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Generalized Propensity Score Evidence from the EU

Pavel Ciaian, d'Artis Kancs and Jerzy Michalek

Katholieke Universiteit Leuven

LICOS Centre for Institutions and Economic Performance
Waaistraat 6 – mailbox 3511
3000 Leuven

BELGIUM

TEL:+32-(0)16 32 65 98
FAX:+32-(0)16 32 65 99
http://www.econ.kuleuven.be/licos

SPS Capitalization into Land Value:
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Pavel Ciaian[2], d'Artis Kancs[3] and Jerzy Michalek[4]

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Abstract

This paper estimates the capitalization of the Single Payment Scheme (SPS) into land values. The theory suggests that the relationship between the SPS and land rents is non-linear and discontinuous, because the SPS impact on land values depends on many factors, such as policy implementation details, market imperfections and institutional regulations. In empirical analysis we employ a unique farm-level panel data set, and apply the generalized propensity score (GPS) matching approach to estimate the capitalization of the SPS. Our results suggest that around 6 percent of the total SPS get capitalized into land rents. On average in the EU, the non-farming landowners' gains from the SPS are only 3 percent. However, there is a large variation in the capitalization rate for different SPS levels, and between Member States (between 0 and 58 percent).

Key words: decoupled subsidies, capitalization, land market, income distributional effects, selection bias.

JEL: Q12, Q18.

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[2]European Commission (DG JRC), Catholic University of Leuven (LICOS), Economics and Econometrics Research Institute (EERI) and Slovak Agricultural University (SAU). E-mail: pavel.ciaian@ec.europa.eu.

[3]European Commission (DG JRC), Catholic University of Leuven (LICOS), and Economics and Econometrics Research Institute (EERI). Correspondence Address: European Commission, DG Joint Research Centre, B-1049 Brussels, Belgium. E-mail: d'artis.kancs@ec.europa.eu.

[4]European Commission (DG JRC), E-mail: jerzy.michalek@ec.europa.eu.

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1 Introduction

The distributional effects of agricultural policy, which Alston and James (2002) refer to as the 'incidence of agricultural policy', have been studied extensively in the literature on the subject. An influential OECD (2001) study came to the conclusion that only 20% of all market and price support resulted in net farm gains in the OECD countries; the rest was dissipated to others, including the owners of production factors.

Theoretical studies have analyzed how income distributional effects differ between policy types (Alston and James, 2002; de Gorter and Meilke, 1989; Dewbre, Anton and Thompson, 2001; Gardner 1983; Guyomard, Mouel and Gohin, 2004), agents along the vertical chain (Desquilbet and Guyomard, 2002; Sheldon, Pick, and McCorriston, 2001), imperfect competition (McCorriston and Sheldon, 1991 and Salhofer and Schmid, 2004), imperfections in factor markets (Ciaian and Swinnen, 2006; 2009), transaction costs and constraints in policy implementation (OECD, 2007; de Gorter, 1992; Munk, 1994; and Vatn, 2001). Theoretical models find that these factors significantly affect the distributional effects of farm policies. Generally, land-based coupled subsidies directly stimulate land demand and hence lead to higher land values, whereas non-land-based subsidies indirectly lead to upward adjustments of land rents through induced higher land demand. Fully decoupled farm polices have no impact on land value.

The empirical findings are less conclusive and not always consistent with the theoretical predictions. Generally, the empirical results tend to confirm that landowners benefit from farm subsidies, both coupled and decoupled. According to Goodwin, Mishra and Ortalo-Magné (2003, 2005); Lence and Mishra (2003); Roberts, Kirwan, and Hopkins (2003); Kirwan (2009); Ciaian and Kancs, (2009); Barnard, et al. (1997); Taylor and Brester (2005); Patton et al. (2008), the capitalization rate of *coupled* subsidies varies between 20% and 100%, whereas the capitalization rate of *decoupled* subsidies varies between 20% and 80%. However, due to the large variation in the estimated impact, there is no robust evidence on income distributional effects of different types of agricultural policy instruments.

In addition, most of the existing empirical studies are on North America (the US and Canada), and only a few cover the EU (Duvivier, Gaspart and de Frahan, 2005; Latruffe et al. 2006; Patton et al. 2008; Ciaian and Kancs 2009; Breustedt and Habermann 2011). The evidence on the Single Payment Scheme (SPS) in the EU is very limited (Kilian et al 2008). Kilian et al (2008) study the capitalization of the SPS and find that the SPS is capitalized by an additional 15% to 19% on top of the previous coupled subsidies. However, since Kilian et al (2008) use traditional estimation techniques (OLS and IV estimators), and only one cross-section of data (2005 – the first year of the SPS), they are not able to control for key econometric issues, such as the unobserved farm-specific effects, implying that their estimates might be biased.

In light of the lack of robust empirical evidence, the main objective of the present study is to assess the capitalization of the SPS into farmland rental prices in the EU. First, we theoretically identify the key factors determining the capitalization of the SPS: the entitlements stock, the tradability of entitlements, the cross-compliance, and market imperfections and institutional regulations. We show that the entitlements stock effect and credit market imperfections *increase* the capitalization of the SPS, whereas the cross-compliance, the tradability of entitlements and land market institutions and regulations *reduce* the capitalization of the SPS into land rents. Furthermore, the theoretical analysis suggests that depending on the SPS implementation details and land market characteristics, the SPS may get capitalized into land rents at different capitalization rates. Moreover, because of farm heterogeneity, and the interactions between the SPS and land market conditions, the capitalization rate of the SPS may be different for different types of farms and for different SPS intensity levels.

We test the theoretical predictions empirically by employing a unique set of farm-level panel data for 2004 – 2007. In the econometric analysis we employ the generalized propensity score (GPS) matching approach, which allows us to address several important sources of bias, from which many previous studies suffer. In particular, by employing the GPS we are able to address the selection bias, simultaneity bias, general equilibrium effects, and functional form misspecification This is important, as the theoretical analysis suggests that the incidence of the SPS is non-linear and discontinuous. In addition, the GPS allows us to estimate the incidence for different SPS levels. In summary, our empirical findings suggest that, on average, 6 percent of the SPS get capitalized into rental prices of farmland in the EU, which benefits landowners. These results are new and have not been reported in the literature before.

2 Agricultural Policy in the EU

2.1 Single Payment Scheme (SPS)

In 2003 the Common Agricultural Policy (CAP) underwent significant reforms. The 2003 CAP reform decoupled most of the direct payments by introducing the SPS starting from 2005.[5] Since then the SPS have been allocated as a fixed set of payments per farm. Farms are entitled to yearly payments, depending on the number of SPS entitlements and the eligible land,[6] because SPS entitlements can only be activated if they are accompanied by eligible land.

When implementing the SPS, the MS could choose between three different SPS implementation models: *the historical model, the regional model*, and *the hybrid model*. Under the historical model, the SPS is farm-specific and equals the support the farm has received in the "reference" period. Under the regional model, an equal per hectare payment is granted to all farms in the region. The hybrid model is a combination of historical and regional models, it has two versions: a static and a dynamic.[7] The key difference between the three models is in the unit value of entitlements. Under the historical and hybrid models the value of entitlement varies between farms (stronger in the former than in the latter), whereas under the regional SPS model all farms in a given region received entitlements with the same unit value. The most commonly implemented SPS model in the EU is the historical model, and none of the studied MS implement the regional model. This has important implications for econometric estimations. Using farm-level data, this permits sufficient variation in the unit value of the SPS among farms.

In the first year of the SPS implementation (2005 or 2006 depending on the country) each farm was allocated a fixed amount of the SPS entitlements.[8] [9] Farms can activate the entitlements and receive the corresponding payments, if they are accompanied by an equal number of eligible hectares. This implies that the SPS is indirectly linked to land because, in the absence of land, farms cannot cash in the SPS entitlements. However, the SPS is not linked to a specific land area. An SPS entitlement can be activated

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[5] MS could choose to introduce the SPS either in 2005 or in 2006. For comparison purposes, the data used in this paper covers the period before and after the introduction of SPS in the EU-15 (see further).

[6] According to SPS regulations, the eligible area includes arable land and permanent pasture except areas under permanent crops, forests or areas used for non-agricultural activities.

[7] In 2007 the *historical model* was implemented in Austria, Belgium, France, Greece, Ireland, Italy, the Netherlands, Portugal and Spain; the *regional model* in Malta and Slovenia; the *static hybrid* in Denmark, Luxembourg and Sweden; the *dynamic hybrid* in Finland and Germany; and a *mixed system* of historical and hybrid models in the UK. Those MS implementing the dynamic hybrid model move gradually to a fully regional model. In MS implementing the static hybrid model, the regional and the historical shares do not change over time (European Commission 2007a).

[8] This setting makes the SPS different compared to a standard area subsidy. Under the standard area subsidy farms receive payments for the entire area they use, whereas with the SPS only a pre-defined quantity of land (determined by the number of entitlements) may obtain payments. The standard area subsidy is implemented in new MS.

[9] In the historical model the initial number of entitlements was determined by the number of hectares that generated previous coupled support to the farm in the reference period 2000-2002. In the regional and hybrid models the initial number of entitlements was equal to the total eligible area the farm used in the first year of SPS application.

by any eligible farmland in the region. Furthermore, farms can expand or decrease their stock of entitlements by buying or selling entitlements on the market from other farms.[10]

2.2 Entitlement tradability

Generally, entitlements are tradable. However, due to regulatory constraints and market imperfections, the tradability of entitlements is heavily constrained as the SPS entitlements are tradable only within MS (not among them) and under certain conditions. The general EU regulations specify that the lease and similar market transactions with entitlements are allowed only if the transferred entitlements are accompanied by an equivalent number of hectares of eligible land (European Council 2003). Farms may transfer their entitlements without land only after they have used at least 80% of their payment entitlements during one year or after they have voluntarily given up all unused entitlements to the national reserve in the first year of the SPS. If more than 20% of the SPS value is allocated from the national reserve then the entitlement cannot be transferred for 5 years.[11] In addition to regulatory constraints, the tradability of entitlements is also constrained by market imperfections; such as imperfectly functioning rural credit markets or policy uncertainty. Given that the SPS represents the right to a future stream of subsidies, a potential buyer would need to pay the seller the present net value of the future stream of subsidies in competitive markets. However, if the buyer is credit constrained then his/her ability to pay for entitlements is reduced, which acts as a tax on entitlement sellers. In addition, policy uncertainty introduces a risk component to the entitlement market, because there is uncertainty about the duration of the SPS. The current CAP framework and the financial allocation run until 2013. The post-2013 CAP is subject to negotiation between MS. However, both the implementation of the SPS and its budgetary allocation may change in the future. Similarly to credit market imperfections, the policy uncertainty reduces the willingness to participate in the entitlement market, the effect of which is similar to an entitlement tax.

2.3 Cross-compliance requirements

Finally, farm eligibility to the SPS is subject to cross-compliance. Each farm that receives the SPS must comply with the Statutory Management Requirements (i.e. public, animal and plant health, environment, and animal welfare requirements), and maintain the agricultural land in Good Agricultural and Environmental Condition. In the past the Statutory Management Requirements were based on EU Directives and Regulations, such as the Nitrates Directive.[12] The 2003 CAP reform made cross-compliance compulsory and extended the coverage of requirements in the fields of environment, public, plant health and animal welfare. A farm's failure to respect these conditions can lead to a reduction or a complete stop of the SPS payments. According to Ciaian, Kancs and Swinnen (2010), adherence to the cross-compliance requirements implies additional costs for farms. Given the heterogeneity of farms in the EU, the costs related to meeting cross-compliance requirements will have heterogeneous impacts on the rental price of land and hence on the capitalization of the SPS (see: 3.4 below).[13]

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[10] Under certain conditions MS can also allocate new entitlements from the national reserve but their allocation is not automatic. Member States create the national reserve by a linear percentage reduction (up to 3%) of their SPS national ceiling.

[11] The MS can impose additional country-specific restrictions on the transfer of entitlements. For example, a MS may decide that payment entitlements may only be transferred or used within a region. Member States may also require that in the case of a sale of payment entitlements without land up to 50% and in the case of sale of payment entitlements with land up to 10% must be reverted to the national reserve. In terms of the entitlement tradability France, Portugal and Spain are the most restrictive countries (Ciaian, Kancs and Swinnen 2010).

