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Do agricultural subsidies crowd out or stimulate rural credit market institutions? The case of EU Common Agricultural Policy*

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Abstract: In this paper we estimate the impact of agricultural subsidies granted under the European Union's Common Agricultural Policy (CAP) on bank loans extended to farms. According to our theoretical analysis, subsidies may either stimulate or crowd out bank loans depending on the timing of subsidies, severity of credit constraint, type of subsidies and bank loans, and the relative cost of internal and external financing. In empirical analysis we use the Farm Accountancy Data Network (FADN) farm level panel data for the period 1995-2007. We employ the fixed effects and generalised method of moment (GMM) models. The estimated results suggest that (i) big farms tend to use subsidies to increase long-term loans, whereas small farms tend to use subsidies to obtain short-term loans; (ii) subsidies tend to crowd out short-term loans for big farms and long-term loans for small farms; (iii) when controlling for the endogeneity, the crowding out effect becomes smaller, but the positive causal effect of subsidies on bank loans remains significant.

Keywords: Economics; agricultural subsidies; financial markets; economic performance; policy analysis; regional development; industrial relations; direct effect; budget; model simulations.

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Introduction

Annually the European Union (EU) spends around 50 billion EUR on the Common Agricultural Policy (CAP) with the aim of supporting farmers' income and the production of agricultural public goods like landscape and a clean environment. The majority of CAP subsidies are disbursed in the form of decoupled direct payments from the EU budget to farms, which are not linked to current and future quantities of agricultural production but are related only to the past production levels. Within the CAP there are also subsidies which are coupled to the production of specific crop or animal commodities, e.g. higher production or use of inputs leads to more subsidies for farms. Finally, financial support is also provided for rural development projects. The current EU agricultural support system will be implemented until 2013. The CAP for the period after 2013 is currently under negotiation between the European Commission, the European Parliament and the Council (European Commission 2011).

Agricultural subsidies have important impacts on agricultural markets. Besides affecting farmers' income, studies have shown that agricultural subsidies distort input and output markets and thus alter rents of other agents active in the agricultural sector (for example consumers or input suppliers). The impact of agricultural subsidies on distribution of income depends heavily on the type of subsidies, structure of markets and the existence of market imperfections (Alston and James 2002; de Gorter and Meilke 1989; Gardner 1983; Guyomard et al. 2004; Salhofer 1996; Ciaian and Pokrivcak 2004; Ciaian and Swinnen 2009). Studies also evaluate, among others, the impacts of subsidies on the environment and agricultural public goods (e.g. Beers Van Cees and Van Den Bergh 2001; Khanna et al. 2002) or productivity and market distortions (e.g. Chau and de Gorter 2005; Goodwin and Mishra 2006; Sckokai and Moro 2006).

With few exceptions (e.g. Ciaian and Swinnen 2009), most of these studies investigate only the direct impacts of agricultural subsidies (on prices, quantities, income, environment, etc.) by assuming that subsidies do not alter the structure of agricultural markets and do not interact with market institutions. In reality, government policies may have various indirect effects. They can change market structure or crowd out some market institutions. An analysis of such effects goes beyond the focus of the current policy analysis literature. In other contexts, however, the "crowding out effect" of government programs has been extensively analysed. For example, the interaction between private transfers and public welfare programs attracted considerable attention among academic writers (e.g. Barro 1974; Galuscak and Pavel 2012; Lampman and Smeeding 1983; Roberts 1984; Maitra and Ray 2003; Cox et al. 2004).

Agricultural subsidies tended to be analysed in the context of the World Trade Organization (WTO) trade liberalization process where the main discussion was centred around the distortionary impacts of different types of subsidies on production, input use, consumption, trade or prices (Meléndez-Ortíz et al. 2009). This may explain the fact that scientific literature has primarily focused on analysis of the direct impacts of agricultural subsidies and has neglected indirect impacts. Moreover, in many countries the use of agricultural subsidies is specifically targeted to achieving certain objectives like increasing farmers' income or productivity, improving environmental performance or enhancing rural employment. Less attention tends to be paid to studying the impact of agricultural subsidies on the functioning of market institutions as the relationship between market institutions and the performance of the agricultural sector is quite complex. However, it is important to study the indirect impacts of agricultural subsidies on market institutions as they may affect the performance of policies. Even in the context of the WTO trade liberalization process, altering market institutions affect the long-term performance of the agricultural sector and the economy. The mechanism on how changing one type of subsidy affects access to credit and development of rural credit markets is relevant from a policy making perspective as this is crucial for the growth of farms' productivity in the long-run.

The objective of this paper is to assess the impact of the European Union's current Common Agricultural Policy (CAP) on bank loans extended to the agricultural sector. First, we theoretically analyze how agricultural subsidies affect bank loans. Then, employing unique farm level Farm Accountancy Data Network (FADN) panel data for the period 1995-2007, we empirically estimate the interaction between CAP subsidies and farm loans. To our knowledge, this paper is the first attempt to empirically study how agricultural subsidies affect bank loans and credit institutions.

A better understanding of the dynamic interaction between CAP subsidies and credit market institutions can provide important insights for policy making. One of the key priorities of the EU agricultural policy, as outlined in the European Commission strategic document for the future Common Agricultural Policy, is to promote competitiveness, innovation, and to maintain viable rural communities. These policy objectives in the EU's CAP stem from increased international competition, higher uncertainty on global commodity markets, economic crisis, and structural problems persistent in EU rural areas (European Commission 2010). Farmers' access to credit, especially during a financial crisis, plays a prominent role in achieving some of these policy objectives. For policy makers it is of utmost importance to understand the interaction between subsidies and credit markets; whether the CAP stimulates or crowds out credit markets. It is well-documented that the agricultural sector faces significant credit constraint 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 have shown that this is also the case in developed countries such as the EU member states and the USA (Blancard et al. 2006; Fałkowski et al. 2012; Lee and Chambers 1986; Färe et al. 1990). Agricultural subsidies may improve farm credit position and thus may partially address market imperfections.

