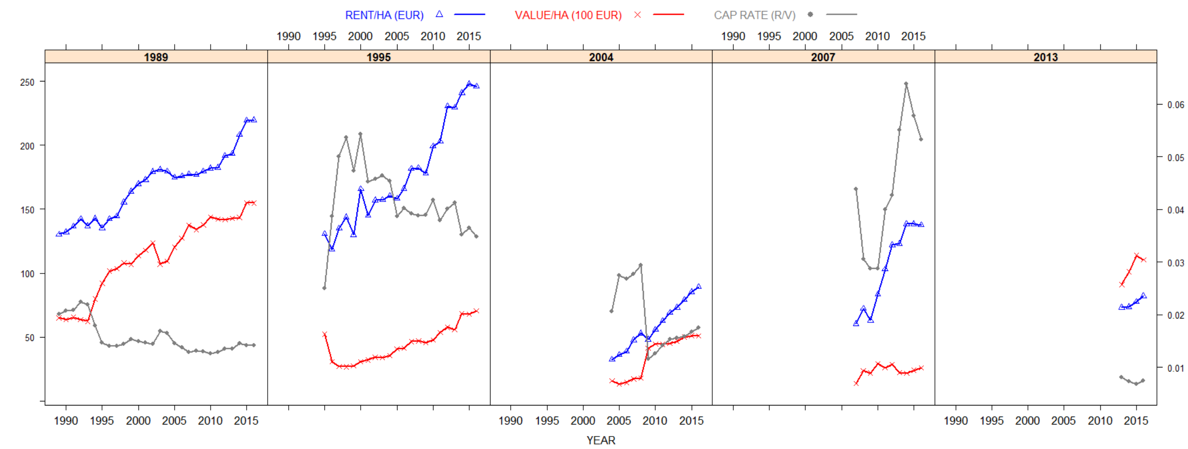
This section provides some preliminary analyses of the relationship between land rents and land values and their potential key divers (i.e. CAP subsidies and output value) that will then be econometrically estimated in the next sections.

Figure 23 presents the evolution of the relationship between rental prices and land values for different MS groupings. The figure also depicts the cap rate, which is an indicator calculated as the ratio between the rental price and the land value (i.e. rent as a percentage of land value), representing relative annual return from land ownership or reflecting the difference between the relative change in rental prices and land values when evaluated over time.

Figure 23 reveals several divergent developments of the cap rate indicator in MS groupings. In old MS – those that accessed the system of FADN accounts in 1989 and in 1995 – the average cap rate exhibits a decreasing trend, implying a decreasing return from land ownership or that the land values increased faster than land rents. For MS that joined the EU before 1989, this decreasing trend seems to have been rather stable, and the cap rate indicator decreased from approximately 2.0 % in 1989 to 1.4 % in 2016. For MS that joined the EU in 1995, besides a drastic increase observed just after the accession, the average cap rate indicator exhibits a fluctuating but decreasing trend: it decreased from 5.0 % in 1997 to 3.4 % in 2016. The cap rate indicator shows a generally increasing trend in the new MS that joined the EU in 2004 and in 2007 ([39]), but there are significant fluctuations and breaks in the date series (particularly in 2009). These results imply that, in these MS, the return from land ownership increased over time. When excluding 2009, the average yearly percentage change in the cap rate indicator for MS that joined the EU in 2004 is 5.5 %; however, when including 2009 the average yearly percentage change is 3.3 %.

A decreasing trend in the cap rate indicator implies that, in the period considered, land values (in nominal terms) have increased more than rental prices (in nominal terms), whereas an increasing trend implies that rental prices have increased more than land values. Given the evolution of the CAP in the successive reforms and the different implementation models of the CAP (particularly DDPs), such an evolution may be important to consider when modelling land prices. In particular, this different evolution of the cap rate indicator might signal different capitalisation mechanisms in the land markets among some MS.

Figure 23. The development of the average rental rates, land values (in nominal terms) and the cap rate indicator by MS groups (by the accession date of MS)



NB: The vertical axis on the left side presents values of land rents (EUR/ha) and land values (EUR 100/ha); the vertical axis on the right side shows the cap ratio as a percentage.

Figure 24 presents the development of the average rental prices, decoupled and coupled direct payments per hectare, and output value per hectare for different MS groupings. Similar is shown for land values in Figure 25. The output value and CAP subsidies represent an important return from land. As a result, the comparison between these variables could shed light on the possible drivers of rental prices. They could provide some understanding of the capitalisation process and how these drivers vary over time and among groups of MS. The figures suggest that, for old MS, the time series of rental prices (in blue) and land values (in red) co-move with the time series of output value (in violet). That is, except for the first few years shown in the figures, rental prices and land values appear to be more closely correlated with the output value than with CDPs or DDPs (in gold and green, respectively). However, the link between land prices and output value seems to be less strong than the link between rental prices and output value. The new MS (those that joined the EU in 2004 and 2007) show a different relationship between the variables. For these MS, the rental prices seem to be much more closely correlated with the development of DDPs than with output value or CDPs. Unlike rental prices, land values co-move more with the output value than with CAP payments in new MS. For Croatia, the limited availability of data makes the evaluation of correlations between these time series more difficult.

The insights obtained from Figure 24 and Figure 25 seem to suggest that the drivers of the capitalisation process into land prices could differ among different groups of MS. In particular, it seems that the main driver

([39]) Owing to limited data availability, it is still difficult to identify a trend in the cap rate indicator for Croatia.

of both rental prices and land values in old MS is the output value, whereas in the new MS the main driver appears to be DDPs for land rents and the output value for land values. No clear relationship could be identified between land prices and CDPs. Given that the CAP implementation model differs between MS, the differences in the CAP implementation might potentially explain these results. At the same time, the drivers of the capitalisation effects might be different between rental prices and land values. This hypothesis will be further investigated next.

Figure 24. The development of the average rental price, CAP payments (decoupled and coupled) and output value per hectare (in nominal terms) by MS groups (by the accession date of MS)

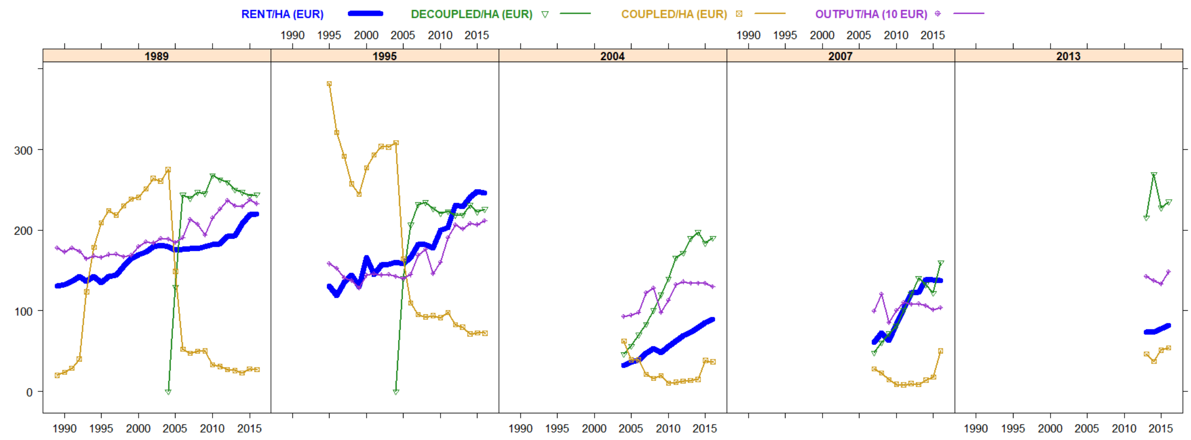
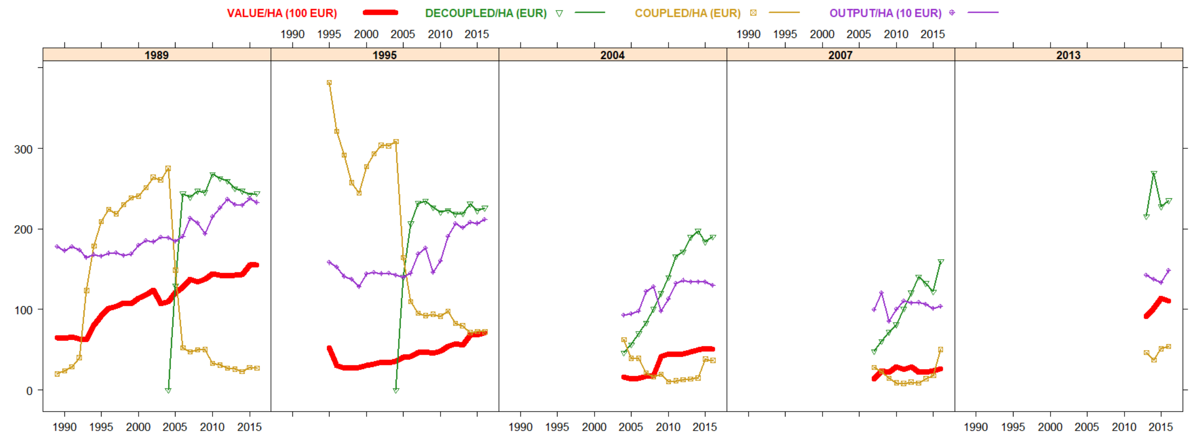


Figure 25. The development of the average of land value, CAP payments (decoupled and coupled) and output value per hectare (in nominal terms) by MS groups (by the accession date of MS)



6.4. Comparison of land prices between Farm Accountancy Data Network and Eurostat

This section compares FADN land prices with those available from Eurostat. This comparison is useful for understanding the features of the FADN land price data with respect to those available from Eurostat. Land prices available from Eurostat are expected to be more representative of the actual values, and thus this analysis will seek to verify whether the FADN land prices portray the main characteristics of the Eurostat data. This is relevant to assessing the generalisability and quality of FADN-based results with respect to the whole agricultural sector as covered by the Eurostat database and to helping interpret the estimated capitalisation effects of CAP subsidies. We compare both the levels and the time dynamics (yearly changes) of land prices between FADN and Eurostat data at MS level. In these comparisons, we use all MS and all years for which data are available in both sources.

Figure 26, Figure 27 and Figure 28 compare the levels (in EUR) of rental prices (left panel) and land values (right panel) between FADN and Eurostat data ([40]) for all MS, old MS and new MS, respectively. The horizontal axes show FADN data, whereas the vertical axes depict Eurostat data. The 45-degree solid lines represent a perfect agreement in which all data points would align exactly in the two data sources.

Overall, the levels of land rents and land values are relatively well aligned between FADN and Eurostat data. The correlation between the two data sources is more than 90 %, and data points are located close to the 45-degree line. Less alignment is observed for higher rental prices and higher land values. Higher values seem to be consistently lower in the FADN database than in the Eurostat database (Figure 26). Similar results are valid when analysing old MS and new MS separately. However, the alignment between FADN and Eurostat data is stronger for new MS (i.e. the correlation is above 90 %) than for old MS (i.e. the correlation is below 90 %). For old MS, higher FADN values of both land rents and land values are consistently lower than the higher Eurostat values. For new MS, less alignment is observed only for higher land values, with no clear pattern observed regarding whether FADN data are undervalued or overvalued (Figure 27 and Figure 28).