[12] Maintaining the agricultural land according to the Good Agricultural and Environmental Condition is a new requirement, which aims to prevent the abandonment and severe under-management of farmland.

[13] According to the European Commission, the cross-compliance requirements do not introduce substantive new obligations for farmers. Their main objective is to enforce the existing EU and national legislation

3 Conceptual framework

3.1 Land market and the SPS

The conceptual framework of the present study builds on Ciaian, Kancs and Swinnen (2008). Agricultural goods are produced by two types of heterogeneous farms. All land is owned by landowners who rent the land to farmers (see Appendix). Figure 1 illustrates the land market. The horizontal axis represents the quantity of land, where the total agricultural land (A^T) is assumed to be fixed. The amount of land rented by farm 1 (A^1) is shown from the left to right on the horizontal axis, and the amount of land rented by farm 2 (A^2) is shown from the right to left with $A^2 = A^T - A^1$. The vertical axis measures the rental price and subsidies. The initial land demands of farm 1 and farm 2 are given by downward sloping curves D^1 and D^2, respectively derived from farm profit maximization (see Appendix). Without the SPS, the equilibrium set of land allocation and land rent is A^*, w^*. Farm 1 rents A^* hectares of land ($A^1 = A^*$) and farm 2 rents $A^2 = A^T - A^*$ hectares of land.

Next, consider the implementation of the SPS. We define E^1 as the total SPS payment for farm 1, and A_E^1 as the maximum amount of entitlements (Figure 1). The payment per entitlement, t^1 is equal to $t^1 = E^1 / A_E^1$. Analogously, $t^2 = E^2 / A_E^2$, where E^2 is the total SPS payment for farm 2, A_E^2 $(= A^T - A_E)$ is the amount of entitlements, and t^2 is the face value of the entitlements.

Under the historical and hybrid SPS models,[14] the face value of the entitlements varies among farms, which implies that $t^1 \neq t^2$. The variation in the face value of entitlements is higher in the historical model than in the hybrid model. The value of entitlements in the hybrid model is composed of a farm-specific component (subsidies received in the reference period) and a regional component, which is equal to all farms in a given region, whereas in the historical model they are calculated only from the farm-specific component.

The SPS creates kinks in the land demand functions (Figure 1). Farms do not receive the SPS for any land that they rent above the amount of entitlements they own, i.e. above A_E^1 and A_E^2 $(= A^T - A_E)$ for farm 1 and farm 2, respectively.[15] In this case, a farm's willingness to pay for land is not affected by the SPS. For additional land farm i cannot pay more than the marginal profitability of land. In the reverse case, when farm i rents less land than its eligible area A_E^i, the marginal profitability of land is increased by the value of entitlement, t^i. Now farms are willing to pay a higher rent, up to t^i. Otherwise the payment is lost to farms. This is illustrated in Figure 1. Starting from the left-hand side and following the thick full lines, the land demand of farm 1 is given by $D_t^1\ D^1$, whereas the land demand of farm 2 is given by $D^2\ D_t^2$.

The capitalization of the SPS into land value can be described by several measures, of which the two most important are: the capitalization level, which is usually expressed in monetary terms (Euro in our study), and the capitalization rate, which is usually expressed in percent per one unit of farm subsidy. Furthermore, both measures can be expressed as average or marginal capitalizations. Average capitalization refers to average rental price effect over all intensities of the SPS, whereas marginal capitalization refers to rental price effect with respect to each additional unit of payment.

The value of the entitlement determines the maximum amount of the SPS, which can be entirely capitalized into land value, which corresponds to the full (100%) capitalization rate. In most cases, however, the actual capitalization rate is less than 100% (less than the value of the entitlement), because the capitalization rate of the SPS depends on many factors (Ciaian, Kancs and Swinnen 2008). Among others, the actual capitalization rate of the SPS depends on factors such as the ratio of entitlements to eligible land, the tradability of entitlements, costs of cross-compliance and market imperfections. Some of

[14] For our empirical analysis only the historical and hybrid SPS models are relevant. The regional model is not implemented by any of the countries included in our data. For this reason we do not consider this model in our theoretical analysis.
[15] For the sake of simplicity, when indexing variables with i we refer to both farms. We drop the text 'for i = 1 and 2'.

these factors increase the capitalization rate of the SPS, e.g. entitlement excess stock relative to the eligible area, whereas some others decrease the capitalization rate of the SPS, e.g. entitlement tradability or excessive costs of cross-compliance (see below). Due to mutual interactions between these factors, the capitalization of the SPS may result in non-linear capitalization effects with respect to the value of the entitlements. Due to non-linearities in the SPS capitalization rate, for policy makers it is important to know not only the average capitalization rate, but also the capitalization rate for different levels of the SPS.

3.2 Entitlement stock effect

The entitlement excess stock (relative to the eligible area) increases the capitalization of the SPS, whereas the excess supply of (eligible) land reduces the capitalization of the SPS. In the extreme, the excess supply of land may drive the SPS capitalization to zero, whereas the entitlement excess stock may lead to full capitalization of the SPS into land values. For the sake of simplicity, graphically, we analyze the two extreme cases, but the results generally also hold for intermediate cases. The difference between the deficit and surplus stock of entitlements (relative to the eligible area) can be best seen with entitlement tradability without cross-compliance requirements in perfectly competitive land markets, which is shown in Figure 1 and Figure 2.

Assume that under the *deficit stock of entitlements* (entitlements are less than the eligible area) the total endowment with entitlements of farms 1 and 2 (A_E^1 and A_E^2, respectively) is strictly smaller than the total eligible area, $A_E^1 + A_E^2 < A^T$ (Figure 1).[16] The land demands without the SPS are D^1 D^1 and D^2 D^2, whereas the SPS shifts them to D_t^1 D^1 and D^2 D_t^2, for farm 1 and farm 2, respectively. This implies that with deficit entitlements the equilibrium with and without the SPS is the same at (A^*, w^*) (Figure 1). Both the equilibrium land rental and the equilibrium rental prices are not affected by the SPS. The SPS has a zero-distortive marginal effect on farm rental decisions. This implies zero capitalization of the SPS.

Next, assume that under the *surplus entitlements* (entitlements are more than the eligible area) farms 1 and 2 receive entitlements such that $A_E^1 + A_E^2 > A^T$ (Figure 2).[17] Given that entitlements are in surplus and farms need land to activate their entitlements, farms will not be able to activate all their entitlements. Profit maximizing farms will compete for land in order to activate their unused entitlements. Competing farms will underbid the market price for land until its marginal profitability (including the SPS). As a result, the SPS will be capitalized into land rents. In Figure 2, land demands without the SPS are D^1 D^1 and D^2 D^2 for farms 1 and 2, respectively. With the SPS their respective land demands shift to D_t^1 D^1 and D_t^2 D^2, the equilibrium shifts from A^*, w^* to A_t^*, w_t^*. In equilibrium the rental rate increases by w_t^* - w^*, meaning that the SPS is reflected in higher rents. Hence, under the excess stock of entitlements, the SPS gets capitalized into land rents.[18]

From the above analyses it follows that the relationship between the level of marginal capitalization and the face value of entitlements is negative. In Figure 2 the higher value entitlement t^1 (where $t^1 > t^2$) is partly reflected in higher rents ($w_t^* - w^* < t^2$), whereas the lower value entitlement t^2 is fully incorporated in land values ($w_t^* - w^* = t^1$). In other words, the marginal capitalization of the SPS, expressed in monetary terms, $w^* - w_t^*$, is equal for both farms. However, the marginal capitalization rates, expressed per unit of

[16] In our model we assume that the entire land (A^T) is eligible for activation of the SPS entitlements, which corresponds to the situation in the countries of our sample.

[17] Several factors may lead to a situation where the number of entitlements exceeds the eligible area in the medium-run. For example, agricultural land conversion to non-agricultural use, or the allocation of new entitlements to farms (e.g. entrants). The relative stock of entitlements tends to be larger in countries which implement the hybrid model than in countries using the historical model. This is because under the historical model the total number of entitlements corresponds to the number of hectares that generated subsidies in the reference period. Under the hybrid model (or the regional model), the total number of entitlements is equal to all land declared eligible at the time of the SPS introduction.

[18] This result is driven, among other things, by the assumption of competitive markets where farms compete for land. If a farm were not willing to pay higher rent, then landowners could always find another farm with some unused entitlements willing to pay this rent.

the SPS, vary between farms. For farm 1 the marginal capitalization rate is $(w_t^* - w^*) / t^1$ and for farm 2 $(w_t^* - w^*) / t^2$, where $(w_t^* - w^*) / t^1 < (w_t^* - w^*) / t^2$. The total weighted average capitalization rate lies between these two values, $(w_t^* - w^*)A^T / [t^1 A_t^* + t^2(A^T - A_t^*)]$.

3.3 Entitlement tradability effect

Entitlement tradability reduces the capitalization of the SPS, whereas barriers to entitlement trade increase the capitalization of the SPS. In the extreme, free entitlement trade may drive the SPS capitalization to zero, whereas prohibitive barriers to entitlement trade may lead to full capitalization of the SPS into land values.[19] For the sake of simplicity, graphically we analyze the two extreme cases, but the results generally also hold for intermediate cases. The difference between tradable and non-tradable entitlements can be best seen by analyzing deficit entitlements in perfectly competitive land markets with two types of heterogeneous farms, which is shown in Figure 1.[20] In particular, farms of type 2 are assumed to be more productive than farms of type 1.[21]

We start with *free entitlement trade*. The productivity advantage of farm 2 shifts its land demand from D_t^2 D^2 to D_{tg}^2 D_g^2 (dotted line), and the land demand of farm 1 is unaffected. With perfectly tradable entitlements the corresponding shift in equilibrium is from A^*, w^* to A_g^*, w_g^*, implying zero capitalization of the SPS. Although the equilibrium rent increases by $w_g^* - w^*$, the SPS does not contribute to this increase. With and without the productivity advantage, the rent is entirely determined in the demand curves segment, which is not affected by the SPS, i.e. it is determined by the D^1 and D_g^2 part of land demand of farm 1 and farm 2, respectively. The rent increase is induced solely by the productivity advantage of farm 2. The amount of traded entitlements between farms is $A_E^1 – A_g^*$. Farm 1 sells entitlements to farm 2 for a price equal to the face value of its entitlements. Both farms gain from trade. Farm 1 gains the full value of the corresponding SPS, $(A_E^1 – A_g^*)t^1$, which more than offsets the loss from reduced land renting, whereas farm 2 benefits from renting more land and hence earning higher income from production (see Ciaian, Kancs and Swinnen 2008 for formal derivations).

Next, consider land market equilibrium with *non-tradable entitlements*.[22] Prohibitive barriers to entitlement trade imply that farm 1 cannot sell entitlements $A_E^1 – A_g^*$. Instead, it uses part of the SPS to compete for land with the aim of retaining its land in order to be able to activate all entitlements. Otherwise, part of the entitlements and the corresponding value of the SPS would be lost to farm 1. In Figure 1 the non-tradability of entitlements implies that the land market equilibrium shifts from A^*, w^* to A_E^1, w_t^*.[23] As shown above, with freely tradable entitlements the equilibrium is A_g^*, r_g^*, implying that with non-tradable entitlements, the SPS capitalization into land rents is equal to $w_t^* - w_g^*$.[24] Note that if the productivity increase of farm 2 is sufficiently high, then entitlement t_1 may be fully capitalized into land rent.

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[19] This also depends on the stock of entitlements.

[20] With surplus entitlements, the SPS is always capitalized into land rents. This is independent of whether the entitlements are tradable or not. The tradability may affect only the level of capitalization rate (see Ciaian, Kancs and Swinnen 2008 and Ciaian and Swinnen 2006 for more details).

[21] The productivity advantage may be caused by several factors. Firstly, it may be induced by general improvement in the technology and rural institutions. Secondly, in the presence of imperfect rural credit markets, the SPS itself may reduce farms' credit constraints and thereby increase productivity (see further). Thirdly, the decoupling, which accompanied the introduction of the SPS, may have stimulated farm production adjustment leading to improved farm efficiency. Finally, the time gap between the reference period used for the entitlement allocation and the time of the SPS implementation in the historical model may have implications for land markets. The allocation of entitlements was based on a historical reference period (2000–02), but not on the land used at the time of the SPS implementation (2005–06). If productivity changed between the two periods, then the land use adjustments may take place.