1. Theoretical framework

We build our theoretical framework on the model of Feder (1985), Carter and Wiebe (1990) and Ciaian and Swinnen (2009). Feder (1985) and Carter and Wiebe (1990) analyze farm production under credit constraints in developing countries while Ciaian and Swinnen (2009) study how credit constraints affect the income distributional effects of area payments in the European Union. In this study we extend the three models by analyzing how subsidies affect bank loans extended to farms.

We consider a representative profit-maximising farm. The farm production is assumed to be a function of the fixed inputs (land and family labour)[1] and non-land inputs (K), which we refer to as "fertilizer" but which also captures other capital inputs used by the farm. We consider short-run farm behaviour with constant fixed inputs.[2]

[1] The assumption of fixed amount of land and family labour is not strictly needed to obtain the results. We introduce this assumption in order to simplify the exposition of the model results.
[2] We relax this assumption later.

An important issue for analyzing bank loans is the timing of costs and revenues. We assume that variable costs are incurred at the beginning of the production season when the farm has to pay for fertilizer and other variable inputs. Meanwhile, revenues are realized at the end of the season when output is sold. Because of the time lag between the payment for fertilizer (variable inputs) and obtaining revenues from the sale of output, the farm has a demand for short-term credit. The demand for credit can be satisfied either internally (cash flow, savings, subsidy) or externally (bank loan, or trade credit). For the sake of simplicity we consider only external financing through the bank loan and later on in the paper also through subsidies[3]. The demand for credit might not be fully satisfied, which means that the farm can be credit constrained in the short-run. As in Ciaian and Swinnen (2009), the short-term credit constraint implies that the farm might be limited with respect to the use of variable inputs like fertilizer, that is, the credit constraint may prevent the farm from using the optimal amount of fertilizer.

The profit-maximising behaviour of the farm implies a downward sloping demand curve for fertilizer, D_K. This is illustrated in Figure 1 where the horizontal axis measures quantity and the vertical axis measures the price of fertilizer.

We first identify the equilibrium with no credit constraint. With perfect credit markets, the farm is not constrained on credit and hence it has no limitation on the quantity of fertilizer it uses. The farm chooses the quantity of fertilizer that maximises its profit. Because we assume that both fertilizer price, k, and the loan interest rate (external cost of financing), i_c, are given,[4] the supply of fertilizer is a horizontal curve, S, in Figure 1. The equilibrium quantity and price of fertilizer with no credit constraint are K^* and k_c, respectively, where $k_c = (1 + i_c)k$. The equilibrium price, k_c, includes the interest costs of the loan, $i_c k$, which are used to finance the purchase of fertilizer at the beginning of the production season.

1.1. Imperfect credit markets

It is assumed that the maximum amount of money that the farm can borrow from the bank for fertilizer purchase, C, depends on the farm collateral, W. For the sake of simplicity we consider that banks accept only farm assets as collateral.[5] That is $C = C(W)$ where $dC/dW > 0$. The short-run credit constraint is given by:

(1) $kK \leq C(W)$

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[3] This assumption is not strictly needed to obtain the results.

[4] We assume that the economy is small and open, which implies that the fertilizer price and the interest rate are fixed.

[5] This assumption is not strictly needed to obtain the results. In reality, the level of farm credit may depend on farm characteristics (e.g. reputation, owned assets, profitability). In general, the evidence from the literature shows that these factors are important determinants of farm credit (e.g. Benjamin and Phimister 2002; Petrick and Latruffe 2003; Briggeman et al. 2009). For example, Latruffe (2005) finds in the case of Poland that farmers with more tangible assets and with more owned land were less credit constrained than others. Briggeman et al. (2009) find for farm and non-farm sole proprietorships in the US that the probability of being denied credit is reduced, among others, by net worth, income, price of assets, and subsidies.

Whether the credit constraint (1) is binding or not depends on the size of credit, C, relative to the optimal fertilizer use with a perfect credit market, K^*. If $C > K^*$, the farm loan availability does not affect the farm's behaviour. The farm's optimal fertilizer use is equal to K^*. However, if $C < K^*$, the farm cannot use the optimal quantity of fertilizer. In Figure 1 the credit constraint curve (i.e. fertilizer supply), represented in terms of fertilizer units, is given by the bold line $k_c D S_K$, where $S_K = C/k$. With the binding credit constraint, the optimal use of fertilizer is equal to K_c^*. At K_c^* the fertilizer supply curve is vertical as determined by the credit constraint condition (1). With a credit constraint the farm uses less fertilizer than under the perfect credit market, $K_c^* < K^*$.

1.2. Subsidies and credit constraint

We define *DS* as a decoupled subsidy which the farm receives irrespective of its level of production. Decoupled subsidies form a major part of the current CAP support for farmers. Subsidies may affect credit constraint in two ways. First, farmers can use subsidies obtained at the beginning of the season to purchase fertilizer directly. Second, even if subsidies are obtained at the end of the season, farmers can use them to obtain a loan for the purchase of fertilizer as future guaranteed payment may serve as collateral for obtaining the bank loan (Ciaian and Swinnen 2009; Janda 2003). Therefore a subsidy may alleviate the credit constraint of the farm irrespective of the timing of the subsidy.