Figure 26. Comparison of the levels of rental prices (left panel) and land values (right panel) between FADN and Eurostat data for all MS

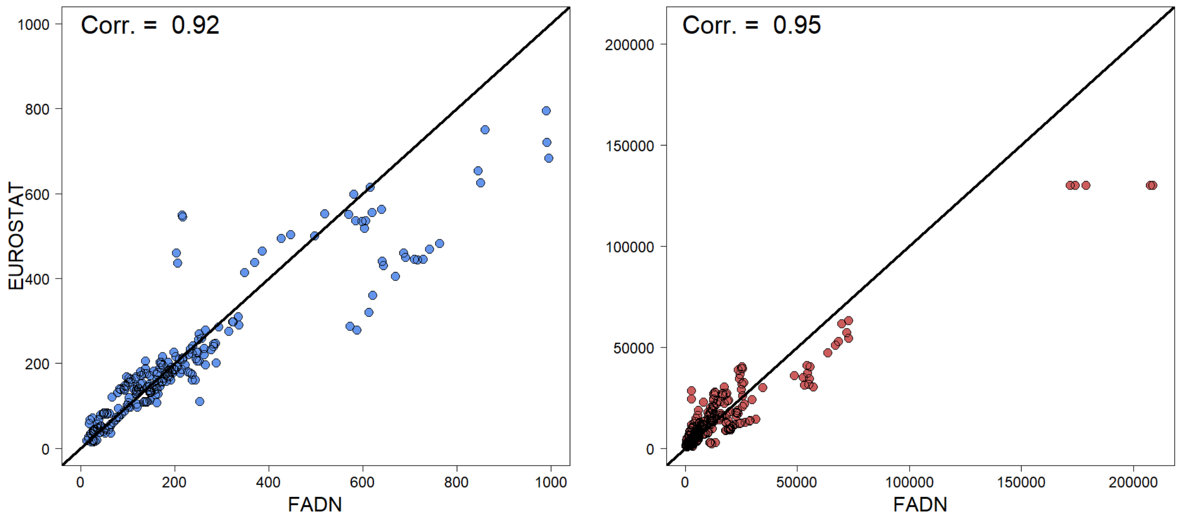
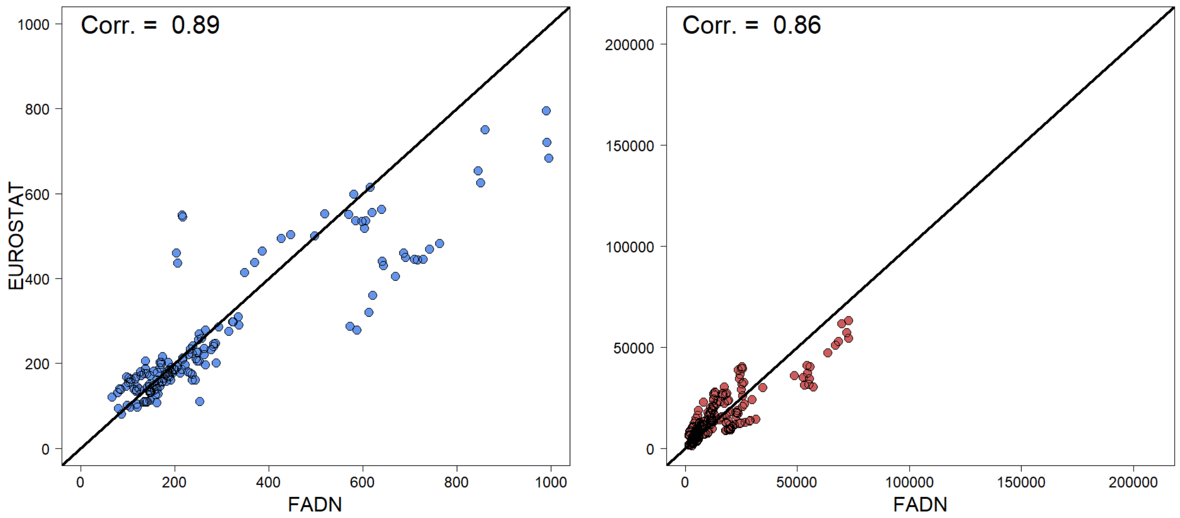


Figure 27. Comparison of the levels of rental prices (left panel) and land values (right panel) between FADN and Eurostat data for old MS



([40]) Eurostat data sources for rental prices are [apri_lrnt] and [apri_lrnt_h], whereas those for land values are [apri_lprc] and [apri_lprc_h].

Figure 28. Comparison of the levels of rental prices (left panel) and land values (right panel) between FADN and Eurostat data for new MS

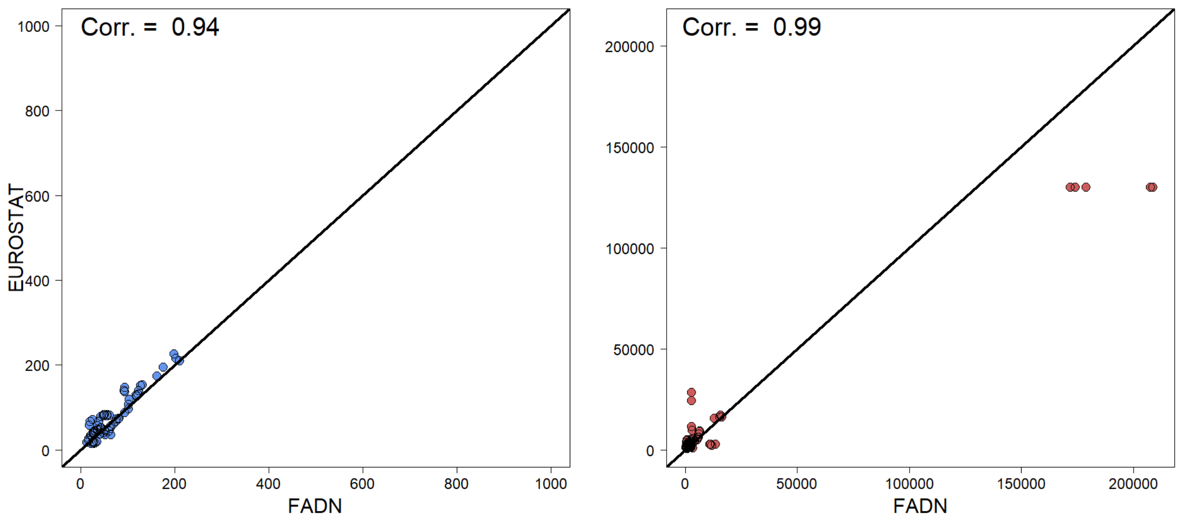


Figure 29, Figure 30 and Figure 31 compare the change (in percentage) in rental prices (left panel) and land values (right panel) between FADN and Eurostat data for all MS, old MS and new MS, respectively. FADN data are shown on the horizontal axes and Eurostat data are shown on the vertical axes. The 45-degree solid lines represent a perfect agreement between the two data sources.

The alignment of the changes in land rents and land values between FADN and Eurostat data is significantly less precise than the alignment of their levels. The correlation between the two data sources for changes in land rents and land values is lower than 30 %, whereas for the levels it is greater than 90 %. Overall, the changes in land rents are better aligned between FADN and Eurostat data (i.e. the correlation is around 22 %) than the changes in land values (i.e. the correlation is around 4 %) (Figure 29). Old MS have equally aligned changes in both land rents and land values between the two data sources (i.e. the correlation is around 25 % for both) (Figure 30). For new MS, the alignment between FADN and Eurostat data is stronger for changes in land rents (i.e. the correlation is around 11 %) than for changes in land values (i.e. the correlation is around – 13 %) (Figure 31).

Overall, these data comparison results between FADN and Eurostat data may have implications for the interpretation of the econometric results on the capitalisation effects of CAP subsidies estimated in Section 7. Although the levels of FADN land prices correspond relatively well to their levels in the Eurostat data, the time dynamics of the FADN data appear to be less precise. This is particularly the case for land values for which the correspondence between FADN and Eurostat data is lowest, implying that the FADN might not capture the full dynamics of their developments over time, which may impact the estimated capitalisation effects.

Figure 29. Comparison of the annual growth rates (%) of rental prices (left panel) and land values (right panel) between FADN and Eurostat data for all MS

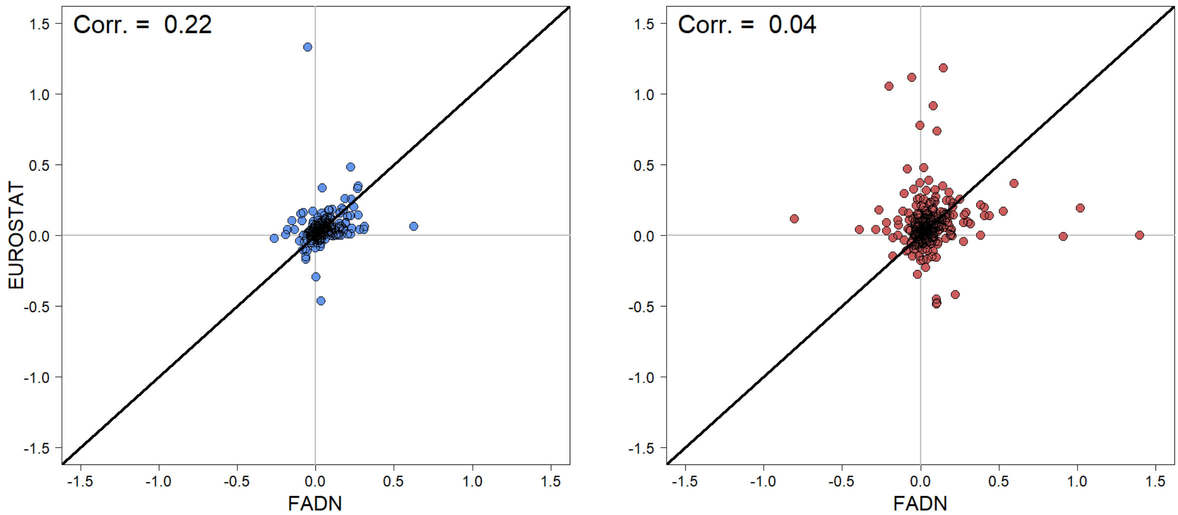


Figure 30. Comparison of the annual growth rates (%) of rental prices (left panel) and land values (right panel) between FADN and Eurostat data for old MS