[22] This could occur either due to regulatory constraints or market imperfections, or both.

[23] Now the sale of entitlements $(A_E^1 – A_t^*)$ is not possible. As a result farm 1 uses the SPS to compete for land.

[24] Note that if the productivity advantage is sufficiently high t^1 is fully capitalized in land rents; in the opposite case if the productivity advantage is sufficiently low, the capitalization is zero even if the entitlements are not tradable (see Ciaian, Kancs and Swinnen 2008; Ciaian and Swinnen 2006).

With tradability constraints, the relationship between the marginal capitalization rate and the face value of entitlements is ambiguous. The relationship could be positive or negative depending on the type of farm heterogeneity. For example, in Figure 1 the high value entitlement, t^1, is capitalized in rent, whereas the low value entitlement, t^2, is not incorporated into land rent, implying a positive correlation between marginal capitalization and the entitlement face value.[25] However, if farm 1 was more productive than farm 2 then the relationship would be negative.

3.4 Cross-compliance effect

Cross-compliance requirements reduce the capitalization of the SPS. Under certain circumstances, cross-compliance requirements may drive the capitalization to zero or even negative values. Cross-compliance requirements decrease the capitalization of the SPS because they create an additional cost for farms by imposing constraints on farm activities, for example with the aim of promoting environmentally friendly farming practices.[26] The heterogeneity in farms' natural endowment, production structure and technology determines the actual costs of cross-compliance, which each farm incurs by complying with the requirements. Moreover, the cross compliance costs can also vary between the MS, regions, and cross-compliance instruments (Alliance Environment 2007; European Commission 2007b).[27] In the extreme, a farmer may choose not to participate in the SPS if his cross-compliance costs exceed the SPS benefits.

In order to simplify the example, we analyze graphically the two cases with zero and positive cross-compliance costs, but the results generally also hold for intermediate cases. The impact of cross-compliance on the SPS capitalization can be best seen by considering heterogeneous farms with entitlement excess stock, which is shown in Figure 3 (which is an extension of Figure 2). With *zero cross-compliance costs* of the SPS, the land demands are $D_t^1 D^1$ and $D_t^2 D^2$, for farm 1 and farm 2, respectively, and the land market equilibrium is at $A_t^* w_t^*$. The SPS amount equal to $w_t^* - w^*$ is capitalized into land rents.

Next, consider a situation with *positive cross-compliance costs*. According to the EU regulations, the entire land area cultivated by farms receiving the SPS must respect the cross-compliance criteria irrespective of whether all or part of the SPS entitlements are activated and irrespective of whether all or part of the agricultural land is used for the activation of the entitlements (EC 2003). This implies that for farms the additional cross-compliance costs are linked to land, but not to entitlements.[28] Hence, the cross-compliance costs reduce the profitability of land, which implies a downward shift in land demand. Positive cross-compliance costs shift the land demand curves downward to $D_{tc}^1 D_c^1$ and $D_{tc}^2 D_c^2$ (dotted lines), for farm 1 and farm 2, respectively. The new land market equilibrium is at $A_t^* w_{tc}^*$. Overall, the cross compliance costs reduce land rental price, implying that the marginal capitalization level is also lower (by $w_t^* - w_{tc}^*$) relative to a situation with zero cross-compliance costs.[29]

Given that cross-compliance costs depend on the farms' natural endowment, production structure and technology, they will differ among heterogeneous farms and, in general, they may or may not be correlated with the face value of entitlements. As a result, similarly to the entitlement tradability effect, the relationship between the level of marginal capitalization and the face value of entitlements is ambiguous.

[25] The marginal capitalization rate for farm 1 is $(w_t^* - w_g^*) / t^1$ and for farm 2 $(w_t^* - w_t^*) / t^2$, where $(w_t^* - w_g^*) / t^1 > (w_t^* - w_t^*) / t^2$ and $w_t^* - w_t^* = 0$. The total weighted average capitalization rate is equal to $(w_t^* - w_g^*)A_E^I / [t^1 A_E^I + t^2 (A^T - A_E)]$

[26] The empirical evidence suggests that cross-compliance requirements imply additional costs not only for farms, but also for public administrations managing the SPS (Ciaian, Kancs and Swinnen 2010).

[27] According to the European Commission (2007b), a farmer's administrative costs of SPS in Denmark, France, Germany, Italy and Ireland were calculated in the range 5-29 euro/ha. This represents between 3 and 9% of the total SPS payments.

[28] The activation of at least one entitlement is sufficient to make cross-compliance obligatory on all farmland. Even areas not used for entitlement activation must be also farmed in accordance with the cross-compliance requirements.

[29] Note that the cross-compliance induced effects are additional to the results obtained above with zero cross-compliance costs, which implies that the actual capitalization of the SPS could be negative or positive. For example, in the above analysis we have shown that with deficit and fully tradable entitlements the SPS capitalization rate is zero (Figure 1). If however cross-compliance costs depress the rents then the combined capitalization rate will be negative.

The relationship depends on how the heterogeneous farms are affected by fulfilling the cross-compliance requirements.

3.5 Land market imperfections and institutional regulations

Rural land markets are often constrained by various rigidities and imperfections (Ciaian, Kancs and Swinnen 2010). Market imperfections can either increase or decrease the capitalization rate of the SPS. The two most important imperfections identified in the literature are credit market imperfections, which usually increase the capitalization rate, and land market institutions and regulations, which usually restrict rental adjustments to the SPS (Ciaian and Swinnen 2009).

First, consider *credit market imperfections*. The agricultural sector is perceived to have significant credit problems, mainly due to the nature of production and the risk specific to agriculture that is present to a lesser extent in other sectors of the economy (Barry and Robison 2001). Studies show that this is also the case in developed countries such as EU Member States and the USA (Blancard et al. 2006; Lee and Chambers 1986; Färe, Grosskopf, and Lee 1990).

We illustrate the credit constraint effect with surplus entitlements in Figure 4 (which is an extension of Figure 2). Without credit market imperfections, the land market equilibrium with the SPS is at A_t^*, w_t^*, implying that the w_t^* - w^* part of the SPS is capitalized into land rents.

According to Ciaian and Swinnen (2009), farms facing credit constraints may use subsidies to substitute missing finances. This has important implications for the land market, as[30] higher input use increases farms' land demand, thereby exerting upward pressure on land rents. This is illustrated in Figure 4. The SPS has two effects on land rents, one direct and one indirect. The direct effect is the standard effect of the SPS, and is shown above in the absence of credit market imperfections, and is equal to a rental price increase by w_t^* - w^*. The indirect effect is the following: the SPS relaxes farms' credit constraints, which allows farms to purchase more inputs. This increases the productivity of land (assuming that farms are credit constrained) and further increases farms' land demand, resulting in higher rent, which reinforces the direct effect. The indirect credit constraint effect results in a shift in land demands from D_t^1 D^1 and D_t^2 D^2 to D_{tc}^1 D_c^1 to D_{tc}^2 D_c^2 (dotted lines), for farm 1 and farm 2, respectively. The new equilibrium rent is A_t^*, w_{tc}^*. Compared to no-credit market imperfections, the SPS marginal capitalization into land rents has increased by w_{tc}^* - w_t^*.

The credit constraint effect depends on the size of the credit constraint. The more credit constrained the farms the larger the productivity effect, and hence the higher the marginal capitalization of the SPS.[31] The relationship between the level of marginal capitalization and the face value of entitlements in the presence of credit market imperfections is negative. Everything else being equal, farms that receive high value entitlements will be able to increase productivity more, resulting in higher SPS capitalization compared to farms with low value entitlements.

Next, consider the impact of *land market institutions and regulations*. The rental market arrangements in the EU may either involve rental price controls or provisions on the duration of rental contracts. The rental price controls such as minimum or maximum prices are usually imposed by government, whereas the duration of rental contracts can be regulated through both formal governmental interventions and/or through informal rural market institutions (Ciaian, Kancs and Swinnen 2010).

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[30] If farms receive the SPS at the beginning of the growing season, the credit constrained farms can use the subsidy payment to directly pay for variable inputs. If farms receive subsidies at the end of the season or need finances for longer term investments, the SPS can still improve their access to credit, because farms may use the future (guaranteed) SPS payments as collateral to obtain credit from banks before the actual SPS payment is realized.

[31] Even if the SPS does not affect land rents directly, e.g. with deficit and tradable entitlements and no cross-compliance, its interaction with credit markets may lead to higher land rents.

Of particular importance for the SPS capitalization is the *maximum price intervention*. The potential capitalization of the SPS into land rents will be reduced in the presence of a rental price ceiling. The duration of rental contracts also has an important implication for rental price adjustments. *Ceteris paribus*, long-term rental contracts for agricultural land will adjust less to policy changes than short-term contracts. According to Ciaian, Kancs and Swinnen (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 in Spain), and market institutions (e.g. Germany, Italy, Sweden). Moreover, in several countries (e.g. France) even the renewal of rental contracts is regulated.

This is shown in Figure 2, where the equilibrium rent with the SPS is w_t^*. If the rental price cannot adjust, e.g. due to land market rigidities, then the actual rent which farms pay will be lower. In Figure 2 the actual rent will lie between w_t^* and w^*, depending on the rigidity of land markets. This implies that the SPS marginal capitalization will be lower with market rigidities than without (i.e. it will be lower than $w_t^* - w^*$). The relationship between the marginal capitalization and the face value of entitlements is ambiguous, because the rental contract duration in particular is farm/region-specific, and differs among heterogeneous farms and between regions.

4 Econometric specification

4.1. Estimation issues

In order to identify the capitalization of the SPS, one needs to estimate the difference between the effect of participation versus the effect of non-participation in the SPS, all else being equal yet still taking into consideration the fact that the SPS may also affect those farms which did not receive the SPS (general equilibrium effects). In practice, the estimation of the SPS capitalization is difficult due to a number of estimation issues. In the context of the EU, the most important issues are selection bias, simultaneity bias, general equilibrium effects, and functional form misspecification.

Selection bias. A potential source of sample selection bias is farms' choice of production structure, which determined the level of coupled subsidies in the past, and hence determines the level of the SPS now.[32] Farms which produced more supported commodities were allocated a higher value SPS per hectare, whereas farms which produced less supported commodities received less SPS per hectare. Given that the choice of production structure was not random, but dependent on farm characteristics (e.g. productivity, managerial skills), farms may have selected themselves a given level of SPS intensity (self-selection bias). Another important source of selection bias is the non-randomness of the non-participation in the SPS. It can be shown that if covariate averages are very different in a given group of farms that received support from the SPS (independent of the obtained level of intensity) compared to a control group, then using the traditional regression methods (e.g. a common effect model) for estimation of the average treatment effects (ATE) of the SPS would yield biased results (Todd 2008)[33].

Simultaneity bias. The SPS payments are not assigned randomly to farms but are endogenous, because they depend on region and farm productivity levels. In general, the CAP is upwardly biased toward more productive regions: more productive regions receive more subsidies than less productive regions. In the past, coupled subsidies were dependent on the regional and farm productivity levels. Farms located in more productive regions received higher coupled subsidies than farms located in less productive regions. The new decoupled SPS were allocated based on the value of coupled subsidies in the reference period

[32] The production structure in the reference period co-determined the value of the SPS in both hybrid and historical models.

[33] In a common effect model ($Y = aX + bt + v$), where the effects of the intervention are estimated via coefficient b (constant across X), bias for the ATE parameter ($E(Y1 - Y0)| X$) arises from the fact that the error term does not have conditional mean zero.

under the historical SPS model and on the average regional productivities and coupled payments under the hybrid SPS model. More precisely, under the historical model, the value of the SPS was set to the value of coupled animal and crop subsidies which the farm received in 2000-2002. Under the hybrid model, the SPS consist of a historical component and a regional component. The historical component is set the same as the previous SPS model, whereas the regional component is positively correlated with regional productivities. This implies that more productive regions are likely to have higher rental prices, and at the same time will also have higher SPS per hectare. Given that the SPS and the land rental price simultaneously determine each other, in standard regressions the positive relationship between the SPS and the rental prices would yield biased estimates.