With subsidies, the credit constraint is given by the following inequality:

(2) $kK \leq C[W + (1-\alpha)DS] + \alpha DS$

where α is a variable with a value between zero and one and which represents the share of subsidies used directly for fertilizer purchase. The remaining $1-\alpha$ indirectly increases loans through enhancing the value of collateral. In other words, α represents the share of subsidies received at the beginning of the season. For example, if the full value of subsidies is paid at the beginning of the season, $\alpha = 1$, the farm can use them immediately to purchase fertilizer. On the other hand, if subsidies are paid at the end of the season, $\alpha = 0$, the farm cannot use them to alleviate its financial needs at the beginning of the growing season. Instead the farm can use subsidies as collateral to obtain a bank loan. In other situations part of the subsidies might be paid at the beginning of the season and the remainder at the end of the season, hence $0 \leq \alpha < 0$. Equation (2) implies that the farm may use two sources to finance the purchase of fertilizer: subsidies, αDS (internal finance), and/or the bank loan, $C[W + (1-\alpha)DS]$ (external finance).[6]

[6] Note that, in reality, farms may use other sources of external financing such as futures and derivatives and credit from non-bank institutions (e.g. from relatives, other farms, input suppliers, etc.). The former source is not extensively used in the context of EU agriculture. The latter might be more relevant. However, data is not available

2. The impact of decoupled subsidy

First, we consider the impact of decoupled subsidy on the bank loan under perfect credit market conditions. Then we analyse the credit constraint case, i.e. the imperfect credit market. We summarise our results in three hypotheses.

Hypothesis 1: *If farms are not credit constrained, (a) decoupled subsidies, if paid at the beginning of the season, may reduce farms' bank loans; (b) decoupled subsidies paid at the end of the season have no effect on bank loans.*

Subsidies will reduce bank loans only if they are received at the beginning of the agricultural production season and if the opportunity cost of subsidies for the farm (cost of internal financing), i_s,[7] is lower than the cost of the loan (cost of external financing), i.e. if $i_s < i_c$ (i.e. $k_s < k_c$).[8] In such a case the farm will substitute the more expensive bank loan with a cheaper subsidy. The situation is illustrated graphically in Figure 1. With no credit constraint and with no subsidies, the equilibrium fertilizer use is K^* and all fertilizer is financed through the bank loan. The availability of cheaper financing through subsidy *DS_1* allows the farm to reduce its bank loans. The fertilizer supply shifts from *S* to k_s *GAS*. The farm will use less of the loan and part of the fertilizer will be financed with a subsidy, equal to K_{s1}^* ($= DS_1/k$). The remaining fertilizer $K^* - K_{s1}^*$, will be financed through the bank loan. Note that with subsidy *DS_1*, the equilibrium fertilizer use is not affected and remains at K^*. Only if subsidies crowd out all bank loans, which occurs for sufficiently high subsidies (if $DS_1 > kK^*$), does the equilibrium fertilizer use increase.

If the subsidy is paid at the end of the season, the farm cannot use it directly to purchase fertilizer. However, the subsidy can still be used as collateral. We assume that the type of collateral does not affect bank loan interest rate; hence the subsidy does not alter the equilibrium quantity of loans.[9]

Next we analyse the case when farm is credit constrained and the subsidy is paid at the beginning of the season. To simplify the analysis we assume that all subsidies are paid at the beginning of the season, $\alpha = 1$.

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to account for this type of credit. The credit from non-bank institutions is partially captured in empirical estimations by farm fixed effects which capture time-invariant unobserved farm heterogeneity.

[7] Farms may use subsidies for non-farm activities (e.g. consumption, non-farm investments). Opportunity costs represent the most profitable use of subsidies in these alternative activities.

[8] In the reverse case (if $i_c < i_s$) loans are not affected by subsidies. In this case it does not pay off for a farm to substitute cheaper bank loans with more expensive subsidies.

[9] In reality, the type of collateral may affect the cost of the loan. For example, if banks perceive subsidies to be more secure and/or have lower transaction costs to administer them than another type of farm collateral, the interest rate may be lower for subsidy-backed loans than for the loans backed by the other type of collateral. In this case subsidies increase credit (and fertilizer use) only if they are sufficiently high that subsidy-backed loans crowd out loans backed by the other type of collateral. Otherwise there is no effect on bank loans and fertilizer use.

Hypothesis 2: *If farms are credit constrained and if decoupled subsidies are paid at the beginning of the season, (a) farms will use the same amount of loans with and without subsidies if subsidies are sufficiently small, whereas (b) farms reduce bank loans if subsidies are sufficiently large.*

If the subsidy is paid at the beginning of the season, the farm can use it directly to finance the purchase of fertilizer. Here we still assume that farms' internal cost of financing is smaller than the cost of the bank loan, $i_s < i_c$.[10] The situation is illustrated in Figure 1. The equilibrium quantity of fertilizer with the credit constraint and with no subsidy is K_c^*. First, consider subsidy DS_1. The subsidy DS_1 shifts the supply of fertilizer from $k_c D S_K$ to $k_s GAE S_{K1}$, where $S_{K1} = (C + DS_1)/k$. The equilibrium quantity of fertilizer is K_{cs1}^* $(= (C + DS_1)/k)$. Part of the fertilizer purchase is financed directly from the subsidy, K_{s1}^* $(= DS_1/k)$, and the rest is financed through the bank loan, K_c^* $(= K_{cs1}^* - K_{s1}^* = C/k)$. Subsidy DS_1 does not change the quantity of the bank loan, however. With the subsidy DS_1 the farm remains credit constrained – the equilibrium amount of fertilizer K_{cs1}^* is lower than the equilibrium amount of fertilizer under the perfect credit market K^*, $K_{cs1}^* < K^*$. Credit constrained farms use both subsidies and loans to finance the purchase of fertilizer because the marginal return from fertilizer (given by D_K) is above its marginal costs, k_c.