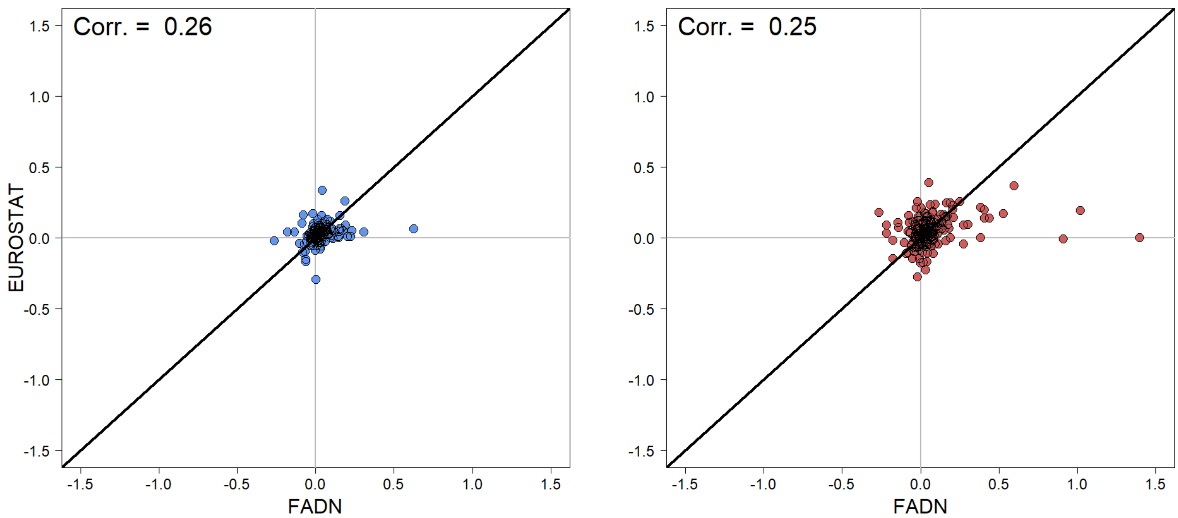
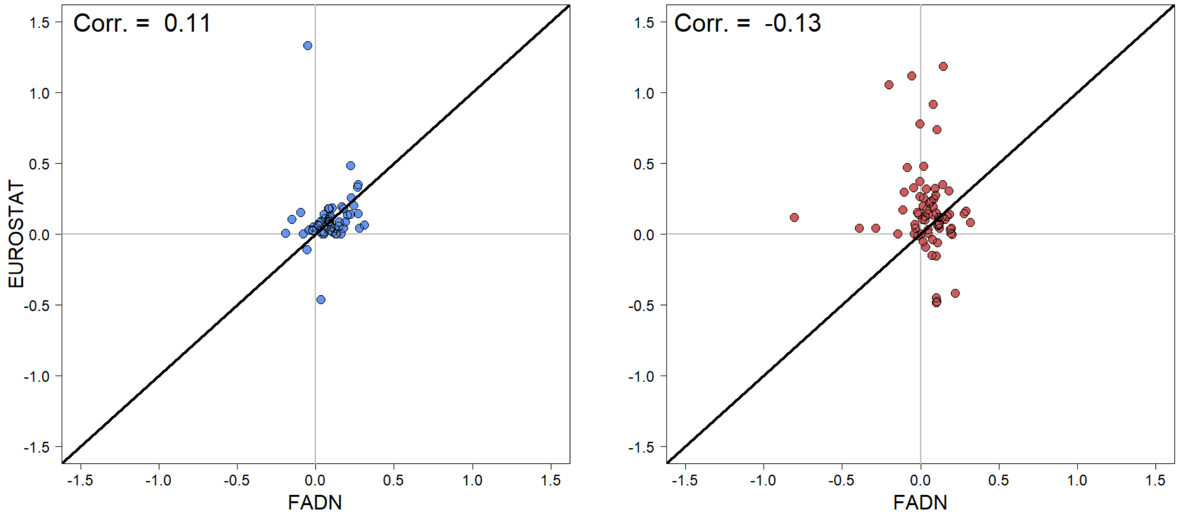


Figure 31. Comparison of the annual growth rates (%) of rental prices (left panel) and land values (right panel) between FADN and Eurostat data for new MS



7. Econometric approach

The objective of this investigation is to understand the extent to which different CAP subsidies have influenced rental prices and land values in the EU. To do so, an explicit econometric model to explain land prices is needed. As argued above, in recent applied economic studies, there have been two main theoretical bases for explaining the land value formation: the hedonic pricing approach and the NPV method (Feichtinger and Salhofer, 2013) ([41]). The hedonic pricing approach assumes that the price of land is a function of its characteristics, whereas the NPV method assumes that the price of land is a function of discounted expectations of future returns from its use. Although the two methods differ in principle, the empirical approaches to implement them converge (Feichtinger and Salhofer, 2013). Here, because of the embedded close link between land values and land rents, and because of data availability, the NPV approach will be used to explain the formation of land values.

According to the NPV approach, the maximum price a farmer would be willing to pay for agricultural land at time t (v_t) equals the sum of the stream of annual expected future incomes (r_t) accruing from owning that land. Mathematically, this can be represented as follows:

(1) $$\mathbf{v_t} = \left(\frac{1}{1+\delta}\right)\mathbf{E}[\mathbf{r_{t+1}}] + \ldots + \left(\frac{1}{1+\delta}\right)^{\mathbf{N}}\mathbf{E}[\mathbf{r_{t+N}}] = \sum_{\mathbf{n}=1}^{\mathbf{N}}\left(\frac{1}{1+\delta}\right)^{\mathbf{n}}\mathbf{E}[\mathbf{r_{t+n}}]$$

where **E**[.] is the expected value operator and δ represents a constant opportunity cost of the investment. There is a strong link between land values and land rents embedded in equation (1), as the expected income, r, at any time period can be interpreted as the net return from land. For a utility-maximising farmer, expected income represents the maximum willingness to pay for land in any time period, t, and therefore r_t can be interpreted as land rent (Feichtinger and Salhofer, 2013).

Because of the close relationship between land values and rents, when subsidies capitalise into land rents it is expected that subsidies will eventually also capitalise into land values. Consequently, a certain degree of correlation between land values and land rental prices, as well as of their associations with subsidies and output measures, is expected. However, as argued in Section 3, land values may be driven by different agricultural and non-agricultural factors, which may reduce this correlation.

To measure the degree of capitalisation of CAP payments, the NPV model should be expressed analytically in a way that can be estimated using econometric techniques. The objective of this section is to describe estimable models of land rents and land values that are consistent with the NPV approach and that allow for the estimation of the degree of capitalisation of CAP payments.

Regarding land rental price, the two main components that are expected to affect the expected land return, r_t, and are central to the objective of this report are market returns (output value), m_t, and CAP payments, s_t. In addition, land return can be affected by other factors. Therefore, to model rental prices and to measure the degree of CAP subsidies' capitalisation, an empirically estimable formulation of land rents could be expressed as follows:

(2) $$r_t = \alpha_0 + \alpha_1 m_t + \alpha_2 s_t + \alpha_3 x_t + \varepsilon_t$$

where r_t represents land rents at time t, m_t represents market returns from agricultural production, s_t is CAP payments, α is a constant, x_t represents other factors that might influence land rents, ε_t is the residual term assumed to be uncorrelated with the deterministic part of the model and α_0 to α_3 are parameters to be estimated. α_2 is the main parameter of interest. It indicates the degree of capitalisation (i.e. capitalisation level) of CAP payments into land rents. It defines how much EUR 1 of CAP subsidies is reflected in land rents. A value equal to 1 would indicate full capitalisation, whereas a value smaller than 1 would indicate partial capitalisation of CAP subsidies into land rents. Similarly, α_1 indicates the impact of the market return on land rents.

Given the uncertainties related to agricultural production and about future policy changes, an important feature of m_t and s_t is that they are usually not known beforehand when a rental contract is stipulated (Lance and Mishra, 2003; Ciaian and Kancs, 2012; O'Neill and Hanrahan, 2016). From a farmer's perspective, these returns are only expected income measures rather than realised measures. As will be discussed, this has important implications for the estimation strategy. To stress the difference between realised and expected returns, equation (2) can be re-expressed as follows:

([41]) Supply and demand frameworks were also considered in early studies, but they have since been abandoned owing to theoretical and empirical inconsistencies (Latruffe and Le Mouël, 2009).

(3) $r_t = \alpha_0 + \alpha_1 m_t^e + \alpha_2 s_t^e + \alpha_3 x_t + \varepsilon_t$

where m_t^e, s_t^e and x_t are expected market returns, CAP payments and other factors, respectively.

If rental markets were perfectly flexible, and s_t^e was observable, equation (3) could be directly estimated using standard statistical techniques, and α_2 would provide the degree of capitalisation of CAP payments. However, rental rates are stipulated, typically, on a multiannual contractual basis, and, in some MS, rental markets are regulated (Roberts et al., 2003; Salhofer et al., 2009; Ciaian and Kancs, 2012; Kilian et al., 2012). At the farm level, because of the multiannual nature of rental contracts, adjustments in rental rates due to policy changes can be observed only at discrete times, when a new contract is stipulated. Furthermore, regulations of rental price setting applied in some MS may also restrict or delay the adjustment of rental prices over time. Thus, rental rates will probably not immediately adjust to a change in the CAP but will have a delay, depending on the rental market rigidity. This delayed response is challenging to model explicitly, because data on the characteristics of the rental contracts and regulations are not available.

In the presence of rental market rigidities, estimation of equation (3) would lead to a downward bias of the estimated capitalisation effects (Patton et al., 2008; Sumner et al., 2010; Ciaian and Kancs, 2012). This bias would be more severe the more rigid the rental markets were. Because equation (3) fails to recognise that not all rental contracts adjust immediately to changes in income expectations (e.g. to changes in the CAP), the estimated parameter α_2 would probably be biased downwards.

These modelling issues can be addressed by estimating equation (3) at regional level ([42]). In fact, it has been shown that asynchronous discrete adjustments of individuals over time can be well represented by partial-adjustment models at an aggregate level (King and Thomas, 2006; Hendricks et al., 2012; Feichtinger and Salhofer, 2015a). In the context of the rental market rigidities, we would expect that observed changes in the average rental prices represent only a fraction of their potential changes:

(4) $\Delta r_t = r_t - r_{t-1} = \varphi(r_t^* - r_{t-1}) + \epsilon_t$

Equation (4) assumes that the change in observed regional rental price between two adjacent periods (Δr_t) can be modelled as a fraction, φ, of the change that would be observed in a perfectly flexible market ($r_t^* - r_{t-1}$). r_t^* represents the regional rental price that would be observed if land markets were perfectly flexible. Parameter φ represents the degree of flexibility of the market. In a perfectly flexible market, φ would tend to converge to 1. In a perfectly non-flexible market, φ would tend to converge to 0. Equation (4) implicitly assumes that adjustments in average rental rates can be observed at every time period. Owing to the FADN sampling strategy and the characteristics of the CAP implementation, a regional level that seems to be appropriate in this case is the FADN regions.

By substituting (3) into (4) and rearranging terms, the following estimable equation is obtained:

(5) $r_t = (1 - \varphi)r_{t-1} + \varphi\alpha + \varphi\alpha_1 m^e{}_t + \varphi\alpha_2 s^e{}_t + \varphi\alpha_3 x_t + (\varphi\omega_t + \epsilon_t) = \rho r_{t-1} + \overline{\alpha}_0 +$
$\overline{\alpha}_1 m^e{}_t + \overline{\alpha}_2 s^e{}_t + \overline{\alpha}_3 x_t + \varepsilon_t$

where ρ represents the degree of rigidity (adjustment) of the rental market and $\overline{\alpha}_2$ is the short-term capitalisation effect of CAP payments into land rents. The parameter $\overline{\alpha}_2$ deviates from the theoretical, long-term capitalisation effects, α_2, by a multiplicative factor φ. Therefore, to obtain the long-term capitalisation effects from the short-term estimates $\overline{\alpha}_2$, the estimated parameter needs be adjusted as follows:

(6) $\alpha_2 = \frac{\overline{\alpha}_2}{1-\rho}$

Regarding land values, assuming a constant real interest rate, an estimable equation of the NPV model in (1) can be represented as follows:

(7) $v_t = \beta_0 + \beta_1 m^e{}_t + \beta_2 s^e{}_t + \beta_3 x_t + \varepsilon$

where β_0 to β_3 are parameters to be estimated. β_2 is the main parameter of interest. It indicates the capitalisation effect of CAP payments into land values. It defines how much EUR 1 of CAP subsidies is reflected in land values. To obtain a comparable indicator as in the case of land rents, the parameter needs to be converted using an NPV formula to obtain an annualised capitalisation level.