General equilibrium effects. As equilibrium market rental price adjustments are determined by the overall marginal change and not by a farm-specific marginal change of subsidies, this implies that a change in land rents may not be a farm-specific effect but that rental prices tend to respond to policy or market changes at the same rate for all farms in a given region. This also implies that farms which did not receive any SPS payments may face a higher land rental price. This can be seen in Figure 2. Under the surplus entitlements, the SPS shifts the equilibrium land rent from w^* to w_t^*. The land rent rises by the same amount (w_t^* - w^*) for both farms implying that the SPS effect cannot be identified from a cross-section although the SPS value varies between farms, $t_1 \neq t_2$. The traditional regression methods are not able to capture the general equilibrium (capitalization) effect because all farms are affected by this effect equally. Only the part of the marginal effects (marginal capitalization) which differs from the general equilibrium effect and is farm-specific can be captured. For this reason, the SPS effect will be underestimated.

Functional form misspecification. The standard econometric approach cannot accurately capture potential non-linearities in the relationship between the SPS and rental price, because in parametric estimations one has to impose a functional form which, however, is not known *a priori*. The theoretical analysis in section 3 suggests that because of farm heterogeneity, interactions between the SPS and land market conditions, the capitalization rate of the SPS will be different for different types of heterogeneous farms and hence for different levels of support (SPS) per hectare. It can be shown that if covariate averages are very different in a given group of farms that received support from the SPS (independent of the obtained level of intensity) compared with a control group, and the traditional regression model is used to predict outcomes (capitalization rate) far from where the parameters were estimated, the estimated SPS effects based on traditional regression methods can be very sensitive to minor changes in model specification. Moreover, unless the linear approximation to the regression function is globally accurate, the regression may lead to severe bias (Imbens and Wooldridge 2008).

4.2 Matching approach

In order to evaluate programme impacts in the presence of the above issues, the evaluation methods based on matching estimators are more adequate than the standard regression techniques (Rosenbaum and Rubin, 1983).[34] Generally speaking, an important advantage of matching estimators is that they do not require the specification of the functional form of the outcome equation, and therefore are not susceptible to bias due to misspecification along the support level (Todd, 2008). Secondly, while selection bias can be significantly reduced via conditioning on observables, a combination of difference-in-differences (DID) techniques with propensity score matching estimators (or conditional DID estimator, as defined in Heckman, Ichimura and Todd, 1997) permits the elimination of the effects of unobservables.[35]

[34] Rosenbaum and Rubin (1983) showed that under unconfoundedness, independence of potential outcomes and treatment indicators also holds after conditioning on the propensity score. Following seminal studies by Heckman, Ichimura and Todd (1997) and Dehejia and Wahba (1999), a binary propensity score matching approach was frequently used for an assessment of the impact of various public policies implemented in a number of countries.

35 The crucial assumption justifying this method is that selection bias from unobservables remains time-invariant.

The propensity score matching (PSM) estimator requires the outcome variable to be mean independent of the support indicator conditional on propensity score. Furthermore, in case of a binary (1-0) PSM it holds only under the Stable-Unit-Treatment-Value-Assumption (SUTVA) (Rubin, 1978), which implies no presence of general equilibrium effects, i.e. that support received by one unit does not affect the outcomes of another unit. Another important precondition for applying the binary propensity score matching estimator is the availability of information about non-participants.

However, the last two conditions of binary propensity score matching estimators (i.e. SUTVA and sufficient data on non-participants) cannot be expected to hold in the case of the SPS. Firstly, it can be expected that the SPS support, which was applied to the majority of farms and regions in the EU, may have important general equilibrium effects. That is to say that it affected the overall level of land prices in a given region (i.e. including the level of rental prices of those farms which were not directly supported). This would violate the underlying assumption that the SPS support received by one farm does not affect the outcomes of other farms. Secondly, while the SPS support embraces almost all farms, information about non-participants is scarce and thus the identification of common support regions for comparison with control farms would be rather problematic.[36] Furthermore, given that the SPS payment is a continuous variable, application of a *binary* (1-0) PSM estimator would be inefficient from the data use perspective.

Due to these limitations, the use of binary propensity score matching estimators for the evaluation of the SPS effects on land values would not be appropriate. Instead, the generalized propensity score matching estimator is more suitable. The generalized propensity score techniques allowing for multi-valued and continuous support effects were originally proposed by Imbens (2000), Lechner (2001), Imai and van Dyk (2004) and Hirano and Imbens (2004). Hirano and Imbens (2004) extended the unconfoundedness assumption for binary support (Rosenbaum and Rubin, 1983) to multi-valued and continuous support[37] and defined the generalized propensity score (GPS) function as the conditional density of the support (SPS in our case) given the observed covariates *X*. They showed that in combination with a weak unconfoundedness assumption,[38] the GPS has a balancing property[39] similar to the balancing property of the propensity score for binary support and thus GPS can be used to eliminate any bias associated with differences in the covariates. This is particularly relevant for the SPS, because the latter is endogenous with respect to productivity as well as farm and regional characteristics. This bias may be reduced with covariates included in the GPS. While weak unconfoundedness given pre-support variables *X* also implies weak unconfoundedness given the GPS, one can estimate *average outcomes* by conditioning solely on the generalized propensity score (Imbens and Wooldrige, 2008).

In the context of the SPS, an essential advantage of the GPS is that it eliminates (or at least substantially reduces) selection bias and allows one to estimate not only the average capitalization rate, but also capitalization rates for different levels of the SPS (it applies to all values of support intensity between 1 and 0), i.e. given the information about policy support intensity it permits the estimation of the average and marginal outcomes that correspond to *each specific* value (level) of support intensity. These results cannot be obtained by employing traditional regression techniques.

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[36] The SPS support, launched in 2005 in nine MS and then extended to 17 MS, had been extended to most farms covering the entire territory of MS implementing SPS, i.e. almost all farms received support, yet at various intensities. In the case of Rural Development Policies, a binary approach can be used to evaluate EU policies which were implemented selectively (e.g. environmental payments, LFA, etc.), i.e. in some regions only, or for specific groups of farms, leaving others unaffected.

[37] Imbens and Hirano (2004) showed that the unconfoundedness assumption for binary treatment made by Rosenbaum and Rubin (1983) can be generalized to the multivalued case. This has been formalized by using a concept of weak unconfoundedness. The latter does not require joint independence of all potential outcomes but instead only a conditional independence to hold for each value of treatment.

[38] While the 'strong' unconfoundedness assumption requires the treatment to be independent of the entire set of potential outcomes, the weak unconfoundedness assumption requires only pairwise independence of the treatment with each of the potential outcomes (Imbens and Wooldrige, 2008).

[39] In order to see whether the specification of the generalized propensity score is adequate one has to verify that it balances the covariates. Yet, the procedure for verifying the balancing property under GPS is more complex than in the case of a binary propensity score (see section 4.3)

In order to derive the average capitalization rate (ACR) and the marginal capitalization rate (MCR) of the SPS, assume that for each observation i we observe the p-vector of covariates X_i, the support intensity received T_i, and the outcome variable corresponding to the received level of support $Y_i(T_i)$. The average and marginal effects of the SPS can be derived from the average dose-response function (ADRF), $\mu(t)$, and the derivative dose-response function (DDRF), $v(t)$, defined as follows:

(1) $\mu(t) = E[Y_i(t)]$

(2) $v(t) = E[Y_i(t+1) - Y_i(t)]$

where i stands for sample of observations $(i = 1 \ldots N)$, Y is potential effect (land rental price), t represents potential support values, where $t \in \mathcal{T}$ and $\mathcal{T}$ is a continuous set of potential support values, and $Y_i(t)$ is the unit-level dose-response function of outcomes that maps a particular potential support t to a potential outcome (outcome function of the potential support intensity)

The dose-response functions measure the relationship between exposure to the support as cause and potential outcomes as effect. The ADRF captures the entire curve of the *average* potential outcomes, which gives the average potential outcome at every possible level (or dose) of the support. (i.e. SPS per hectare).

Given that the ADRF provides information about the estimated average outcome that corresponds to a specific level of support (SPS level),[40] we postulate that the potential outcome which relates to a support level which equals zero (t=0) describes the magnitude of *general equilibrium effects*, i.e. it shows the extent to which farms that have not received any SPS support were affected by the SPS. The estimated general equilibrium effects are assumed to affect all farms equally (in levels), i.e. they do not change an individual farm behavior compared to other farms.

Furthermore, the estimated $\mu(t)$ can be used to calculate the ACR and MCR of the SPS where:

(3) $ACR = [\mu(t) - \mu(t0)]/t$

(4) $MCR = [\mu(t+1)] - \mu(t)] / [t-t(-1)]$

4.3 Empirical strategy: Generalized propensity score matching

In light of the above advantages, the analytical approach employed in the present study for assessing the effects of the SPS is based on the GPS and dose-response functions, and follows the methodology of Hirano and Imbens (2004) and Bia and Mattei (2008).[41] Empirical implementation of the GPS approach consists of three main steps:

(i) The first step involves the estimation of the GPS as a conditional density of support given the covariates. The estimation of the GPS density is important for finding the similarity of farms receiving the SPS, in terms of their individual characteristics. The adjustment for the GPS should improve the balance. If covariates are sufficiently balanced, the GPS eliminates bias in the estimates of the dose-response function.

This step consists of several routines. Firstly, we assume that the support (or its transformation) has a normal distribution conditional on covariates. The estimation of parameters of support function, g, (conditional distribution of support) is conducted using the maximum likelihood estimator.

[40] In other words, the average dose-response function shows us how average responses vary along the domain of treatment doses.
[41] Other empirical applications of a generalized propensity score (GPS) matching to the evaluation of various public policies can be found in Bia and Mattei (2007), Kluve et al. (2007), and Becker, et al. (2010).

(5) $g(T_I)|X_I \sim N\{h(\gamma, X_I), \sigma^2\}$

where X_i is an observed vector of pre-support covariates for each unit i in the sample, $g(T_i)$ is a given transformation of the support variable; $h(\gamma, X_I)$ is a function of covariates with linear and higher order terms which depends on a vector of parameters γ.

Secondly, the validity of the assumed normal distribution is assessed using Kolomogorov-Smirnov, Shapiro-Francia, Shapiro-Wilk or skewness and kurtosis tests for normality.

Thirdly, the GPS, or $\hat{R}_i$, function is estimated. The $\hat{R}_i$ returns the conditional density of the actual support intensity given the observed covariates.

(6) $$\hat{R}_i = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left[-\frac{1}{2\hat{\sigma}^2}\{g(T_I) - h(\hat{\gamma}, X_I)\}\right]$$

where $\hat{\gamma}$ and $\hat{\sigma}^2$ are the estimated parameters in step in equation (5).

Fourthly, we test the balancing property of the estimated GPS function:

- We divide the set of support values (i.e. support intensity) into k intervals.
- Within each support interval k, we calculate the median intensity and compute the GPS at this representative point.
- We subdivide the values of the GPS evaluated *at the representative point of each support interval* into j blocks
- For each block j of the GPS scores and within each interval k we calculate the mean difference of each covariate between units that belong to the support interval and units which belong to another support interval but are in the same GPS interval.
- Next we combine the differences in means calculated in the previous step, by using a weighted average with weights given by the number of observations in each GPS interval.
- For each computed difference we perform t-test which indicate whether the mean difference of each covariate between units that belong to the given support interval k is statistically different from the mean difference of units which belong to another support interval but are from the same GPS block. If the mean differences for a given covariate are statistically significant this would imply that for this specific variable the estimated GPS was not able to completely eliminate a selection bias (although some reduction of bias could have been achieved)

(ii) The second step in the GPS approach involves the estimation of the SPS impact on land rental price using a flexible function (polynomial approximation) of T_i and R_i:

(7) $Y_i = f(T_i, R_i)$

Equation (7) can be rewritten in terms of $\varphi\{E(Y_i|T_i,R_i\} = \hat{\psi}(T_i,R_i;\alpha)$ where:

(8) $\hat{\psi}(T_i,R_i;\alpha) = \alpha_0 + \alpha_1 T_i + \alpha_2 T_i^2 + \ldots \alpha_4 R_i + \alpha_5 R_i^2 + \alpha_6 R_i^3 + \alpha_7 T_i R_i$

Estimation of a full or reduced form of equation (8) allows us to find for each farm unit i an appropriate functional relationship between an impact indicator (e.g. land rental price) on one side and intensity of support (T) and the estimated values of GPS at the first stage = (R) on the other. While R's control for selection into support intensities, we anticipate that respective parameters (α_4 to α_6) will be statistically significant. Information obtained from equation (8) is used later to derive the average dose-response function and derivative dose-response functions.