However, if the subsidy is sufficiently high, farms will reduce the amount of bank loans. For example, with subsidy DS_2, where $DS_2 > K^* - K_c^* > DS_1$, the supply of fertilizer shifts to $k_s HBF S_{K2}$, where $S_{K2} = (C + DS_2)/k$ (Figure 1). The equilibrium fertilizer use changes to K^*: K_{s2}^* $(= DS_2/k)$ is financed directly by the subsidy and $K^* - K_{s2}^*$ is financed with the bank loan. Now, subsidies crowd out loans. The amount of fertilizer financed with the bank loan is lower with than without subsidies: $K^* - K_{s2}^* < K_c^*$. Intuitively subsidy DS_2 eliminates the credit constraint (i.e. the credit constraint (2) is not binding with DS_2) and the farm substitutes part of more expensive bank loans with cheaper subsidies. Because with subsidy DS_2 the farm is not credit constrained, in equilibrium it uses the same level of fertilizer as under the perfect credit market, K^*.

Finally, we consider the situation with binding credit constraint when the subsidy is paid at the end of the season. Analogous to the above case we assume that all subsidies are paid at the end of the season $\alpha = 0$.

[10] This assumption is not strictly needed to obtain the results. Only in certain situations (e.g. if farms' opportunity costs are prohibitively high, asymmetric marginal return between agricultural and non-agricultural activities) will farms not allocate subsidies to agricultural production.

Hypothesis 3: *If farms are credit constrained and if decoupled subsidies are paid at the end of the season, the farm increases bank loans.*

The graphical analysis is in Figure 2. The fertilizer supply without the subsidy and with the credit constraint is $k_c A S_K$ and the equilibrium fertilizer use is K_c^*. If the credit constraint (1) is binding, it is profitable for the farm to use the subsidy *DS* paid at the end of the season ($\alpha = 0$) as collateral for obtaining a bank loan for the purchase of fertilizer at the beginning of the season. Higher collateral increases bank loans from $C(W)$ to $C(W + DS)$, where $C(W) < C(W + DS)$. The availability of more loans shifts the fertilizer supply to $k_c B S_{K1}$ and the equilibrium fertilizer use to K_{c1}^*, where $K_{c1}^* > K_c^*$.[11] Note that with a sufficiently high subsidy, the farm may become credit unconstrained. For example, this is the case when the subsidy shifts the fertilizer supply to $k_c D S_{K2}$ which increases fertilizer quantity to the perfect market equilibrium level K^*.

Extension 1: Coupled subsidies

Up to now we have considered decoupled subsidies. However, under the CAP some subsidies are coupled (linked) with specific farm activities such as the production of certain crops, animal products, or other farm performance (e.g. farm investments). First, coupled subsidies may have a smaller impact on bank loans extended to farms than decoupled subsidies. There are two reasons behind this: (i) coupled subsidies are more often capitalized into input and/or output prices than decoupled ones and (ii) coupled subsidies are conditioned on specific production, while decoupled are not. Second, because coupled subsidies are conditional on farm activities, they may actually stimulate bank loans.

Studies have shown that coupled subsidies are capitalised in input and output prices. Subsidizing specific activities increases their production and input use thus raising input prices. By the same token, increased production of subsidized activities reduces output prices. In other words, coupled subsidies are partially leaked to input suppliers or consumers. The extent of the leakage depends primarily on input supply and output demand elasticities (Alston and James 2002; de Gorter and Meilke 1989; Gardner 1983; Guyomard et al. 2004; Salhofer 1996). Leakages reduce the value of subsidies to farmers and hence the possibility of subsidy use for credit (either directly or indirectly) is also reduced. The leakage of decoupled subsidies is likely lower because they are linked to specific farm activities to a lesser extent.

While farms receive decoupled subsidies irrespective of their production level, coupled subsides are related to production of specified commodities. For example, a farm receives a specific cereal subsidy only when it produces cereals. The amount of the subsidy normally increases with the

[11] Note that in Figure 2 we assume the same interest rate for subsidy-backed loans and for loans based on other type of collateral. In reality the interest rate for subsidy-backed loans may be lower because in general subsidies are a relatively secure and liquid source of farm income. This consideration does not affect the general results in Figure 2.

growing production of cereals. The conditionality of coupled subsidies increases the monitoring costs of banks. Banks have to check what farms produce to learn about future eligibility for subsidies of the farm. Furthermore, coupled subsidies are more risky because future production of subsidized commodities is uncertain. Due to severe weather conditions and other regional and farm-specific uncertainties (e.g. diseases), production can decline, which consequently leads to lower subsidies.

On the other hand, because coupled subsidies are conditional on farm activities, they tend to be allocated after a given activity is realised by the farm which in many circumstances occurs at the end of the production season. Following hypotheses 1 and 2, this factor reduces the possibility to use them directly for the purchase of inputs and hence their crowding out effect on loans is diminished. In fact, they may be more likely to be used indirectly to obtain loans as they increase the value of collateral, and hence may lead to more loans compared to decoupled subsidies (hypothesis 3).

Overall, the impact of coupled subsidies relative to decoupled ones is ambiguous. The capitalization of coupled subsidies in input and output prices and their conditionality on production reduces bank loans, while because they tend to be paid to farmers at the end of the season it may lead to a stronger impact on loans due to pre-financing needs at the beginning of the production season.