([42]) Furthermore, an advantage of using regional data is its usefulness in identifying the capitalisation level, α_2, in equation (3). This might not be possible when using individual farm data because of the regional nature of land markets and reduced heterogeneity of some CAP subsidies (particularly in the case of the flat-rate SPS model and the SAPS for which the per hectare value of the payment is the same for farms from the same region/MS).

Given the land market rigidities, analogously to rental price, the model for land value can also be expressed with a dynamic specification to account for the delayed adjustment of land values:

$$(8)\ v_t = \bar{\beta}_0 + \theta v_{t-1} + \bar{\beta}_1 m^e{}_t + \bar{\beta}_2 s^e{}_t + \bar{\beta}_3 x_t + \varepsilon$$

Equation (8), together with equation (7), allows for the estimation of the long-run capitalisation effect, β_2, of CAP payments into land values. This long-run effect can be computed by adjusting the short-term estimates, $\bar{\beta}_2$, with the coefficient θ, measuring the degree of rigidity (adjustment) of the land market as follows:

$$(9)\ \beta_2 = \frac{\bar{\beta}_2}{1-\theta}$$

To econometrically estimate equations (5) and (8), three identification issues need to be taken into account besides the land price rigidities (inertia in land markets): unobserved heterogeneity, expectation errors and simultaneity between land prices and subsidies ([43]). These identification issues were found, in the literature, to potentially bias the estimated subsidy capitalisation into land prices (e.g. Kirwan, 2009; Michalek et al., 2014; Guastella et al., 2018).

The unobserved heterogeneity relates to the difficulties in accounting in a statistical model for all the information relevant to determining the land prices. These difficulties arise because some factors, such as soil properties, farmers' skills and technology, are challenging to measure and data may not be available to be included in a statistical model. These and other factors, such as droughts and pests (Kirwan, 2009), may be linked to agricultural productivity and eventually impact land prices. The potential correlation between these unobserved factors and CAP subsidies may lead to biased estimates of the capitalisation effect. To control for the unobserved heterogeneity, we exploit the panel data used in this report by transforming the estimated model in first differences. This transformation eliminates fixed effects, which capture unobserved time-invariant regional characteristics and time-related characteristics of the regions.

The second source of bias may arise if observed returns (i.e. CAP subsidies and market returns from agricultural production) are used in the econometric model in place of expected returns. In fact, expected returns are unobservable, and, often in empirical studies, actual or realised returns are used as a proxy for these unobserved returns (Patton et al., 2008). However, the use of realised returns may lead to the so-called expectation error bias that arises because the measurement error between expected and realised returns is correlated with the error term of the estimated equation (Lance and Mishra, 2003). To address the expectation error bias, we employ an instrumental variable approach. Following the literature, the lagged realisations of returns are used as instruments, given that they are both correlated with current payments and are likely to be uncorrelated with the residual terms (Patton et al., 2008).

Another potential source of bias is the simultaneity between land prices and CAP subsidies. Similar to the unobserved heterogeneity problem, the simultaneity bias may arise because both CAP subsidies and land prices may depend on past productivity levels. If subsidies were assigned to farms randomly, then parameters $\bar{\alpha}_2$ and $\bar{\beta}_2$ would correctly measure the capitalisation effects of CAP subsidies. In reality, however, CAP subsidies are not assigned randomly. For example, the value of the DDPs depends on coupled payments in the past, and on the average country/regional productivity. The value of CDPs received by farms in a given region depends on the farms' crop choice. Farms producing supported outputs have higher subsidies than farms producing non-supported outputs. The RDP subsidies are allocated based on project proposals of farms and are subject to fulfilling certain criteria (e.g. farm size, location and specialisation). Hence, the RDP subsidies 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 CAP subsidies may imply that the endogeneity between CAP subsidies and land prices may arise because regions with higher productivity levels will tend to have higher CAP subsidies and, at the same time, are also likely to have higher land prices (Michalek et al., 2014). If subsidies are not assigned randomly, then subsidy payments are correlated with the error term, implying that the estimates of $\bar{\alpha}_2$ and $\bar{\beta}_2$ will be biased if not controlling for the simultaneity. We address the simultaneity problem by resorting to fixed-effect estimation and then using first differences to eliminate the levels in land prices and CAP subsidies (see below).

The last identification issue that we account for is the land price rigidities (inertia in land markets). As explained above, to capture the capitalisation mechanism in the presence of rigidities of land markets, it is

([43]) As the empirical investigation is based on data aggregated at the FADN region level, it is not applicable to account for the selection bias of farms that rent land. Furthermore, since the exact nature of the potential measurement errors in the dependent variable is unknown, it is not possible to explicitly consider it in estimates.

necessary to include an autoregressive term in the estimation equation. However, accounting for both inertia and unobserved heterogeneity leads to a correlation between the error term and the explanatory variables. Similar to the case of expectation errors and simultaneity, this correlation may lead to biased and inconsistent estimates (Arellano and Bond, 1991). A solution to this estimation problem has been provided in the literature on the dynamic panel data models (Arellano and Bond, 1991; Blundell and Bond, 1998), which proposed transforming the model in first differences to eliminate individual fixed effects and to apply instrumental variables, with internal instruments, to resolve this endogeneity/simultaneity issue.

To address the above econometric issues, the GMM framework seems the most suitable and has been adopted here. With the use of internal instruments, Arellano and Bond (1991) and Blundell and Bond (1998) have shown that it is possible to address these identification issues at once. A similar approach was applied in the subsidy capitalisation literature, for example in Hendricks et al. (2012), Feichtinger and Salhofer (2016) and O'Neill and Hanrahan (2016).

7.1. Model specifications

As explained above, the empirical estimation is conducted at regional level. To both leverage the characteristics of the FADN sampling plan and take into account the specificities of the CAP implementation, the estimation is conducted at the FADN region level. The econometric model is estimated for 1989–2016.

To account for differences in CAP payments, we consider DDPs, CDPs and RDP subsidies (AEM support, LFA payments and investment support) in equations (5) and (8). Section 3 shows that different implementation of DDPs may impact their land capitalisation. For this reason, we account for different implementation methods of DDPs: the heterogeneity of DDPs between farms, scarcity of entitlements relative to total land, and the implementation of the redistributive payment. To account for these implementation differences of DDPs among MS in equations (5) and (8), we introduce a dummy variable for each of them and interact them with the DDP variable.

The first dummy variable, entitlement deficit, $\mathrm{I_t}^{\mathrm{ed}}$, aims to capture the scarcity of entitlements. It takes value 1 whenever the FADN region has a deficit of entitlements relative to UAA and value 0 otherwise. This variable is constructed using FADN data. The data on entitlements have been retrieved from the FADN database in order to derive an indicator of relative entitlement availability at regional level. However, entitlement data were not available for all MS in all years. The data gaps have been filled with the information from the previous years in a given MS.

The second dummy variable related to DDP implementation, heterogeneous payments, $\mathrm{I_t}^{\mathrm{hp}}$, captures the variation in decoupled payments between farms within regions. This variable is set equal to 1 if a given MS or region has heterogeneous payments (e.g. historical SPS model and partial convergence) and 0 otherwise (e.g. the SAPS).

The third dummy variable, $\mathrm{I_t}^{\mathrm{rp}}$, related to DDP implementation, identifies the presence/absence of the redistributive payment. This variable takes value 1 whenever the redistributive payment has been applied in a region and a year and value 0 otherwise.

Furthermore, to account for the diversity in land regulations across the EU, a land market dummy variable, $\mathrm{I_t}^{\mathrm{reg}}$, is included in equations (5) and (8), with an attempt to separate the capitalisation effect between more and less regulated land markets across the EU, and to account for differences in land regulations across MS. This dummy variable is constructed based on the land market regulation index available in Swinnen et al. (2014). The variable takes value 1 in those regions belonging to a more flexible land market and value 0 otherwise. This dummy has been interacted with both DDPs and CDPs.

Following these considerations, equations (5) and (8) are redefined as follows:

$$(10)\ \mathrm{r_t} = \rho \mathrm{r_{t-1}} + \bar{\alpha}_0 + \bar{\alpha}_1 \mathrm{m^e}_\mathrm{t} + \bar{\alpha}_{21}\mathrm{dpp^e}_\mathrm{t} + \bar{\alpha}_{22}\mathrm{I_t}^{\mathrm{ed}}\mathrm{dpp^e}_\mathrm{t} + \bar{\alpha}_{23}\mathrm{I_t}^{\mathrm{hp}}\mathrm{dpp^e}_\mathrm{t} + \bar{\alpha}_{24}\mathrm{I_t}^{\mathrm{rp}}\mathrm{dpp^e}_\mathrm{t} +$$

$$\bar{\alpha}_{25}\mathrm{I_t}^{\mathrm{reg}}\mathrm{dpp^e}_\mathrm{t} + \bar{\alpha}_{26}\mathrm{cpp^e}_\mathrm{t} + \bar{\alpha}_{27}\mathrm{I_t}^{\mathrm{reg}}\mathrm{cpp^e}_\mathrm{t} + \bar{\alpha}_{28}\mathrm{aem^e}_\mathrm{t} + \bar{\alpha}_{29}\mathrm{lfa^e}_\mathrm{t} + \bar{\alpha}_{30}\mathrm{is^e}_\mathrm{t} + \bar{\alpha}_{31}\mathrm{ordp^e}_\mathrm{t} + \bar{\alpha}_3\mathrm{x_t} + \varepsilon_\mathrm{t}$$

$$(11)\ \mathrm{v_t} = \theta \mathrm{v_{t-1}} + \bar{\beta}_0 + \bar{\beta}_1 \mathrm{m^e}_\mathrm{t} + \bar{\beta}_{21}\mathrm{dpp^e}_\mathrm{t} + \bar{\beta}_{22}\mathrm{I_t}^{\mathrm{ed}}\mathrm{dpp^e}_\mathrm{t} + \bar{\beta}_{23}\mathrm{I_t}^{\mathrm{hp}}\mathrm{dpp^e}_\mathrm{t} + \bar{\beta}_{24}\mathrm{I_t}^{\mathrm{rp}}\mathrm{dpp^e}_\mathrm{t} +$$

$$\bar{\beta}_{25}\mathrm{I_t}^{\mathrm{reg}}\mathrm{dpp^e}_\mathrm{t} + \bar{\beta}_{26}\mathrm{cpp^e}_\mathrm{t} + \bar{\beta}_{27}\mathrm{I_t}^{\mathrm{reg}}\mathrm{cpp^e}_\mathrm{t} + \bar{\beta}_{28}\mathrm{aem^e}_\mathrm{t} + \bar{\beta}_{29}\mathrm{lfa^e}_\mathrm{t} + \bar{\beta}_{30}\mathrm{is^e}_\mathrm{t} + \bar{\beta}_{31}\mathrm{ordp^e}_\mathrm{t} + \bar{\beta}_3\mathrm{x_t} + \varepsilon_\mathrm{t}$$

where $\mathrm{dpp^e}_\mathrm{t}$ stands for decoupled payments; $\mathrm{I_t}^{\mathrm{ed}}\mathrm{dpp^e}_\mathrm{t}$, $\mathrm{I_t}^{\mathrm{hp}}\mathrm{dpp^e}_\mathrm{t}$, $\mathrm{I_t}^{\mathrm{rp}}\mathrm{dpp^e}_\mathrm{t}$ and $\mathrm{I_t}^{\mathrm{reg}}\mathrm{dpp^e}_\mathrm{t}$ are interaction variables between DDPs and dummy variables for the deficit in entitlements, the heterogeneity of DDPs, the implementation of the redistributive payment and land market regulations, respectively; $\mathrm{cpp^e}_t$ is coupled payments and $\mathrm{I_t}^{\mathrm{reg}}\mathrm{cpp^e}_t$ is its interaction with the land market dummy; $\mathrm{aem^e}_t$, $\mathrm{lfa^e}_t$, $\mathrm{is^e}_t$ and $\mathrm{ordp^e}_t$ are AEM payments, LFA payments, the investment support and other RDP payments.