(iii) The third step in the GPS involves estimation of the average potential outcome for each potential level of support t and the entire dose-response function:

$$(9)\quad E\left\{\hat{Y}(t)\right\} = \frac{1}{N}\sum_{i=1}^{N}\hat{\beta}\{t,\hat{r}(t,X_i)\} = \frac{1}{N}\sum_{i=1}^{N}\varphi^{-1}\left[\hat{\psi}\{t,\hat{r}(t,X_i);\hat{\alpha}\}\right]$$

where $\hat{\alpha}$ is the vector of the estimated parameters in equation (8).

The average response at each t is estimated as the average of the estimated conditional expectations $\hat{\beta}\{t,\hat{r}(t,X_i)\}$ averaged over the distribution of the pre-support covariates X_i, i.e. $\hat{\beta}\{t,\hat{r}(t,X_i)\} = \varphi^{-1}\left[\hat{\psi}\{t,\hat{r}(t,X_i);\hat{\alpha}\}\right]$, which equals the average value of the estimated regression function over the score function evaluated at the desired level of support. In order to obtain estimates of the entire dose-response function, the estimation of the average potential outcome is repeated for each level of support.

5 Empirical analysis

5.1 Data sources and variable construction

The main source of the data we employ in the present study is the Farm Accountancy Data Network (FADN), which is compiled and maintained by the European Commission. The FADN is a European system of sample surveys that take place each year and collect structural and accountancy data on EU farms.[42] In total anonymous information exists on approximately 150 variables relating to farm structure and yield, output, inputs, costs, subsidies and taxes, income, balance sheet, and financial indicators. The balanced panel we employ in this study contains 19 000 farms and covers 4 years (2004-2007) for EU-15.[43] The choice of the period 2004-2007 was determined by the availability of data and also in order to cover the period before (i.e. 2004) and few years after (i.e. 2007) the introduction of the SPS. We have excluded new MS from the sample because they implement a different payment system.

The FADN data is unique in the sense that it is the only source of harmonized (the bookkeeping principles are the same across all EU Member States) and representative micro-economic data for the whole EU. Farms are selected to take part in the survey on the basis of stratified sampling frames established at the level of each region in the EU. The FADN survey does not, however, cover all agricultural farms in the EU, but only those which are of a size allowing them to classify as commercial holdings.

The dependent variable – a difference in farmland rental rates paid by farms between 2004 and 2007 - is constructed from the FADN data. Directly, the FADN data does not report the rental rate. However, it reports the total amount of rent paid for the rented land, the rental costs (SE375), and the utilized agricultural areas rented by the holder under a tenancy agreement for a period of at least one year (SE030). From these two variables we construct the per hectare rental rate by dividing the total rent paid by the hectares rented.

Similarly, the support variable (T) - the SPS - is constructed from the FADN data. Every agricultural

[42] The surveys are conducted by national authorities

[43] Initially, the SPS was introduced in the old Member States (MS). The new MS were required to switch to the SPS at a later stage. Therefore, the new MS are not considered in our analysis.

producer in the FADN sample is asked to report both the total subsidies received, as well as the amount of specific subsidy type received. Among the different types of received subsidies, the sampled farms have to report the SPS. Per hectare payments of the SPS are obtained by dividing the total SPS amount obtained in 2007 by rented hectares. According to the FADN data, in 2007 the SPS accounted for 53 percent of all the subsidies in the EU.

Analogously, all farm-level covariates (X_1 to X_{10}) are constructed from the FADN data. We selected the following covariates: X_1 − UAA area per family labor, X_2 − economic size per family labor, X_3 − total output per family labor, X_4 − gross farm income per family labor, X_5 − total liabilities per family labor, X_6 − the ratio of total subsidies to gross farm income, X_7 − the ratio of subsidies on investment to net investment, X_8 − the ratio of coupled subsidies to gross investment, X_9 − land entitlements per family labor and X_{10} − the ratio of rented land to UAA. The selection of covariates was made based on consideration of economic theory and presumption that these should be the most crucial variables determining both outcome as well as intensity of obtained SPS support.

The total UAA area per family labor covariate is constructed by dividing the FADN variable SE025 (Total utilized agricultural area of holding, which excludes areas used for mushrooms, land rented for less than one year on an occasional basis, woodland and other farm areas. It consists of land in owner occupation, rented land, land in share-cropping. It includes agricultural land temporarily not under cultivation for agricultural reasons or being withdrawn from production as part of agricultural policy measures) by the FADN variable SE016 (time worked in hours by unpaid labor input (generally family) on holding).

The economic size per family labor covariate is constructed by dividing the FADN variable SE005 (The economic size of holding expressed in European size units on the basis of the Community typology) by the FADN variable SE016.

The total output per family labor covariate is constructed by dividing the FADN variable SE131 (The total of output of crops and crop products, livestock and livestock products and of other output. Sales and use of (crop and livestock) products and livestock + change in stocks of products (crop and livestock) + change in valuation of livestock -purchases of livestock + various non-exceptional products) by the FADN variable SE016.

The gross farm income per family labor covariate is constructed by diving the FADN variable SE410 (Output - intermediate consumption + balance current subsidies and taxes) by the FADN variable SE016.

The total liabilities per family labor covariate is constructed by dividing the FADN variable SE485 (Value at closing valuation of total of (long- , medium- or short-term) loans still to be repaid) by the FADN variable SE016.

The ratio of total subsidies (excluding investment) to gross farm income covariate is constructed by dividing the FADN variable SE605 (Subsidies on current operations linked to production (not investments). Payments for cessation of farming activities are therefore not included. Entry in the accounts is generally on the basis of entitlement and not receipt of payment, with a view to obtain coherent results (production/costs/subsidies) for a given accounting year) by the FADN variable SE410.

The ratio of subsidies on investment to net investment covariate is constructed by dividing the FADN variable SE406 (Subsidies on investments) by the FADN variable SE521 (Net Investment on fixed assets = Gross Investment on fixed assets - Depreciation).

The ratio of coupled subsidies to gross investment covariate is constructed by dividing the sum of FADN variables SE610 (Total subsidies on crops = All farm subsidies on crops, including compensatory payments/area payments and set-aside premiums) and SE615 (Total subsidies on livestock = All farm subsidies on livestock and livestock products) by the FADN variable SE516 (Gross Investment on fixed assets = Purchases - Sales of fixed assets + breeding livestock change of valuation).

The land entitlements per family labor covariate is calculated by diving the FADN variable L470I (quantity of entitlements for payments under SPS) by the FADN variable SE016.

The ratio of rented land to UAA covariate is calculated by dividing the FADN variable SE030 (Rented UAA = utilized agricultural areas rented by the holder under a tenancy agreement for a period of at least one year (remuneration in cash or in kind)) by the FADN variable SE025.

The final sample for this study contains all those FADN farms in the EU-15 countries which rented land in the whole period 2004-2007, and paid less than 3000 EUR/ha for land rental. Furthermore, those farms which obtained SPS payments higher than 10000 EUR/ha were dropped from the analysis. The above data cleaning resulted in the retention of 16428 farm observations for each year (panel data). Note that the values of all covariates are from 2004 except for the variable X_9 (2007).

5.2 Specification tests

The conditional distribution of support intensity (support function) given the farm-specific covariates (5) is estimated with covariates (X_1 to X_{10}) as arguments, and the SPS intensity level per farm (T) as the dependent variable. As usual, we assume normal distribution for the support intensity given the covariates in equation (5). The support function is estimated by applying the maximum likelihood estimator to the log transformed function (5). The estimation results are reported in Table 1. The results reported in Table 1 show that a conditional distribution of the SPS is well explained by the selected covariates. Approximately 60 percent of covariates (including a constant) exert a significant impact on support intensity, at a significance level of 10 percent.

In order to assess the validity of the assumed normal distribution model, it is necessary to perform normality tests. The tests for normality of disturbances (STATA skewness and kurtosis test for normality) confirm that the assumption of normality was statistically satisfied at 5 percent significance level.

Given the farm-specific information on T_i, X_i, and parameters $\hat{\gamma}$ and $\hat{\sigma}^2$ estimated under equation (5), the value of the GPS for each farm i is calculated (evaluated) according to equation (6).

As discussed above, the GPS allows the elimination of any bias associated with differences in covariates. Yet, its applicability in the estimation of a dose-response function depends on whether the covariates are sufficiently balanced. In the next step we therefore investigate whether the underlying GPS specification is adequate, i.e. whether it balances the covariates. In order to implement the balancing property tests, the range of support intensity is divided into four support intervals (k=4), t_1 to t_4 (i.e. t_1 = SPS less than 35 €/ha; t_2 SPS ranging between 35-900 €/ha; t_3 = SPS between 900-1200 €/ha; and t_4 = SPS between 1200-10000€/ha). The values of the GPS evaluated at the representative point of each support interval (median) are subdivided into three 3 blocks. As usual, balancing tests using t-statistics are carried out to measure whether the conditional mean difference of each pre-support covariate given the generalized propensity score is not different between farms belonging to a particular support interval and farms belonging to all other support intervals. The balancing tests are performed for each single variable included in the list of covariates (X_1 to X_{10}) and each mean support interval (t_1 to t_4). In other words, for each GPS block it is tested whether the mean difference of variables for farms belonging to the group of the particular intensity level of support are significantly different from those farms with a different intensity level of support, but with the same GPS level. The results of standard two-side t-tests show that in all support intervals the balancing property is satisfied at 5 percent significance level. This implies that given the estimated generalized propensity scores, the means of the covariates used later for an estimation of support effects do not differ significantly across various groups of farms with different levels of support. The results of the t-tests for each of the 10 covariates and each four groups of intervals are shown in Figure 4.

The results demonstrate that building on the conditional density of receiving SPS payments, and given the covariates, the GPS calculated for all support intervals differ considerably from one to another, the lowest being (i.e. almost zero) in the support group 1, i.e. in a group where the obtained level of SPS support was less than 35 EUR/ha, and the highest in the support group 2, i.e. SPS payments ranged between 35 and 900 EUR/ha. The summary statistics of the distribution of the GPS calculated at mean points of each of the support intervals is shown in Table 2.

As an outcome indicator we use the *difference* between the land rent of farm *i* in 2004, (prior to the SPS introduction), and 2007 (after a full implementation of SPS). Hence, the outcome indicator reflects the rental price change over the three-year period after the SPS introduction. We use differences value rather than levels in order to eliminate the *unobservable* regional and farm-specific effects and thus eliminate the endogenous component from the rental values, which is likely correlated with the SPS value. This implies that our outcome indicator is a difference value, i.e. $Y = \Delta w$. Following equation (8), the conditional expectation of the outcome indicator $Y = \Delta w$ was specified as a flexible function of its two arguments T_i and R_i (i.e. a polynomial of a linear function of T and a cubic function of R_i) and specifically the following outcome equation was selected and estimated:

(10) $$Y_i = b_0 + b_1 T_i + b_2 R_i + b_3 R_i^2 + b_4 R_i^3 + T_i R_i$$

The parameters of model (8) are estimated by ordinary least squares (OLS) using the observed T_i and the *estimated* GPS (R_i) from the previous steps. While GPS was not observed but estimated, the parameters in eq. (8) are estimated using a block-wise bootstrap procedure (100 replications). The estimation results are reported in Table 4. According to Hirano and Imbens (2004), the estimated coefficients do not have a causal interpretation in this model, except that they serve to test whether all coefficients involving the GPS are equal to zero and can be interpreted as a test of whether the covariates introduce any bias. Our results suggest that all coefficients involving the estimated GPS (linear, square and cubic) are statistically significant. This implies that the sample selectivity is important and that the GPS estimation is relevant and significantly reduces bias in the estimated response function.