Extension 2: Long-term loans

Farms use long-term loans to finance long-term investments which generate a multi-annual income stream. In general, the impact of decoupled subsidies on long-term loans is similar to the case of short-term loans.[12] If subsidies are received at the beginning of the season, they may be used to also finance long-term farm investments in addition to variable inputs such as fertilizers. If subsidies are allocated at the end of the season, they may alter loans only by affecting the farm's collateral value of long-term loans. Hence, all three hypotheses derived in the previous section also hold in the case of long-term loans.

What is important for long-term loans is the expectation of markets regarding a multi-annual flow of subsidies because long-term loans tend to be repaid by farms over a longer period than just one year. Market expectations about the continuation of the CAP affect the ability of farmers to use subsidies to obtain long-term loans. If lenders perceive CAP subsidies as uncertain and subject to change, they may reduce their incentive to provide loans collateralised by subsidies. In its history, the CAP was reformed several times. Some reforms involved the change of subsidy levels while other reforms altered subsidy types (Kay 2000; Pokrivcak et al. 2006; Swinnen 2008). Changing subsidy levels affects the value of collateral for obtaining loans which increases

[12] Although the interest rate may differ between the short- and the long-term loans, the intuition is the same for both cases.

the risk for farmers and banks. On the other hand, altering types of subsidy changes administration and monitoring costs for banks and increases the risk because different activities might be subsidised in the future to those that were in the past.

Furthermore, due to the fact that the value of long-term investment tends to be substantially larger than the annual value of received subsidies, annual subsidies may not be sufficient to cover the full value of investment. Instead, expected future subsidies may be used indirectly to enhance the value of collateral for long-term loans. Following hypotheses 1 - 3, subsidies increase long-term loans to a larger extent than they increase short-term loans. Since subsidies are not sufficiently high to be used for long-term investments, the potential crowding out effect on long-term loans is reduced (hypotheses 1 and 2). Therefore, subsidies might be used as collateral for long-term loans (hypothesis 3).

In summary, the impact of subsidies on long-term loans relative to short-term loans is ambiguous. Due to the uncertainties associated with the future CAP, one may expect a lower impact of subsidies on long-term loans compared to short-run loans. On the other hand, due to the fact that the value of long-term investment tends to be substantially larger than the annual value of subsidies, the reverse holds (long-term loans may be more stimulated by subsidies than by short-term loans).

2.1. Econometric specification

Theoretically the impact of decoupled subsidies on agricultural loans is ambiguous. Agricultural subsidies paid at the end of the production season have no impact on bank loans under perfect credit markets, while they may reduce bank loans when paid at the beginning of the season. Under credit constraint, subsidies paid at the beginning of the season have no impact on bank loans if they are sufficiently small but they reduce bank loans if they are sufficiently high. Furthermore, under credit constraint when subsidies are paid at the end of the season they are likely to result in increased bank loans. The effects of subsidies on bank loans are also ambiguous when we consider coupled versus decoupled subsidies or when short- versus long-term loans are compared. The relationship between subsidies and bank loans is therefore an empirical question.

Following our theoretical analysis, the amount of farm loan depends on the farm's subsidy, profitability, and assets. We therefore estimate the following econometric model:

$$loan_{jt} = \beta_0 + \beta_s S_{jt} + \beta_a assets + \beta_\pi \Pi_{jt} + \beta_x X_{jt} + \varepsilon_{jt} \quad (3)$$

where subscripts *j* and *t* represent farm and time, respectively, $\beta_0, \beta_s, \beta_a, \beta_\pi, \beta_x$ are coefficients to be estimated, *loan* stands for farm bank loans, S_{jt} are subsidies received by farm, *assets* are farm assets, Π_{jt} is farm income and X_{jt} is a vector of observable covariates such as farm characteristics, regional, and time variables. As usual, ε_{jt} is the residual term.[13]

We are especially interested in estimating the parameter β_s which measures the impact of subsidies on bank loans. A statistically significant negative value of the coefficient confirms either hypothesis 1a (subsidies crowd out bank loans in perfect credit markets case if received at the beginning of the season) or hypothesis 2b (sufficiently high subsidies paid at the beginning of the season crowd out bank loans with binding credit constraint). A statistically significant positive coefficient confirms hypothesis 3 (farms are credit constrained and subsidies are paid at the end of the season). Finally, if the coefficient is statistically insignificant, then either the hypothesis 1b or 2a holds (perfect credit market situation and credit constraint case with relatively low value of subsidies, respectively). However, a statistically insignificant coefficient may also imply that there is no relationship between subsidies and farm credit behaviour. This situation may occur, for example, if farms are credit constrained but prefer not to invest in agriculture but in non-agricultural activities (e.g. real estates, consumption, etc.).

We expect that data will confirm either hypothesis 2 or 3 because there is overwhelming evidence that farms are credit constrained (Carter 1988; Blancard et al. 2006; Lee and Chambers 1986; Färe et al. 1990). Further, anecdotal evidence indicates that (at least a share of) subsidies are paid at the end of the season[14] which implies that hypothesis 3 should hold.

The estimation of equation (3) is subject to the omitted variable bias and particularly to the endogeneity problem of CAP subsidies. There are unobservable characteristics like the farmer's ability and skills that affect bank loans and thus may be correlated with explanatory variables. Ignoring this unobserved farm heterogeneity leads to biased results. We use panel data and estimate the fixed effects model which helps us to control for the unobserved heterogeneity component that remains fixed over time, thus reducing considerably the omitted variable bias problem. In order to control for endogeneity we also estimate the generalised method of moment (GMM) model. This approach was applied in various contexts such as in growth studies (Caselli et al. 1996), and in relation to labour productivity (Yamamura and Shin 2012), effects of economic reforms (Easterly et al. 1997) and effects of trade liberalization (Greenway et al. 2002).