The interpretation of the coefficients in equations (10) and (11) is as follows. Regarding the coefficients associated with DDPs, $\overline{\alpha}_{21}$ and $\overline{\beta}_{21}$, the model captures the capitalisation effects of DDPs on land prices in regions with a surplus of entitlements (homogeneous DDPs) without the redistributive payment and with less flexible land markets. This group of regions represents the reference group of the estimated model, and any other coefficient related to decoupled payments represents a deviation of the capitalisation effect from this reference group. For example, $\overline{\alpha}_{21} + \overline{\alpha}_{22}$ captures the capitalisation level of DDPs into land rents in regions with the same characteristics as those of the reference group except for the presence of a deficit in entitlements. That is, it indicates how much EUR 1 of DDPs is capitalised into rental prices in regions with deficit entitlements (homogeneous DDPs) without the redistributive payment and with less flexible land markets. Analogously, the coefficients $\overline{\alpha}_{23}$ to $\overline{\alpha}_{25}$ and $\overline{\beta}_{23}$ to $\overline{\beta}_{25}$ represent deviations from the capitalisation level relative to the reference group. The coefficient $\overline{\alpha}_{26}$ ($\overline{\beta}_{26}$) quantifies the capitalisation effect of CDPs in MS with less flexible markets, whereas $\overline{\alpha}_{26} + \overline{\alpha}_{27}$ ($\overline{\beta}_{26} + \overline{\beta}_{27}$) quantifies it in more flexible markets. The remaining coefficients $\overline{\alpha}_{28}$, $\overline{\alpha}_{29}$, $\overline{\alpha}_{30}$ and $\overline{\alpha}_{31}$ ($\overline{\beta}_{28}$, $\overline{\beta}_{29}$, $\overline{\beta}_{30}$ and $\overline{\beta}_{31}$) measure the capitalisation effect of AEM payments, LFA payments, the investment support and other RDP subsidies, respectively.

Note that equations (10) and (11) also account for factors other than CAP subsidies that may impact rents and land values, namely $\mathrm{m^e}_t$ and $\mathrm{x_t}$. Although these variables are not the primary interest of this report, their inclusion in the econometric model is important in order to control for all relevant factors that may impact land prices. Otherwise, the estimated capitalisation effect might be biased. These control variables can be classified into four categories: regional fixed effect, yearly fixed effect, region-level (time-varying) control variables and MS-level (time-varying) control variables. The regional fixed effect is an important component of the model, as it aims to capture regional-specific factors such as soil quality, land productivity, topography, and other factors that do not change significantly over time and that may be correlated with the level of CAP payments but that may be difficult to quantify. Yearly fixed effects aim to capture effects that are common to every region in each year of the panel. The remaining control variables, both region level and MS level, included in the estimated model are described in Table 14.

Table 14. Descriptive statistics of region-level and MS-level time-varying control variables

Level	Variable	Mean	Standard deviation	25th percentile	50th percentile	75th percentile
Region	Average farm size (ha)	0.645	0.892	0.146	0.401	0.761
	Average farm size (livestock units)	0.443	0.528	0.072	0.241	0.644
	Proportion of family annual working units (%)	0.765	0.193	0.694	0.821	0.899
	Fixed assets per ha (EUR/ha)	3 223.311	3 959.220	1 347.469	2 175.725	3 452.904
	Livestock units/ha	0.809	0.737	0.351	0.612	1.049
	Proportion rented UAA (%)	0.525	0.252	0.314	0.520	0.746
	Assets to liabilities (ratio)	0.880	0.116	0.769	0.928	0.986
	Herfindahl–Hirschman concentration index	0.012	0.031	0.004	0.006	0.011
	Population density (population/km^2)	187.714	269.071	65.268	111.982	206.283
	Population growth (%)	0.002	0.010	– 0.001	0.002	0.006
	Proportion irrigated UAA (%)	0.053	0.112	0.000	0.000	0.056
	Proportion UAA: energy crops (%)	0.002	0.008	0.000	0.000	0.000
	Proportion UAA: cereals (%)	0.312	0.181	0.175	0.336	0.447
	Proportion UAA: other crops (%)	0.098	0.088	0.027	0.077	0.149
	Proportion UAA: horticulture (%)	0.022	0.059	0.002	0.007	0.018
	Proportion UAA: vineyards (%)	0.034	0.060	0.000	0.008	0.044
	Proportion UAA: orchards (%)	0.045	0.115	0.001	0.007	0.034
	Proportion UAA: olives (%)	0.029	0.076	0.000	0.000	0.013
	Proportion UAA: forage crops (%)	0.408	0.258	0.221	0.365	0.571
	Proportion UAA: out of production (%)	0.068	0.080	0.012	0.041	0.095
	Proportion UAA: woodland (%)	0.056	0.170	0.000	0.006	0.034
	Deviation in minimum temperatures (%)	0.018	1.840	– 0.023	0.037	0.104
	Deviation in maximum temperatures (%)	0.026	0.059	– 0.007	0.023	0.057
	Deviation in rainfall (%)	0.009	0.207	– 0.128	– 0.006	0.120
	Real GDP growth (%)	0.017	0.026	0.007	0.019	0.033
	Employment rate (%)	0.495	0.065	0.455	0.497	0.539
MS	Real interest rate (%)	0.030	0.022	0.015	0.028	0.043
	Inflation rate (%)	0.025	0.023	0.014	0.021	0.032

NB: All percentages are in decimal form.

8. Econometric estimates

The objective of this section is to present the econometric estimates of the capitalisation effect for both rental prices and land values. These results are obtained by estimating model specifications (10) and (11) for rental prices and land values, respectively, by applying the GMM estimator. For both rental prices and land values we estimate six models. Model M4 represents the standard specification as expressed in equations (10) and (11). The rest of the estimated models are modified versions of the standard specification M4. That is, model M1 is the basic model, which does not consider the different implementation aspects of DDPs across regions. Model M2 extends model M1 by adding the interaction variables that capture the effect of the 2013 CAP reform, whereas model M3 adds implementation details of DDPs. The difference between models M3 and M4 is that the latter model further extends the estimated model by considering the implication of land market regulations for CAP subsidy capitalisation. Finally, models M5 and M6 explore the time dynamics of the DDP capitalisation by introducing interaction terms between DDPs and time dummies: model M5 considers only the time dimension of the DDP capitalisation, whereas model M6 also accounts for DDP implementation details, similar to model M3.

The estimated results are reported in Table 15 and Table 17 for rental prices and land values, respectively. The diagnostics statistics of the estimated models do not suggest the misspecification of the model or invalidity of instruments. Serial correlation of an order higher than 1 would imply a misspecification of the model. 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 Hansen test statistics suggest that we cannot reject the null hypothesis that the over-identifying restrictions are valid for the estimated equations; otherwise, the Hansen test would imply that instruments might be correlated with residuals, and thus would fail to fulfil the exogeneity condition.

8.1. Rental prices

The results reported in Table 15 suggest that CAP subsidies are capitalised into land rents in the EU. However, there are significant differences in the capitalisation rates according to different subsidy types and the statistical significance of the estimated coefficients.

DDPs are found to impact land rents. When considering the basic model, M1, the land rental prices increase by EUR 0.238 for each EUR 1 of DDPs. This implies a 23.8 % capitalisation rate of DDPs into land rents. In model M2, in which we account for the 2013 CAP reform (i.e. by including the interaction term between DDPs and a dummy variable for the years of the implementation of the 2013 reform), the capitalisation of DDPs decreases slightly to 21.9 %. However, the effect of the 2013 CAP reform is positive but statistically insignificant.

When accounting for the DDP implementation models (M3 and M4), the estimated capitalisation of DDPs changes. The capitalisation rate of DDPs increases to 46.2 % and 45.9 % in model M3 and model M4, respectively. These figures represent the reference capitalisation rate, and they need to be interpreted in conjunction with the interaction variables between DDPs and variables identifying the DDP implementation models estimated in models M3 and M4. That is, the rates 46.2 % and 45.9 % reflect the capitalisation rate for the DDP model with surplus entitlements (homogeneous DDPs) without the redistributive payment and with less flexible land markets. Regarding the interaction variables, only the one that captures the heterogeneity of DDPs (DDPs – heterogeneous payments) is statistically different to 0. Its estimated value is negative, at – 0.371 and – 0.338 in model M3 and model M4, respectively, implying that regions that have heterogeneous DPPs across farms have lower capitalisation rates than regions that have homogenous DDPs. That is, in these regions the capitalisation rate is between 9.1 % (= 46.2 % – 37.1 %) and 12.1 % (= 45.9 % – 33.8 %). This result is consistent with the theoretical analysis, which shows that the capitalisation rate of DDP models with heterogeneous payments (e.g. historical or hybrid SPS models under the 2003 CAP reform and the SPS model with partial convergence under the 2013 CAP reform) should be lower than for flat-rate systems (e.g. the SAPS). Other implementation characteristics of DDPs appear not to affect their capitalisation into land rents. That is, the scarcity of entitlements (DDPs – deficit entitlements) and the redistributive payments (DDPs – redistributive payment) are statistically insignificant (Table 15). These estimated capitalisation effects (between 9.1 % and 46.2 %) are well in the range estimated by other studies in the literature. Our results also confirm the findings of Michalek et al. (2014) that the capitalisation level decreases with the heterogeneity of DDPs.

The capitalisation rate of CDPs is lower than the capitalisation rate of DDPs. The estimated coefficient is relatively stable across the estimated models: between 0.058 and 0.062. This implies that rental prices increase by between EUR 0.058 and EUR 0.062 per additional EUR 1 of CDPs. These figures represent a capitalisation rate of CDPs between 5.8 % and 6.2 % (Table 15). These results are in line with expectations, as land-based subsidies (i.e. DDPs) directly increase the profitability of land, which increases the competition for land resources, leading to higher land rents, in contrast to CDPs. Compared with findings in the literature, our estimate for CDPs is in the lower range of those found in other studies.