5.3 SPS impact on land rental prices

Using the parameters of the estimated regression model (10) we estimate the dose-response function. The estimation results are reported in Table 5 and Figure 5. The average dose-response function (column 2 in Table 5) shows how land rental price changes (difference between 2004-2007) respond to changes in the intensity of the SPS payments per ha (column 1). From the average dose-response function we calculate the marginal (column 3) and average (column 4) SPS capitalization rates.

The results reported in Table 5 can be summarized as follows: (i) the capitalization rate of the SPS is not zero; and (ii) the capitalization rate of the SPS is different for different levels of support (SPS) per hectare whereby the capitalization rate is negatively correlated with the support level. The marginal capitalization rate varies between -32 and 58 percent, whereas the average capitalization rate varies between 0 and 58 percent. These results suggest that farms possessing low value SPS entitlements return a bigger share of the SPS to landowners through higher land rents than other farms. The distribution of farms suggests that in 2007[44] up to 60 percent of all farms in EU-15 have an average capitalization rate of 0.09 or lower, whereas the rest (40 percent) have a capitalization rate between 12 and 58 percent. These results are not comparable with the evidence available in the literature because most studies estimate only the total average capitalization rate using a standard regression approach, but do not report estimates for different support (i.e. SPS) intensities.

[44] To calculate the distribution of farms we use farm level FADN data for 2007. The data contain weights that each farm included in the sample represents in the total population.

Our results are in line with the underlying theoretical model (see section 3), according to which the capitalization rate should be larger than zero if not all conditions necessary for zero capitalization rate, e.g. full tradability, zero-cross compliance costs, deficit entitlements, no credit constraint, are satisfied. This is likely the case in the data for the EU. As suggested by the theoretical model, because of farm heterogeneity and interactions between the SPS and land market conditions, the capitalization rate of the SPS is different for different types of heterogeneous farms and hence for different levels of support (SPS) per hectare.

Our results suggest that the total capitalization rate, which is calculated as the weighted average of average capitalization rates, is 6 percent (column 4 in Table 5).[45] Our estimates are lower than estimates on decoupled payments in the US, according to which the capitalization rate of decoupled subsidies varies between 20% and 80% (Goodwin, Mishra and Ortalo-Magné 2003, 2005; Lence and Mishra 2003). The lower capitalization rate estimated for the EU could be due to the rigidity of rental markets, which may be induced by formal and informal land market institutions and regulations. According to the theoretical model, in the presence of maximum rental price intervention and long durations of rental contracts, land rents would not adjust instantly to market signals, but would stay unchanged over time. On the one hand, given that our estimates reflect rental price changes over a four-year period, the problem of market rigidity should be minor. On the other hand, due to the fact that the duration of rental contracts is longer than five years in several MS and because maximum rental price interventions are applied in some MS, our estimated capitalization rate may be understated.

From the average doze-response values we can calculate the general equilibrium effect of the SPS. The general equilibrium effect represents changes in rental price due to the SPS, which is the same for all farms (in our study EU-15 average). We can identify the effect by estimating the SPS impact on land rents for farms with zero SPS value (capitalization rate at intensity level T=0). Although these farms do not receive the SPS they are affected by the overall rental price adjustment to the SPS. According to results reported in Table 5 (column 2), the rental prices decreased by 23 EUR/ha for farms with zero SPS, which represents 8 percent of the SPS per hectare. Hence the introduction of the decoupled SPS decreased land rents. In principle, the general equilibrium effect represents the effect of decoupling, and it suggests a decapitalization of another type of subsidies. Our estimates contrast with the estimates of Kilian et al. (2008), according to which the SPS increases the capitalization by an additional 15% to 19% above the previous coupled subsidies. However, given that Kilian et al. (2008) use traditional estimation techniques (OLS and IV), and only cross-sectional data, they are not able to control for various econometric issues, e.g. *unobservable* farm-specific effects, implying that their estimates might be biased. However, our findings are in line with previous studies on decouples subsidies, which find that the impact of decoupled subsidies is larger than expected from the theory with perfect markets. This can be explained by the fact that decoupled subsidies are often land-based and are conditioned on other policy measures (Goodwin, Mishra and Ortalo-Magné 2003, 2005; Lence and Mishra 2003; Roberts, Kirwan, and Hopkins 2003; Kirwan 2009; Ciaian and Kancs, 2009; Barnard, et al. 1997; Taylor and Brester 2005; Patton et al. 2008).

5.3 Differences across EU-15 countries

Based on the estimated SPS incidence reported in Table 5 and on the farm-level FADN data on land renting and SPS values for 2007, we calculate the aggregate capitalization rate and non-farming landowner gains from the SPS by farm size, by MS and for the EU-15. The capitalization rate represents the SPS gain for all landowners (farming and non-farming landowners), whereas non-farming landowner gains represents the policy benefit only for those landowners who are not involved in farming. The results are reported in Table 6. The share of the SPS channeled either to farms or to non-farming landowners is relatively low. On average, 6 percent of the total SPS support (column 9) is channeled to landowners through higher rental prices in the EU-15. Non-farming landowners gain only 3 percent of the SPS because a substantial share of land is owned by farmers in EU-15 (69 percent of UAA, column 5). The small value of the SPS leakage to landowners is due to the fact that farms with a high value SPS per hectare have a

[45] The total value of the SPS was used as weight.

lower capitalization intensity than low value SPS per hectare, implying that the former significantly offsets the latter when calculating the weighted average capitalization over all farms. However, large farms lose a higher share of the SPS than small farms due to the higher share of land renting (columns 10-12 and 14-16).

The highest leakages of the SPS to landowners (11 percent) are in Spain due to the low hectare value of the SPS, followed by Finland, Portugal, Sweden, Austria and France where around 8-9% of the SPS flow to landowners (column 9). In Denmark, Greece and the Netherlands the leakages are the smallest, 2-4% of the SPS. Furthermore, the results suggest that for some countries bigger farms channel more (e.g. Austria Greece, Spain, Italy, Portugal), and for some countries small farms channel more SPS to landowners (e.g. France, Luxemburg, Sweden), whereas in others there are minor differences between small and big farms (e.g. Belgium, Denmark, Ireland, the UK). The main driver for the non-farming landowner's gains from the SPS is the share of land renting in the overall UAA. Countries with a high share of land renting tend to channel more SPS to non-farming landowners (e.g. France) than countries with low farm renting (e.g. Denmark, Ireland) (column 13). At the same time, in most countries large farms channel a higher share of the SPS to non-farming landowners than small farms (columns 14-16) because the former group of farms rent more land than the latter group.

6 Conclusions

This paper studies the capitalization of the SPS into land rents. First, we theoretically analyze how the SPS implementation characteristics (stock of entitlements, tradability, cross-compliance), market imperfections and institutional regulations affect the capitalization of the SPS into land rents. We show that the relationship between the SPS and land rents is non-linear and discontinuous. Theoretical analysis suggests that the entitlement stock effect and credit market imperfections *increase* the capitalization rate of the SPS, whereas the cross-compliance, the tradability of entitlements and land market institutions and regulations *reduce* the capitalization rate of the SPS. Hence, in certain situations, the SPS my even result in the reduction of land rents (e.g. if the cross-compliance effect is strong). Furthermore, because of farm heterogeneity and because of various factors interacting with the SPS payments, the capitalization rate will be different for different levels of SPS intensity.

The complexity in the relationship between the SPS and land rents poses problems for empirical analysis. Firstly, a standard econometric approach may not be suitable for identifying such discontinuities and non-linearities. At the same time, the standard econometric approaches suffer from problems identifying the general equilibrium effect of the SPS on land rents. For example, because the SPS may also affect rent to non-participant farms, the standard regression would underestimate the capitalization of SPS. Moreover, simultaneity and selection bias are additional econometric issues present when estimating the SPS capitalization.

In order to properly address estimation issues, in the empirical analysis we employ the generalized propensity score (GPS) matching approach for estimating the capitalization of the SPS. The application of the GPS matching for the assessment of the impact of the SPS payment on the land rental price enables a less biased and more precise estimation of the overall effects of the SPS support, compared with traditional estimations based on the standard regression techniques. Among others, an important advantage of the GPS is that it can address several econometric issues relative to the standard regression approach.

Our results suggest that, on average, 6 percent of the SPS are capitalized into land rents, implying that landowners do not absorb much of the SPS. However, there is considerable variation in the capitalization rate for different SPS levels: lower value SPS are capitalized more than higher value SPS. Farms with low value SPS entitlements channel substantially more SPS to landowners than farms with high value entitlements. The capitalization rate varies between 12 percent and 58 percent for SPS smaller than 200

EUR/ha. For larger payment values (i.e. SPS greater than 200 EUR/ha) the capitalization rate is much lower, between 0 percent and 9 percent. Hence, our findings are consistent with the theoretical hypothesis.

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Appendix: The model

Following Ciaian, Kancs and Swinnen (2008) and Ciaian and Swinnen (2006), we assume that agricultural goods are produced by two types of heterogeneous farms.[46] The output of each farm type is assumed to be a continuous and increasing function of the amount of land used (A^i with i = 1, 2). The output price (p) is assumed fixed and the same for all farms. The entire land is owned by landowners, who rent it to farmers.[47] Farms maximize profits (Π^i) which is the difference between sales revenue and land rent:

(1) $\Pi^i = pf^i(A^i) - wA^i$

where r is rental rate and $f^i(A^i)$ is a well-behaved production function with $f_A^i > 0$, $f_{AA}^i < 0$, for i = 1, 2. Farms compete for land by renting the amount of land that maximizes their profits:

(2) $pf_A^i = w$ with i = 1, 2

(3) $A^1 + A^2 = A^T$

The marginal condition (2) determines farms' land demands given in Figure 1 by D^1 and D^2 for farm 1 and farm 2, respectively. Equation (3) determines the equilibrium in the land market.

In the presence of the SPS and the possibility to trade entitlements, farm i profit maximization problem (1) changes as follows:

(4) $\Pi^i = pf^i(A^i) - wA^i + t^i A_{ET}^i - \gamma p_e^i (A_{ET}^i - A_E^i)$

subject to the entitlement activation constraint $A_{ET}^i \le A^i$ for i = 1 and 2; where A_{ET}^i is total number of activated entitlements, A_E^i is the initial entitlement endowment, p_e^i is the entitlement price and γ is a dummy measuring the tradability of entitlements: $\gamma = 0$ implies no-tradability of entitlements, while $\gamma = 1$ is the case with full tradability.[48] The activation constraint $A_{ET}^i \le A^i$ represents the fact that farms can activate entitlement payments t^i only if accompanied by land. The FOC and market clearing conditions yield (3) as well as:

(5) $pf_A^i = w - \lambda^i$ for i = 1 and 2

(6) $\gamma p_e^i \le t^i - \lambda^i$ for i = 1 and 2

(7) $A_{ET}^1 + A_{ET}^2 \le A_E^1 + A_E^2$

where λ^i is the LaGrangean multiplier associated with the inequality constraints $A_{ET}^i \le A^i$.

Equations (5) and (6) imply that if entitlements are tradable ($\gamma = 1$) the equilibrium price for the entitlement and the land rent are simultaneously determined by the marginal value product of land plus the

[46] See Ciaian, Kancs and Swinnen (2008) and Ciaian and Swinnen (2006) for full description of the formal model.
[47] This distinction between landowners and farmers is convenient for our explanation but is not essential for the analysis and the derived results.
[48] In reality both the extreme situations may not hold. The entitlements are likely partially tradable. However, partial tradability of entitlements does not change the main intuition of the distribution SPS effects derived in this paper. The two extreme cases considered in this paper represent upper and lower bounds of how entitlement tradability affects the SPS income distributional and structural effects. The implication of the partial tradability is in between these two corner cases and therefore it is not analyzed separately.

face value of the entitlement: $pf_A^i + t^i = w + p_e^i$, i.e. everything else is equal, the t^i, is either capitalized into land rent, w or it gets positive price p_e^i. The more paid for land renting the less remains to be paid for entitlement purchase. In contrast, the more the farm pays for the entitlement, the less money is available for the rent. If the activation constraint $A_{ET}^i \leq A^i$ is binding, $\lambda^i > 0$, (e.g. surplus entitlements), equation (6) implies that the buyers of entitlements are willing to pay less than the face value of the entitlement t^i, $p_e^i < t^i$, i.e. the SPS is capitalized in land rents. Reversely, if the activation constraint $A_{ET}^i \leq A^i$ is not binding, $\lambda^i = 0$, (e.g. deficit entitlement), the entitlement price is determined by the entitlement face value, $p_e^i = t^i$, implying that the SPS is not capitalized in land rents.