[13] The definition of the rest of the variables is the same as in the theoretical section.
[14] There is not available consistent data on the exact timing of CAP subsidies allocation to farms. Moreover, the allocation varies by subsidy type and country.

Fixed effects model

The following fixed effects model estimation implies the following specification:

$$loan_{jt} = \beta_0 + b_j + \beta_s S_{jt} + \beta_a assets + \beta_\pi \Pi_{jt} + \beta_x X_{jt} + \varepsilon_{jt} \tag{4}$$

where b_j is the fixed effect for farm j, which captures time-unvarying farm-specific characteristics. These fixed effects represent farm heterogeneity. For example, they could reflect different technologies and productivities for different farms, or they could reflect different managerial skills or other unobservable fixed farm-specific characteristics.

Endogeneity

Endogeneity might bias our estimates. If subsidies were assigned to farms randomly, then parameter β_s would measure the true impact of subsidies on bank loans. In reality, however, subsidies are not assigned randomly to farms. For example, decoupled and coupled animal and crop subsidies depend on regional and farm level productivities. Historical principle is used in the EU for distribution of subsidies among Member States and among farms. This principle assures that more productive countries and farms receive higher subsidies than less productive countries and farms. Also in rural development projects farms apply to participate and only those with the best projects (usually the more productive farms) are granted the rural development support. This structure of CAP subsidies implies that they are endogenous variables reflecting the characteristics of countries/regions' land and farmers' behaviour. Hence, subsidies are not assigned randomly, which implies that subsidy payments are correlated with the error term. As a result, the ensuing standard estimates of β_s may be biased.

To address this source of endogeneity, we employ the Arellano and Bond (1991) robust two-step GMM estimator. Arellano and Bond (1991) have shown that lagged endogenous variables are a valid instrument in panel data setting. This allows us to use lagged levels of the endogenous variables as instruments (additionally to exogenous variables), after the equation has been first-differenced to eliminate the farm-specific effects. The GMM estimator is particularly suitable for datasets with a large number of cross-sections and few time periods and it requires that there is no autocorrelation. The FADN dataset matches these requirements, because it is a panel data and contains a very large number of farm-level observations relative to the period covered. Additionally, the GMM estimator controls for unobserved fixed effects of farms. These create a particular problem in our dataset since farm productivities and abilities, among others, are not observed. Given that the robust two-step GMM standard errors can be severely downward biased, we use the Windmeijer (2005) bias-corrected robust variances.

We have opted for the Arellano and Bond (1991) estimator instead of the GMM estimator system developed by Arellano and Bover (1995) and Blundell and Bond (1998). Arellano and Bond

(1991) permit the introduction of more instruments and can improve the efficiency of the model. The GMM system imposes the assumption that the first differences of the instrument variables are uncorrelated with the fixed effects. This could be problematic for CAP subsidies which are the main interest of our study. Given that CAP subsidies received by each farm also largely depend on the farm's productivity, which is captured by fixed effects, the assumption of the GMM estimator system might be violated meaning that instrumental variables for subsidies are likely correlated with fixed effects.

3. Data and variable construction

The main source of the data used in the empirical analysis 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 farms. In total there is information about 150 variables on farm structure and yield, output, costs, subsidies and taxes, income, balance sheet, and financial indicators. Sample sizes vary from country to country (roughly between 500 and 20 000 observations, while most countries have about 1 500-10 000 observations) representing a population of around 5,000,000 farms, covering approximately 90% of the total utilised agricultural area and accounting for more than 90% of the total agricultural production. The aggregate FADN data are publicly available. However, farm-level data are confidential and, for the purposes of this study, are accessed under a special agreement.

To our knowledge, the FADN is the only source of micro-economic data that is harmonised (the bookkeeping principles are the same across all EU Member States) and it is representative of commercial agricultural holdings in the whole EU. Holdings are selected to take part in the survey on the basis of sampling plans established at the level of each region in the EU. The survey does not, however, cover all the agricultural holdings in the EU, but only those which are of a size allowing them to rank as commercial holdings.

The FADN data is a panel dataset, which means that farms that stay in the panel in consecutive years can be traced over time using a unique identifier. In this study we use panel data for 1995-2007 covering all EU Member States except Romania and Bulgaria. Romania and Bulgaria were excluded from the sample, because for these countries the data were available only for one year (2007).

The description of constructed variables is presented in Table 1. All variables except for ratios are calculated per hectare of utilised agricultural area (UAA) in order to reduce the potential problem of heteroskedasticity. The dependent variables in equation (4) – *total loan, long-term loans*, *short-term loans* – are constructed from the FADN data by dividing total, long-, medium-term and short-term loans, respectively, with the total utilised agricultural area.

Similarly, all subsidy variables (*sub_total_ha*, *sub_decoupled_ha*, *sub_coupled_ha*) are constructed from the FADN data and are calculated on a per-hectare basis. Every agricultural producer in the FADN survey is asked to report both the total subsidies received as well as to specify the amount by subsidy type. Decoupled subsidies, *sub_decoupled_ha*, include single payment subsidies (SPS) applied in old Member States and single area payment scheme (SAPS) payments that are applied in new Member States. Coupled subsidies, *sub_coupled_ha*, include payments linked to farm inputs or outputs such as crop area payments, animal payments and rural development payments. The total subsidies, *sub_total_ha*, variable is the sum of coupled and decoupled CAP subsidies. The independent variables *assets_ha* and *income_ha* represent the value of farm assets and farm cash flow calculated on a per hectare basis.