RDP subsidies are found not to have a statistically significant impact on the land rents across all estimated models. The exceptions are 'other RDP' subsidies. However, the estimated capitalisation rate of other RDP subsidies is rather unstable across the estimated models. It is relatively high in all models, varying between 71.8 % and 91.1 % (Table 15).

According to estimates in model M4, land regulations appear not to affect the capitalisation of CAP subsidies. That is, the interaction variables between the land regulation dummy and DDPs and CDPs (DDPs – land regulations; CDPs – land regulations) are statistically insignificant (Table 15). This is contrary to expectations given that, according to the theoretical prediction, land regulations should constrain rental price adjustments and induce lower capitalisation of subsidies. One explanation behind these results could be that the land regulation variable considered in this report is an imperfect proxy for land market regulations. It is static in nature, and it reflects the status of the land market regulation at one point in time (i.e. around 2014 when the study by Swinnen et al. (2014) was conducted). It does not capture changes in land regulations made by MS over time. Moreover, a part of the rigidity of land rents' adjustment might have been captured by the autoregressive term (i.e. the lagged rental price).

The estimated coefficient for the lagged rental price, ρ, is between 0.17 and 0.18, which indicates relatively moderate rental price adjustments to changes in market conditions and/or CAP subsidies. This implies a degree of rental market adjustment equal to around 0.82–0.83 ($= 1 - \rho$). Using the adjustment coefficient as specified in equation (6), the long-run capitalisation rate of DDPs varies between 29 % in model M1 and around 55 % in models M3 and M4. The heterogeneous DDP models have lower capitalisation rates by between 41 % and 45 % in the long run than the flat-rate DDP models. This implies that the long-run capitalisation of DDPs with homogenous payments is between 11 % and 15 %. Similarly, the long-run capitalisation rate of CDPs is around 7 % across the estimated models.

As expected, market return has a positive and statistically significant impact on land rents (Table 15). These results confirm previous findings that agricultural profitability is an important determinant of farmland rental rates (e.g. Goodwin et al., 2003, 2005; Lance and Mishra, 2003; Roberts et al., 2003; Ciaian and Kancs, 2012). The estimated coefficient is statistically significant at 1 % and consistent across all estimated models. The estimated coefficient implies an increase in rental prices by EUR 0.015–0.016 for each EUR 1 of market return.

Other variables that are found to affect land rents are farm size (farm size and livestock units), the importance of land renting (proportion rented UAA), population density, employment rate and inflation rate.

8.1.1. The variation in the capitalisation of decoupled payments over time

Table 16 provides a more detailed analysis of the development of the DDPs' capitalisation into land rents over time in which the DDP variable is interacted with time dummies representing years of implementation of decoupled payments. These interaction terms allow for the estimation of a single capitalisation coefficient for every year of decoupled payments' implementation and, therefore, enable inference about year-to-year variation in the capitalisation effects. Model M5 includes interaction terms between DDPs and time dummies without accounting for DDPs' implementation details, whereas model M6 also accounts for implementation details, similar to model M3 ([44]).

The results for both model M5 and model M6 show that the capitalisation levels of DDPs change over time. For most years, capitalisation effects are found to be significant. The only exceptions are 2005, in which the effect is not significant in both models, and 2010, in which the effect is not significant in model M6. The results of these estimates are summarised in Figure 32, which presents the average year-to-year capitalisation level of DDPs for all regions altogether (in red) and separately for regions with homogeneous DDPs (in yellow) and those with heterogeneous DDPs (in blue). The average capitalisation rate of DDPs across all regions seems to have a non-monotonous increasing trend over time (increasing from around 0 % in 2005 to around 33 % in 2016). When the effect is split between regions with heterogeneous and homogeneous

([44]) Note that the results for 2004 are not available in Table 16. Owing to the dynamic specification employed, the first observations of any unit of analysis are lost by construction (there is no $t - 1$ period for the first period of analysis).

DDPs, there seems to be no clear trend. For both types of regions, the capitalisation level of DDPs increases between 2005 and 2008, decreases between 2009 and 2011 and increases thereafter. In line with the estimates obtained in models M3 and M4, the difference in the capitalisation rate between regions implementing heterogeneous DDPs and those implementing homogeneous DDPs is around 36 %.

Table 15. GMM estimates for land rents

	Model			
	M1	M2	M3	M4
Rent (*t* – 1)	0.182 (**) (0.080)	0.175 (**) (0.080)	0.172 (**) (0.083)	0.168 (*) (0.086)
DDPs	0.238 (***) (0.053)	0.219 (***) (0.050)	0.462 (***) (0.142)	0.459 (***) (0.158)
DDPs – 2013 CAP (interaction)		0.040 (0.048)		
DDPs – land regulations (interaction)				– 0.033 (0.108)
DDPs – deficit entitlements (interaction)			0.052 (0.068)	0.015 (0.077)
DDPs – heterogeneous payments (interaction)			– 0.371 (**) (0.148)	– 0.338 (*) (0.179)
DDPs – redistributive payment (interaction)			– 0.071 (0.163)	– 0.150 (0.183)
CDPs	0.062 (***) (0.012)	0.060 (***) (0.011)	0.059 (***) (0.011)	0.058 (***) (0.011)
CDPs – land regulations (interaction)				– 0.063 (0.128)
AEM	0.060 (0.146)	– 0.046 (0.131)	0.089 (0.102)	0.057 (0.111)
LFA	– 0.101 (0.098)	– 0.100 (0.096)	– 0.104 (0.104)	– 0.096 (0.136)
Investment support	– 0.004 (0.071)	– 0.006 (0.075)	0.016 (0.074)	0.008 (0.080)
Other RDP subsidies	0.921 (**) (0.446)	0.718 (*) (0.410)	0.745 (*) (0.393)	0.773 (*) (0.448)
Market return (per ha)	0.016 (***) (0.001)	0.015 (***) (0.001)	0.016 (***) (0.001)	0.015 (***) (0.001)
Farm size (ha)	– 67.475 (***) (23.592)	– 68.014 (***) (22.243)	– 97.390 (***) (27.216)	– 103.854 (***) (26.502)
Farm size (ha) squared	8.455 (**) (3.415)	8.456 (**) (3.452)	12.918 (***) (3.952)	13.616 (***) (3.926)
Livestock units	115.918 (***) (37.420)	118.086 (***) (35.573)	135.779 (***) (42.955)	141.332 (***) (47.156)
Livestock units squared	– 30.844 (***) (10.985)	– 31.276 (***) (11.248)	– 41.137 (***) (12.070)	– 42.797 (***) (13.488)
Proportion rented UAA	– 112.599 (***) (28.612)	– 120.171 (***) (28.549)	– 111.994 (***) (27.606)	– 95.866 (**) (40.181)
Population density	0.095 (**) (0.046)	0.100 (**) (0.043)	0.081 (**) (0.041)	0.089 (**) (0.043)
Population density squared	– 0.000 (***) (0.000)	– 0.000 (***) (0.000)	– 0.000 (***) (0.000)	– 0.000 (***) (0.000)
Real interest rate	208.498 (182.977)	216.162 (190.872)	122.102 (246.885)	209.969 (323.049)
Employment rate	209.783 (*** (67.426)	206.677 (***) (70.763)	233.150 (**) (96.399)	196.141 (**) (91.253)
Real GDP growth	– 88.572 (80.855)	– 92.701 (103.175)	28.837 (103.830)	– 21.868 (145.772)
Inflation rate	468.339 (**) (232.661)	431.646 (*) (254.166)	796.855 (**) (359.338)	863.181 (**) (338.402)
Total number of observations	2 831	2 787	2 660	2 660
Number of regions	131	131	131	131
AR(1) p-value	0.0342	0.0382	0.0372	0.0382
AR(2) p-value	0.203	0.199	0.320	0.317
Hansen p-value	0.104	0.127	0.675	0.602

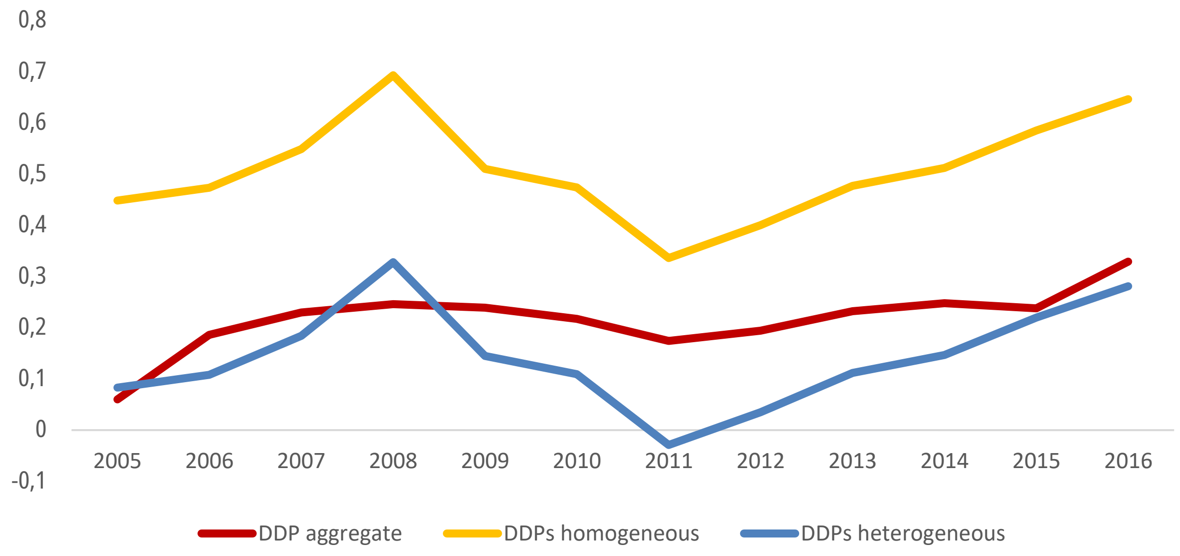
NB: Statistically significant at *10 %, **5 % and ***1 % levels; error terms in parentheses.