With non-tradable entitlements ($\gamma = 0$), it follows from equations (5) and (6) that the farm equilibrium conditions with and without binding activation constraint $A_E^i \leq A^i$ are $pf_A^i = w - t^i$ and $pf_A^i = w$, respectively. In the latter case the farm land renting is not affected by the SPS; in the former case the entitlement is used to compete for land.

Equation (7) determines the equilibrium in the entitlement market which constrains the total number of activated entitlements ($A_{ET}^1 + A_{ET}^2$) to the level not higher than the total entitlement endowment ($A_E^1 + A_E^2$).

Table 1. Estimates of the support equation

	Coef.	Std.Err.
eq1		
UAA per FL 2004	-0.0002005*	0.000103
economic size per FL 2004	0.0002868**	0.000101
output per FL 2004	-1.50e-08	9.48E-08
gross farm income per FL 2004	3.78E-09	1.60E-07
liabilities per FL 2004	1.32e-07***	2.54E-08
total subsidies to gross farm income 2004	0.0026854	0.002732
investment subsidies to net investment 2004	-0.000793	0.002400
coupled subsidies to gross investment 2004	3.94E-07	0.002358
rented land to UAA 2004	-0.244827	0.030837
entitlements per FL 2007	-3.28e-06***	1.14E-06
constant	5.53674***	0.022214
eq2		
constant	1.197378***	0.0066058
Observations	16428	

*** p<0.01, ** p<0.05, * p<0.1
Notes: FL: family labour

Table 2. Summary statistics of the distribution of the GPS

	Obs	Mean	Std.Dev.	Min	Max
gps_1	16428	0.0000	0.0016	0.0000	0.2068
gps_2	16428	0.3254	0.0075	0.0003	0.3332
gps_3	16428	0.1458	0.0137	0.0000	0.3327
gps_4	16428	0.0664	0.0093	0.0000	0.3017

Table 3. Difference test of conditional means

	Support Int. No 1 - [0, 35]			Support Int. No 2 - [35, 900]			Support Int. No 3 - [900, 1200]			Support Int. No 4 - [1200, 10000]		
	Mean Difference	Standard Deviation	t-value	Mean Difference	Standard Deviation	t-value	Mean Difference	Standard Deviation	t-value	Mean Difference	Standard Deviation	t-value
UAA per FL 2004	19.75	30.13	0.66	-25.60	22.53	-1.14	43.98	54.21	0.81	45.08	47.69	0.95
economic size per FL 2004	13.89	22.55	0.62	-6.62	16.82	-0.39	-8.37	40.46	-0.21	-11.42	35.26	-0.32
output per FL 2004	12139	24558	0.49	-4327	18367	-0.24	-41983	44973	-0.93	3794	38716	0.10
gross farm income per FL 2004	8274	15885	0.52	-33.07	11881	0.00	-18220	28809	-0.63	-14565	25083	-0.58
liabilities per FL 2004	43395	77041	0.56	-47426	56895	-0.83	16926	140000	0.13	65338	120000	0.55
total subsidies to gross farm income 2004	0.12	0.09	1.27	-0.10	0.08	-1.19	0.10	0.24	0.42	0.04	0.20	0.19
investment subsidies to net investment 2004	-0.11	0.12	-0.95	0.09	0.10	0.92	-0.02	0.25	-0.09	-0.06	0.22	-0.30
coupled subsidies to gross investment 2004	22.19	81.51	0.27	-21.62	62.68	-0.34	12.55	155.92	0.08	13.39	134.96	0.10
rented land to UAA 2004	0.00	0.00	-0.33	0.01	0.00	1.71	0.01	0.01	0.64	-0.01	0.01	-1.24
entitlements per FL 2007	464.26	3021.00	0.15	-646.36	2251.70	-0.29	1513.20	5397.30	0.28	1429.80	4752.30	0.30

Notes: FL: family labour

Table 4. GPSM regression (dependent variable: land rent difference 2007-2004)

	Coef.	Std.Err.	t	P>|t|
T	-0.006	0.005	-1.390	0.166
R	761.395	199.622	3.810	0.000
R^2	-5090.853	1343.682	-3.790	0.000
R^3	9040.258	2417.125	3.740	0.000
T*R	0.031	0.049	0.630	0.532
constant	-23.105	6.917	-3.340	0.001
Observations	16428			

Notes: Estimated equation: Rent diff. 2007-2004 = SPS + GPS + GPS^2 + GPS^3 + SPS*GPS

Table 5. Capitalization rate of the SPS into land rents

Support level (T=SPS/ha)	Average dose response (Δw)	Marginal capitalization $[\Delta w(T+1) - \Delta w(T)]/[(T+1)- T]$	Average capitalization $[\Delta w(T) - \Delta w(T_0)]/(T)$
(1)	(2)	(3)	(4)
0	-23.09		
50	5.95	0.58	0.58
100	-10.18	-0.32	0.13
150	-4.93	0.11	0.12
200	-0.12	0.10	0.12
250	-0.27	0.00	0.09
300	-3.02	-0.06	0.07
350	-6.09	-0.06	0.05
400	-8.33	-0.04	0.04
450	-9.41	-0.02	0.03
499	-9.42	0.00	0.03
>499	2.15	0.02	0.00
Total weighted average			0.06

Table 6. Farm size, land renting and non-farming land owner gains from the SPS (2007)

	SPS per ha (EUR/ha)				Land renting				Capitalization rate				Non-farming landowners gain			
	All farms	Farm size (ha)			All farms	Farm size (ha)			All farms	Farm size (ha)			All farms	Farm size (ha)		
		0-10	10-50	50>		0-10	10-50	50>		0-10	10-50	50>		0-10	10-50	50>
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
BEL	272	38	328	305	0.64	0.20	0.70	0.75	0.05	0.06	0.04	0.06	0.04	0.03	0.03	0.04
DAN	356	87	340	374	0.19	0.19	0.10	0.25	0.04	0.05	0.05	0.04	0.01	0.01	0.01	0.01
DEU	329	44	342	343	0.51	0.37	0.42	0.65	0.05	0.06	0.04	0.05	0.03	0.03	0.02	0.04
ELL	757	816	493	291	0.24	0.16	0.64	0.85	0.02	0.01	0.02	0.06	0.01	0.00	0.02	0.05
ESP	144	156	152	108	0.18	0.07	0.17	0.36	0.11	0.02	0.09	0.13	0.04	0.00	0.02	0.05
FRA	198	9	161	230	0.77	0.50	0.64	0.85	0.08	0.11	0.07	0.08	0.07	0.05	0.05	0.07
IRE	320	340	316	325	0.16	0.01	0.13	0.21	0.05	0.04	0.05	0.05	0.01	0.00	0.01	0.01
ITA	276	276	293	212	0.26	0.17	0.37	0.45	0.05	0.03	0.05	0.07	0.02	0.01	0.02	0.03
LUX	265	1	281	274	0.45	0.15	0.33	0.47	0.07	0.13	0.06	0.07	0.03	0.02	0.02	0.03
NED	393	52	460	424	0.34	0.09	0.36	0.38	0.02	0.03	0.02	0.03	0.01	0.00	0.01	0.01
OST	240	232	256	152	0.25	0.14	0.25	0.27	0.08	0.06	0.07	0.12	0.02	0.01	0.02	0.03
POR	221	305	133	59	0.23	0.15	0.33	0.36	0.09	0.02	0.08	0.21	0.03	0.00	0.02	0.08
SUO	232	13	247	229	0.29	0.00	0.24	0.35	0.09	0.12	0.08	0.09	0.03	0.00	0.02	0.03
SVE	231	84	241	229	0.43	0.17	0.30	0.48	0.09	0.08	0.08	0.09	0.05	0.02	0.03	0.05
UK	283	14	341	280	0.32	0.10	0.22	0.33	0.07	0.15	0.04	0.07	0.03	0.02	0.01	0.03
EU-15	349	496	283	257	0.31	0.15	0.33	0.51	0.06	0.02	0.05	0.07	0.03	0.00	0.02	0.04

Notes: The values for land renting, SPS per ha, capitalization rate and non-farming landowners gain are weighted averages over all farms in the 2007 FADN sample. For land renting, UAA is used as the weight; for the rest of the variables, the value of SPS is used as the weight. The weights account also for the number of farms each farm represents in the total population.