The covariates matrix X_{jt} includes other explanatory variables which affect farm loans. The *land rented ratio* and *labour own ratio* are included in the equations to control for potential differences in incentives between own and rented/hired land/labour as well as to account for the higher cost level of farms using rented/hired land/labour. A variable capturing the economic size (*farm size*) of the farms is also available from the FADN data. The economic size of farms is expressed in European size units. In order to account for the various technological, sectoral and regional covariates we include variables accounting for effects such as irrigated land, area under glass, fallow land, and sectoral, regional and time dummies (for more details see Table 1).

4. Estimation results

The results are reported in Table 2 for total farm loans (models 1-3), for long-term farm loans (models 4-6) and for short-term farm loans (models 7-9).[15] Additional to the complete equation specification (4), we add an interaction variable between subsidies and farm size (models 2, 3, 5, 6, 8 and 9) and the square value of subsidies (models 3, 6 and 9) to account for heterogeneity in effects and non-linear relationships between subsidies and loans.

The model-adjusted R^2s ranges from 0.10 to 0.49. The most consistently significant variables (prob(t) < 0.10) across all models are assets (*assets_ha*), trend variable (*year*), own labour ratio (*labor_own_ratio*), and rented land ratio (*land_rented_ratio*).

The estimated results suggest that subsidies influence farm loans but the effects are heterogeneous and non-linear. The coefficient for subsidies in models 1, 4 and 7, where only a linear subsidy term is used, are statistically not significant for any type of loan. However, when interacting subsidies with farm size (models 2 and 5) its coefficient is statistically significant but only for total loans and for long-term loans. At the same time, the coefficient associated with the linear subsidy term *sub_total_ha* is statistically significant and takes a negative value. This

[15] We estimate fixed effects models with heteroskedasticity-consistent standard errors.

indicates that subsidies stimulate farm loans but only for larger farms, whereas the linear term has a reducing effect on total and long-term loans (models 2 and 5). For the short-term loans (model 8) both coefficients (i.e. for the interaction variable and the linear term *sub_total_ha*) are not significant.

Moreover, the results indicate that the relationship between subsidies and loans is non-linear. A small value of subsidies per hectare reduces bank loans (the coefficient for *sub_total_ha* is negative and significant in models 3 and 6) and as the value of subsidies increases farms use more bank loans (the coefficient for the squared value of subsidies *sub_total_ha_sq* is positive and significant in models 3 and 6). Again this holds only for total loans and for long-term loans. The short-term loans are also not affected by subsidies when the non-linear relationship is considered (model 9).

These results indicate that hypothesis 3 holds for the total and the long-term loans and for certain farm types (larger farms and those with higher subsidies) whereby subsidies increase farm collateral and thus farm loan use. For the short-term loans, the estimated results suggest the validity of the hypothesis 1b or 2a.[16] However, this does not imply that farms are not credit constrained with respect to short-term loans. Farms may still be credit constrained and may use subsidies to finance short-term inputs if they are either receiving them at the beginning of the production season or if they use other informal sources which are collateralised by subsidies. On the other hand, the difference in the statistical significance between the long-term and the short-term loans may indicate that farms might prefer to use subsidies to finance long-term investments, and not the short-term variable input purchase. This is possibly because of the stronger credit constraint present in the former type of input than in the latter or due to the fact that the value of long-term investment tends to be substantially larger than the annual value of subsidies which may motivate farms to use subsidy-collateralised long-term loans (extension 2).

Furthermore, results indicate that smaller farms' long-term loans may be reduced by subsidies implying the validity of hypothesis 2b. This could be due to the higher cost of loans relative to the opportunity costs of subsidies for small farms compared to big farms which may have access to cheaper loans. This intuition may explain the crowding out effect of subsidies estimated for long-term loans in the former type of farms.

The results reported in Table 2 for total subsidies may hide heterogeneity in effects between subsidy types. In Table 3 we disaggregate subsidies into coupled (*sub_coupled_ha*) and decoupled (*sub_decoupled_ha*) payments and again estimate their impact on total loans (models 1-3), long-term loans (models 4-6) and short-term loans (models 7-9). The results indicate important differences in the impacts the two types of payments have on the farm loans.

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[16] These results may also indicate that there is no relationship between subsidies and farm credit behaviour.

For the long-term loans (models 4-6) the effects are similar to those shown in Table 2. Both coupled and decoupled subsidies have a heterogeneous (likely stimulating loans to big farms and reducing loans to small ones) and non-linear impact on long-term loans.

For the short-term loans, the effects of disaggregated subsidies (Table 3) differ with respect to the results reported in Table 2. The short-term loans are affected only by decoupled subsidies. However, the linear term (the coefficient for *sub_decoupled_ha* in model 9) is positive and significant, whereas the interaction term (the coefficient for *sub_decoupled_fsize* in model 9) is negative and significant. These results suggest that decoupled subsidies are used as collateral to increase short-term loans but this is more important for small farms than for big farms. The coupled subsidies do not affect the short-term loans: i.e. the coefficients for variable *sub_coupled_ha*, *sub_coupled_ha_sq* and *sub_coupled_fsize* are statistically not significant in model 9.

In general, the results in Table 3 indicate that big farms tend to use subsidies to increase long-term loans, whereas small farms tend to use subsidies to increase short-term loans. A crowding out effect may occur as subsidies tend to reduce short-term loans for big farms and long-term loans for small farms. This implies that hypothesis 3 tends to hold for big farms, whereas hypothesis 2b likely holds for small farms for long-term loans.