Table 16. GMM estimates for land rents with time interactions

	Model	
	M5	M6
Rent (t – 1)	0.175 (**) (0.089)	0.191 (**) (0.091)
DDPs – time dummy 2005 (interaction)	0.060 (0.122)	0.448 (0.288)
DDPs – time dummy 2006 (interaction)	0.186 (0.135)	0.473 (***) (0.147)
DDPs – time dummy 2007 (interaction)	0.230 (**) (0.112)	0.549 (***) (0.140)
DDPs – time dummy 2008 (interaction)	0.246 (***) (0.095)	0.693 (***) (0.147)
DDPs – time dummy 2009 (interaction)	0.239 (**) (0.107)	0.510 (***) (0.144)
DDPs – time dummy 2010 (interaction)	0.217 (**) (0.086)	0.474 (0.139)
DDPs – time dummy 2011 (interaction)	0.174 (*) (0.094)	0.336 (**) (0.157)
DDPs – time dummy 2012 (interaction)	0.194 (**) (0.093)	0.400 (**) (0.164)
DDPs – time dummy 2013 (interaction)	0.232 (**) (0.113)	0.477 (**) (0.204)
DDPs – time dummy 2014 (interaction)	0.248 (**) (0.120)	0.512 (***) (0.164)
DDPs – time dummy 2015 (interaction)	0.238 (**) (0.120)	0.585 (***) (0.164)
DDPs – time dummy 2016 (interaction)	0.329 (**) (0.157)	0.646 (***) (0.199)
DDPs – deficit entitlements (interaction)		0.097 (0.170)
DDPs – heterogeneous payments (interaction)		– 0.365 (*) (0.192)
DDPs – redistributive payment (interaction)		– 0.210 (0.166)
CDPs	0.060 (***) (0.013)	0.065 (***) (0.013)
AEM	– 0.076 (0.151)	– 0.068 (0.122)
LFA	– 0.083 (0.120)	– 0.167 (*) (0.094)
Investment support	– 0.013 (0.068)	– 0.004 (0.088)
Other RDP subsidies	0.863*) (0.510)	0.628 (0.468)
Market return (per ha)	0.015 (***) (0.001)	0.016 (***) (0.001)
Total number of observations	2 787	2 787
Number of regions	131	131
AR(1) p-value	0.041	0.028
AR(2) p-value	0.201	0.184
Hansen p-value	0.432	0.980

NB: Statistically significant at *10 %, **5 % and ***1 % levels; error terms in parentheses.

Figure 32. Time dynamics of the short-term capitalisation level of DDPs into rental rates



8.2. Land values

The estimated results for land values are reported in Table 17 ([45]). For most subsidy types, the estimated capitalisation effect is statistically insignificant. The only exception is DDPs, for which a significant capitalisation effect has been identified.

When considering the basic model, M1, land values on average increase by EUR 13.4 for each EUR 1 of DDPs. The capitalisation effect is slightly lower (at EUR 12.0) when accounting for the CAP reform in model M2. Although these estimates seem rather large in comparison with the capitalisation estimates obtained for rental prices, the two values are not directly comparable. In fact, when using land values, a transformation needs to be applied to the estimated capitalisation coefficient before being interpreted as an annual capitalisation rate, similar to the case of the capitalisation rate obtained for land rents. Following the NPV model, the land value represents a discounted stream of expected future returns from land. This implies that the estimated land value change due to the subsidies (i.e. the estimated coefficient) represents the discounted stream of expected future change in land returns induced by (EUR 1 of) subsidy change. This value needs to be divided by the discounted future stream of EUR 1 of subsidy to obtain the annual capitalisation rate. The discounted future stream of EUR 1 of subsidy is equal to $1/\delta$, where δ is a discount rate. Then the annual capitalisation rate is obtained by multiplying the estimated coefficient (e.g. 13.4 for DDPs in model M1) by the discount rate δ ([46]). As in Section 4, we use the average 10 years' maturity US government bond yield between 2010 and 2019 (i.e. 2.396 %) as a proxy for the discount rate extracted from Eurostat. Using this formula, the EUR 13.4 and EUR 12.0 capitalisation estimates for DDPs in models M1 and M2 translate into annual capitalisation rates of 32.1 % and 28.8 %, respectively, which are slightly higher than the rates obtained for the land rents in models M1 and M2 in Table 15 (23.8 % and 21.9 %, respectively).

When accounting for the DDP implementation models (M3 and M4), the estimated capitalisation of DDPs changes. The variable capturing the heterogeneity level of payments seems to be especially important in determining the capitalisation effect of DDPs. Other implementation characteristics of DDPs appear not to affect their capitalisation into land values. That is, the scarcity of entitlements (DDPs – deficit entitlements) and the redistributive payments (DDPs – redistributive payment) are statistically insignificant (Table 17). The estimates indicate that, in regions with heterogeneous DDPs, the capitalisation effect is estimated to be positive and significant. That is, around EUR 15.7 (= 64.588 – 48.860) and EUR 5.1 (= 48.874 – 43.740) per

([45]) Estimates are obtained after cleaning the data set by excluding observations with an extreme year-to-year land value change. Figure 15 to Figure 19 show that year-to-year fluctuation of land prices can be very high in some MS in some years. Large fluctuations at MS level are in fact the results of regional-level fluctuation in land prices. Given that these extreme changes in land values probably do not reflect the true land value development but could be an outcome of the methodology change or of other data structural issues, the regional observations exhibiting larger than 100 % year-to-year change in land values were excluded from the data set used in the econometric estimates.

([46]) Note that this formula assumes the continuation of subsides in future.

EUR 1 of DDPs are estimated to be capitalised into land values in models M3 and M4, respectively. This implies that the annual capitalisation rates are 38 % and 12 %, respectively.

Surprisingly, capitalisation effects for regions that implement homogeneous DDPs have been estimated as negative (– 48.8 and – 43.4 in M3 and M4, respectively). These results are contrary to expectations, given that the literature often finds that agricultural subsidies have positive impacts on land values. These results could indicate the presence of data issues and the way the land values are constructed in the FADN database (e.g. they are evaluated at historical value if it is not possible to provide the fair value). As a result, land values available in the FADN database may not reflect well the dynamics of the actual market (sale) value of land (even after cleaning for the extreme changes) and thus may not correspond correctly to the actual dynamics of market returns (including subsidies). This was shown in Section 5, which indicated that the alignment of the time dynamics of land values relative to Eurostat data appears to be less precise than the alignment of the levels of rental prices. The negative capitalisation rates could also indicate the presence of misspecification issues in the estimated model for land values (e.g. omitted variables explaining land values and inadmissibility of the assumptions of the NPV formula).

The estimated coefficients for the lagged land value are between 0.804 and 0.813. This implies that the degree of land market adjustment is equal to around 0.187–0.196, suggesting rigid markets characterised by a slow adjustment of land values to changes in land returns (including CAP subsidies). For example, using these adjustment coefficients as specified in equation (9), the long-run capitalisation rate of DDPs varies between 154 % and 164 % based on estimates provided in models M1 and M2.

A major driver of land values appears to be market returns (Table 17). The estimated coefficient is statistically significant and consistent across all estimated models. The estimated coefficient implies an increase in land values by between EUR 0.25 and EUR 0.39 for each EUR 1 of market return.

The only other variable with a rather stable and significant effect on land values across specifications is population density. This result points to an important effect of non-agricultural-related variables, and, in particular, urban pressure, on determining agricultural land values (Table 17).

8.2.1. The variation in the capitalisation of decoupled payments over time

As for the land rents, Table 18 provides the estimated results capturing the development of the DDPs' capitalisation into land values over time. The results are not stable across the estimated models M5 and M6, both in terms of statistical significance and in terms of sign and magnitude of estimated coefficients. Although in model M5 estimates of capitalisation levels are often positive and significant, the introduction of variables that control for implementation of DDPs in model M6 yields mostly negative and statistically insignificant estimated capitalisation effects. Significant capitalisation effects are estimated for 2006, 2007, 2011, 2012, 2014 and 2016. The average yearly capitalisation level of DDPs estimated in M5 is around EUR 11.6 (27.8 % annual capitalisation rate).

Figure 33 presents the (annual) capitalisation levels of DDPs estimated in model M5 and compares them with those obtained for rental prices, as shown in Figure 32. The capitalisation rates are similar (around 20 %) between 2006 and 2010. However, from 2011 onwards the two time series diverge. The yearly capitalisation rate increases more for land values than for land rents between 2010 and 2016: from 24 % in 2010 to 51 % in 2016 for land values and from 22 % in 2010 to 33 % in 2016 for land rents. Note that the capitalisation rates for land values are not always statistically significant. It is also important to note that, as explained above, the estimated capitalisation rates of subsidies into land values are not robust and thus need to be analysed with care.

Table 17. GMM estimates for land values

	Model			
	M1	M2	M3	M4
Land value (t – 1)	0.804 (***)	0.813 (***)	0.813 (***)	0.814 (***)
	(0.035)	(0.038)	(0.040)	(0.039)
DDPs	13.386 (**)	12.022 (**)	– 48.860 (**)	– 43.740 (*)
	(6.541)	(5.580)	(24.432)	(25.990)
DDPs – 2013 CAP (interaction)		– 1.861		
		(5.196)		
DDPs – land regulations (interaction)				19.155
				(15.890)
DDPs – deficit entitlements (interaction)			15.598	12.539
			(11.246)	(9.790)
DDPs – heterogeneous payments (interaction)			64.588 (**)	48.874 (*)
			(29.957)	(27.702)
DDPs – redistributive payment (interaction)			7.801	– 5.201
			(15.896)	(16.069)
CDPs	1.687	1.671	1.950	1.659
	(1.920)	(1.1794)	(1.925)	(1.829)
CDPs – land regulations (interaction)				12.264
				(23.532)
AEM	– 24.585	– 22.728	– 27.881	– 27.172
	(19.290)	(19.471)	(23.798)	(22.624)
LFA	14.675	13.775	14.241	– 4.334
	(16.018)	(15.128)	(16.574)	(13.380)
Investment support	– 20.847	– 21.076	– 19.528	– 22.761
	(19.215)	(19.664)	(17.572)	(18.329)
Other RDP subsidies	– 104.200	– 93.309	– 58.633	– 102.329
	(80.828)	(71.792)	(58.129)	(82.247)
Output value (per ha)	0.357 (**)	0.392 (**)	0.286 (***)	0.250 (**)
	(0.159)	(0.158)	(0.095)	(0.094)
Farm size (ha)	354.143	356.238	653.058	– 332.463
	(1 353.214)	(1 222.508)	(2 148.455)	(1 774.798)
Farm size (ha) squared	– 37.734	– 17.101	– 58.415	107.603
	(232.088)	(217.285)	(373.112)	(301.520)
Livestock units	– 1 693.97	– 1 478.771	– 1 092.791	– 71.455
	(2 093.178)	(2 025.702)	(2 359.014)	(2 185.920)
Livestock units squared	381.718	302.770	143.646	– 129.858
	(452.550)	(425.488)	(597.208)	(497.381)
Proportion rented UAA	2 863.86	2 757.012	1,1916.999	1 809.604 (**)
	(2 205.90)	(2 334.794)	(2 343.131)	(2 641.599)
Population density	4.609 (**)	4.996 (**)	5.318 (**)	6.019 (***)
	(2.105)	(1.958)	(2.581)	(2.268)
Population density squared	– 0.004 (***)	– 0.004 (***)	– 0.004 (**)	– 0.004 (***)
	(0.001)	(0.001)	(0.001)	(0.001)
Real interest rate	– 841.285	2 113.326	– 16 023.270	– 27 302.891
	(15 012.4)	(18 429.061)	(20 789.305)	(19 675.991)
Employment rate	626.958	8.598	824.203	– 2 595.235
	(5 748.434)	(5 014.819)	(5 558.499)	(6 825.775)
Real GDP growth	– 3 705.727	– 6 812.580	– 9 444.487	– 8 372.716
	(9 810.328)	(9 336.206)	(14 658.437)	(18 176.314)
Inflation rate	32 326.193	26 878.955	– 322.326	– 435.239
	(29 256.380)	(26 621.931)	(21 871.423)	(26 706.646)
Total number of observations	2 812	2 769	2 769	2 769
Number of regions	131	131	131	131
AR(1) p-value	0.075	0.077	0.074	0.070
AR(2) p-value	0.188	0.200	0.189	0.196
Hansen p-value	0.187	0.328	0.503	0.776