Figure 1. The effect of the SPS with deficit entitlements

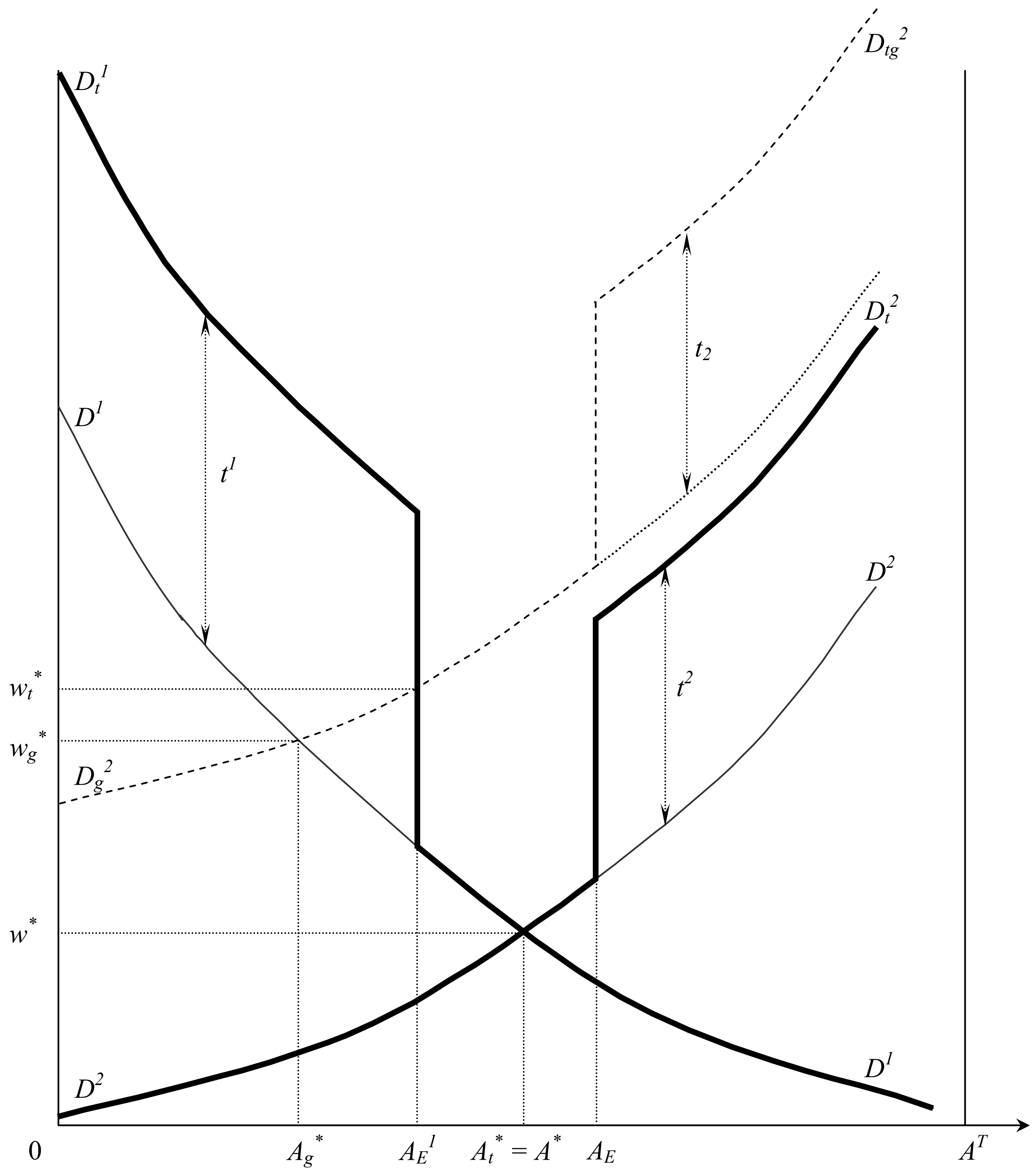

Figure 2. The effect of the SPS with surplus entitlements

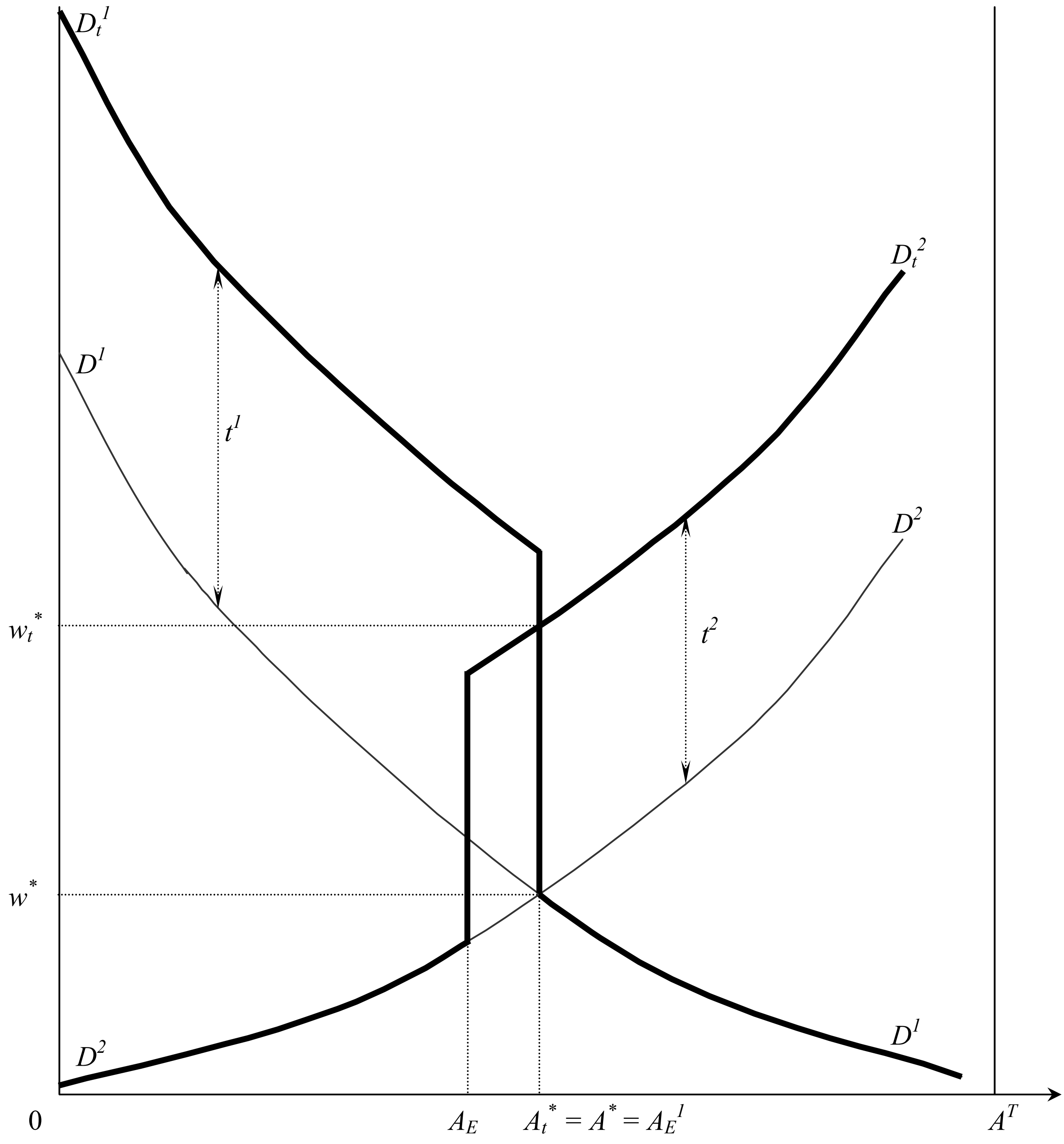

Figure 3. The effect of the SPS with cross-compliance

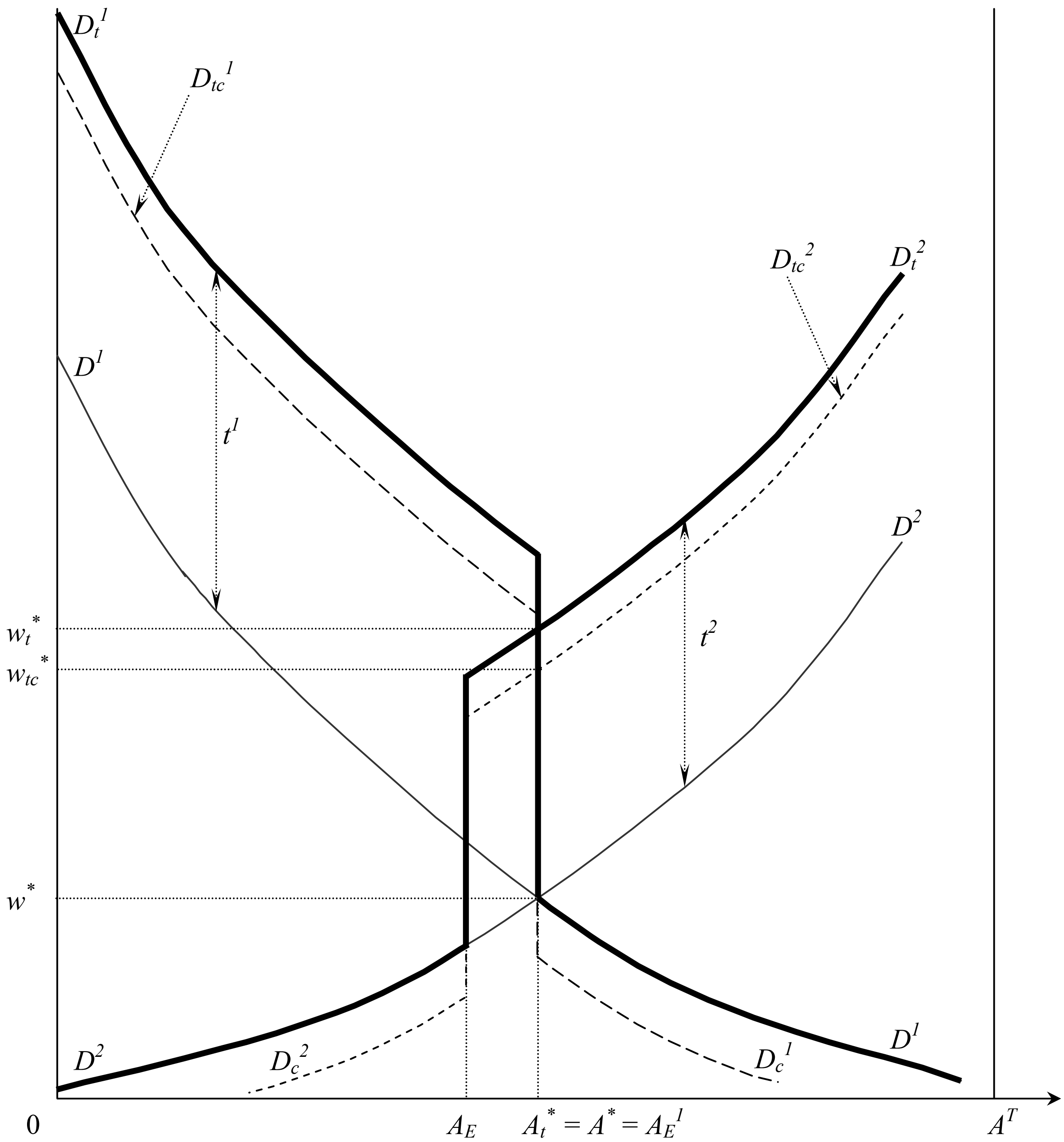

Figure 4. The effect of the SPS with credit market imperfections

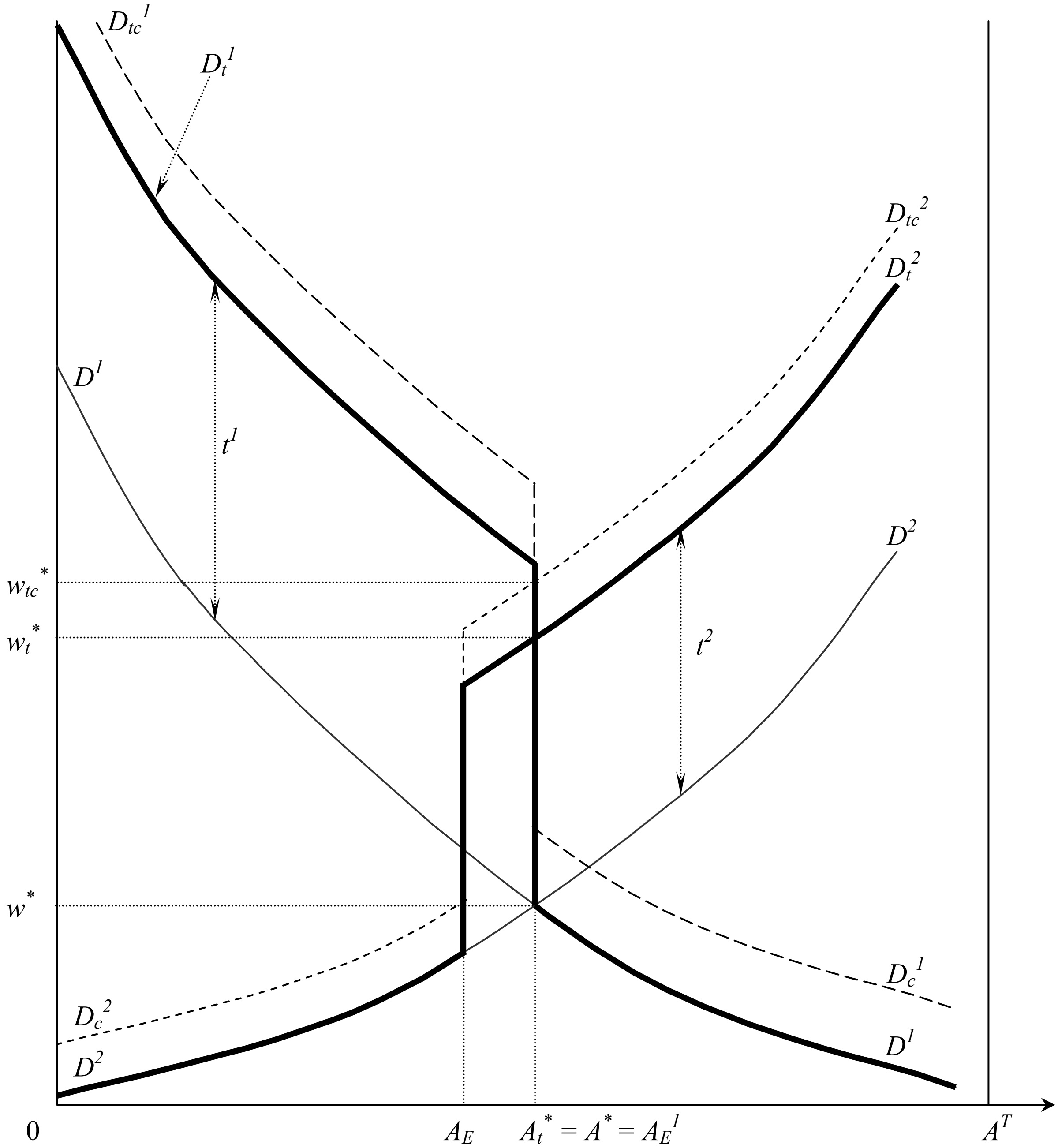

Figure 5. Capitalization rate of the SPS for different support levels