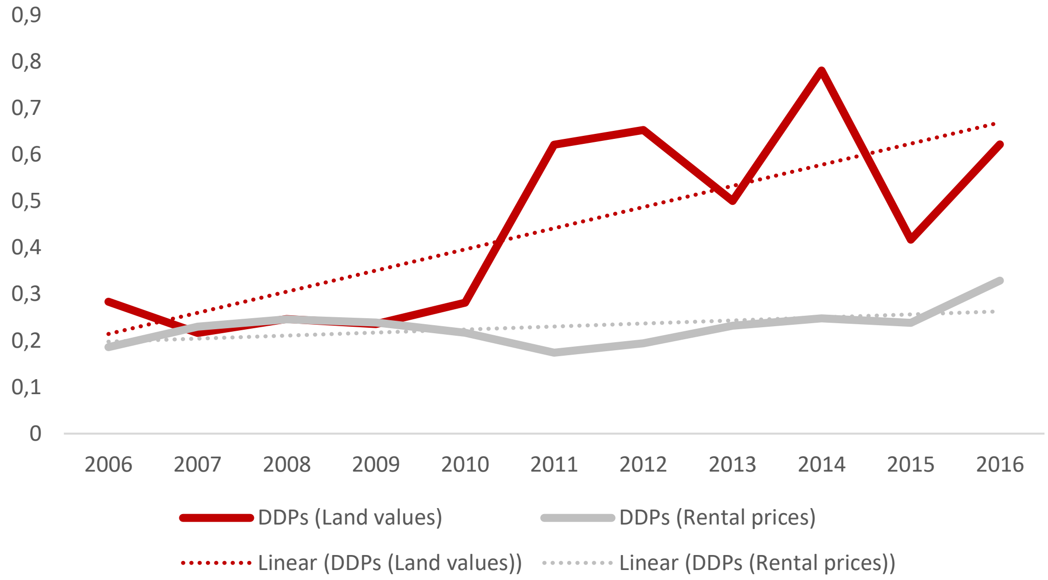
NB: Statistically significant at *10 %, **5 % and ***1 % levels; error terms in parentheses.

Table 18. GMM estimates for land values with time interactions

	Model	
	M5	M6
Land value (t – 1)	0.818 (**)	0.836 (**)
	(0.036)	(0.040)
DDPs – time dummy 2005 (interaction)	– 62.977	– 46.766
	(40.326)	(38.780)
DDPs – time dummy 2006 (interaction)	11.823 (*)	– 22.522
	(6.460)	(24.885)
DDPs – time dummy 2007 (interaction)	9.032 (*)	– 28.937
	(5.347)	(26.692)
DDPs – time dummy 2008 (interaction)	10.285	– 22.182
	(7.163)	(23.774)
DDPs – time dummy 2009 (interaction)	9.822	– 29.000
	(6.824)	(21.919)
DDPs – time dummy 2010 (interaction)	11.763	– 28.759
	(7.752)	(22.571)
DDPs – time dummy 2011 (interaction)	25.926 (*)	– 14.473
	(14.911)	(29.768)
DDPs – time dummy 2012 (interaction)	27.237 (*)	– 14.374
	(15.194)	(21.784)
DDPs – time dummy 2013 (interaction)	20.873	– 18.160
	(13.763)	(30.644)
DDPs – time dummy 2014 (interaction)	32.589 (*)	– 8.660
	(18.675)	(23.228)
DDPs – time dummy 2015 (interaction)	17.418	– 25.802
	(11.217)	(25.419)
DDPs – time dummy 2016 (interaction)	25.969 (*)	– 11.022
	(14.470)	(26.373)
DDPs – deficit entitlements (interaction)		0.867
		(14.494)
DDPs – heterogeneous payments (interaction)		53.801
		(35.778)
DDPs – redistributive payment (interaction)		5.775
		(20.079)
CDPs	2.020	2.139
	(1.932)	(2.422)
AEM	– 32.932	– 37.453
	(26.707)	(26.965)
LFA	14.377	15.689
	(16.401)	(20.747)
Investment support	– 17.264	– 17.660
	(17.485)	(16.794)
Other RDP subsidies	– 63.331 (*)	– 45.883
	(54.230)	(58.088)
Market return (per ha)	0.280 (***)	0.252 (***)
	(0.090)	(0.083)
Total number of observations	2 769	2 769
Number of regions	131	131
AR(1) p-value	0.058	0.069
AR(2) p-value	0.254	0.852
Hansen p-value	0.658	0.980

NB: Statistically significant at *10 %, **5 % and ***1 % levels; error terms in parentheses.

Figure 33. Short-term average (annual) capitalisation levels over time (comparison between DDP estimates of M1 and M7)



9. Conclusions

This report provides an analysis of the capitalisation effects of CAP subsidies into land rental prices and land values in the EU. According to the underlying theoretical framework, in well-functioning land markets, CAP subsidies are expected to be incorporated into land prices, thus benefiting landowners. The theory suggests that the capitalisation of CAP subsidies is heterogeneous in and between different types of subsidies. The impact of DDPs on land prices may vary from zero to full capitalisation depending on the implementation model, scarcity of entitlements and heterogeneity of payments across farms. In general, CDPs and RDP subsidies (with the exception of LFA payments) are expected to be less capitalised into land prices than DDPs. When considering the complex nature of the actual functioning of (real) land markets, several factors are present that may either impede or enhance the land capitalisation of CAP subsidies, such as the elasticity of land supply, greening and cross-compliance requirements, farmers' credit constraints, land market regulations, long-term duration of rental contracts, social capital, tradability of SPS entitlements and future expectations about CAP subsidies. Moreover, because of the inherent differences in the natures of land sale markets and rental markets, the capitalisation of CAP subsidies into land values may differ from their capitalisation into land rents.

There is a relatively large body of literature attempting to empirically estimate the impact of agricultural subsidies on land rents and land prices. Most of the existing empirical studies on agricultural subsidy capitalisation focus mainly on the EU and the United States. Most studies estimate the capitalisation effects on rental prices (particularly in the EU), usually determined by data availability. Overall, this literature provides the evidence that agricultural subsidies do get capitalised into land prices, but the magnitude of the estimated capitalisation rates varies significantly between studies and the rates are often found to be lower than predicted by the theory. However, there seems to be a pattern in capitalisation rates for each type of subsidy. Regarding decoupled subsidies, the estimated capitalisation rate into land prices has been typically found to be smaller than 100 % across most studies, with most estimates varying between around 5 % and 60 %. For the EU, the capitalisation rate of DDPs seems to be lower, varying between 0 % and 61 % across most studies. The estimated capitalisation rates vary more widely across studies for coupled subsidies than for decoupled subsidies. However, consistent with theoretical predictions, coupled subsidies seem to be less capitalised into land prices than decoupled payments: their capitalisation rate varies between 0 % and 50 % across most EU and US studies. There are also several studies that find either a relatively high positive capitalisation rate (greater than 100 %) or a negative rate for coupled subsidies. The impact of RDP subsidies on land prices is less investigated in the literature. The available studies consider aggregated CAP Pillar II payments or environmental payments separately, and usually the estimated capitalisation rates vary between negative and positive. Environmental payments seem to be largely associated with a negative or small positive capitalisation effect.

To estimate empirically the impact of CAP subsidies on rental prices and land values in the EU, we employed the GMM estimator and used the FADN regional-level panel data for 1989–2016. The FADN data were complemented by other data sources (e.g. Eurostat and the World Bank) to obtain other control variables that were expected to impact land prices.

The estimated results suggest that CAP subsidies are capitalised into land rents. According to estimates, the short-run capitalisation rate of DDPs varies between 9.1 % and 46.2 %. The heterogeneous DDP models appear to have a lower capitalisation rate by between 34 % and 37 % than the flat-rate DDP models. Other implementation details of DDPs (e.g. the scarcity of entitlements and the redistributive payments) appear not to impact the capitalisation of DDPs. The long-run capitalisation rate of DDPs varies between 11 % and 55 %; the heterogeneous DDP models have a lower long-run capitalisation rate by between 41 % and 45 % than the homogenous DDPs models. The estimated results tend to show that the capitalisation of DDPs increased over 2005–2016.

The short-run capitalisation rate of CDPs is found to be lower than the capitalisation rate of DDPs, varying between 5.8 % and 6 %. The long-run capitalisation rate of CDPs is around 7 %. RDP subsidies are generally found not to affect land rental prices.

In contrast to rental prices, the estimates for land values suggest that only DDPs may cause statistically significant capitalisation effects. The results suggest a capitalisation rate between 28.8 % and 32.1 % in the short run and between 154 % and 164 % in the long run. However, estimates for land values are not robust and consistent across models, and thus they need to be interpreted with care. The unstable capitalisation effects estimated for land values could be caused by (i) the fact that the land values available in the FADN database do not reflect accurately the development of the actual market (sale) value of land, (ii) the methodology used to obtain land values in the FADN database, (iii) econometric issues or (iv) the combination of these three factors.

The results of this report have several policy implications. The conceptual and empirical analyses carried out for this report suggest that the CAP contains instruments that can limit (reduce) the capitalisation of CAP subsidies. The key instruments that may limit capitalisation include redistributive payments, degressivity, capping, a shift from direct payment to the CAP Pillar II support, environmental payments and environmental conditionality of direct payments. These effects arise because these instruments reduce land market distortions, have a smaller direct impact on (marginal) land returns (i.e. reduce the marginal subsidy value) or reduce the linkage of subsidies to land.

Despite the comprehensiveness of the analysis, the results in this report should be interpreted with care, as there are several factors that need to be taken into consideration. First, we have attempted to account for land market regulations and institutions in our analyses, which are often argued to impact the subsidy capitalisation. However, data that would allow the measurement of their presence and dynamics across MS and over time are not available. For this reason, the role of land market regulations and institutions in impacting on capitalisation could not be identified empirically. Second, owing to data issues, the capitalisation estimates for land values are not robust and thus more accurate results could not be provided in this report in this respect. Third, the data considered in this report cover only a few years when the CAP 2013 reform had been implemented in MS (including the CAP greening measures), and thus its impact could not be identified in the estimates. Despite these limitations, the report provides updated and overarching conceptual and, in particular, empirical evidence of the impact of CAP subsidies on land values in the EU. The issues identified above are a promising avenue for future research and should be addressed as soon as more data become available.

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List of abbreviations

AEM	agri-environmental-climate measure
CAP	common agricultural policy
CDP	coupled direct payment
DDP	decoupled direct payment
EU	European Union
FADN	Farm Accountancy Data Network
GDP	gross domestic product
GMM	generalised method of moments
LFA	less favoured area
MS	Member State(s)
NPV	net present value
NUTS	Nomenclature of Territorial Units for Statistics
RDP	rural development programme
SAFER	Sociétés d'aménagement foncier et d'établissement rural
SAPS	single area payment system
SPS	single payment scheme
UAA	utilised agricultural area

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