Decoupled subsidies have a positive effect on short-term loans for small farms (hypothesis 3), and a negligible or negative impact on large farms (hypothesis 2b). The insignificant coefficient for coupled subsidies in the short-term loan equation suggests that hypothesis 1b/2a or the non-existence of a subsidy-credit relationship may better represent the reality.

The GMM estimates are shown in Table 4. Similar to the fixed-effect estimates, the GMM results indicate a stronger impact of subsidies on long-term loans than on short-term loans (model 1 versus model 4). Furthermore, the GMM results indicate that the significance of impacts is changed when non-linearities and interaction terms are considered too.[17] In models 3 and 6 only the coupled subsidies affect loans and the relationship between subsidies and bank loans is non-linear. A small value of coupled subsidies has no impact on bank loans (the coefficients for *sub_decoupled_ha* and *sub_coupled_ha* are not significant in models 2, 3 and 4, 6) and higher subsidies stimulate the use of bank loans by farms (the coefficient for the squared value of subsidies *sub_coupled_ha_sq* is positive and significant in models 3 and 6). This holds for both types of loans. Farm size appears to be significant for decoupled but less so for coupled subsidies (model 2 versus model 5). Decoupled subsidies tend to increase long-term loans for bigger farms (model 2). Overall, the results in Table 4 tend to confirm the validity of hypothesis 3 (positive impact of subsidies on farm loans) and tend to reduce the validity of the crowding out effect (hypothesis 2b). Note that insignificant coefficients do not necessarily imply that subsidies do not play a role with respect to farm credit. As shown in hypothesis 2a, when farms are credit constrained they may use subsidies directly to finance input purchase keeping the level of loans unchanged.

[17] Note that this could also be due to multicolinearity between variables.

Conclusions

In this paper we estimate the impact of the European Union's agricultural subsidies on bank loans extended to farms. First, we theoretically derive the demand for loans by farms under perfect and imperfect credit market assumptions. In an empirical analysis we use the FADN farm level panel data to examine the theoretical predictions.

Our theoretical model does not provide an unambiguous prediction about the impact of subsidies on bank loans. Subsidies may increase bank loans, reduce them or have no impact at all. The outcome depends on whether farms are credit constrained, whether subsidies are allocated to farms at the beginning or at the end of the production season, on the type of loans and subsidies, and on the relative cost of internal and external financing. If the external financing (bank loan) is more expensive than the internal financing (subsidy), subsidies affect bank loans even if the farm is not credit constrained. This occurs when subsidies are paid at the beginning of the production season which allows farms to replace more expensive bank loans with cheaper subsidies. With credit constraint, farms have an incentive to expand either internal or external financing (or both) to invest in purchasing variable inputs. If subsidies are paid to farmers at the beginning of the season, farms may use them directly to purchase inputs with no effect on bank loans. However, if subsidies are sufficiently large they eliminate the farms' credit constraint and crowd out more expensive bank loans. Alternatively, if subsidies are received at the end of the season, farms cannot use them directly to finance inputs. Instead they may use subsidies as collateral to obtain more bank loans thus increasing the availability of external financing for inputs at the beginning of the season.

The impact of coupled subsidies on bank loans, in relation to decoupled ones, is ambiguous. The capitalization of coupled subsidies into input and output prices and their conditionality on specific production may result in a smaller effect on loans; whereas coupled subsidies tend to be allocated to farmers at the end of the season which may lead to a stronger impact on loans due to pre-financing needs at the beginning of the production season.

The impact of subsidies on long-term loans may be different compared to the impact on short-term ones. On the one hand, due to the uncertainty associated with the future agricultural policy, one may expect subsidies to have a lower impact on long-term loans compared to short-run loans. On the other hand, due to the fact that the value of long-term investment tends to be substantially larger than the annual value of subsidies, more long-term loans may be required to be backed by subsidies relative to short-term loans.

We employ the fixed effects and GMM models to estimate the impact of subsidies on bank loans extended to farms. The empirical results are summarised in Table 5 and suggest the following impacts of subsidies on farm loan use: (i) Subsidies influence farm loans and the effects tend to be non-linear and heterogeneous among farms. (ii) Big farms tend to use subsidies to increase long-term loans, whereas small farms use subsidies to increase short-term loans. A crowding out effect may occur in the reverse situation: subsidies tend to reduce short-term loans for big farms and long-term loans for small farms. (iii) Coupled subsidies tend to affect loans differently than decoupled subsidies. Both coupled and decoupled subsidies may reduce long-term loans to small farms (crowding out effect), whereas they may stimulate long-term farm loans to big farms. Short-term loans are affected only by decoupled subsidies. They increase the short-term loans of small farms more than those of large farms. For large farms the effect of decoupled subsidies may even result in a crowding out effect. (iv) When controlling for endogeneity, the crowding out effect tends to be reduced in favour of a positive effect of subsidies on loans. (v) In general, our empirical results indicate that hypothesis 3 (positive impact) may hold although the crowding out effect cannot be completely excluded.

The analysis of the response of credit markets to subsidies adds additional insights into the effects of agricultural subsidies on the economy. Our results suggest that the impact of the European Union's Common Agricultural Policy on agricultural credit markets is complex and varies by credit type and size of farms as well as by type of subsidy. Overall, our estimates indicate that CAP subsidies offset the credit-tightening accompanying the financial crisis, and in a time of increasing global market volatility they stabilize agricultural production by correcting credit market imperfections. However, one should be careful in drawing general policy implications from this, since a complete analysis should include the deadweight cost of taxation as well as the comparison of agricultural subsidies with other policy instruments that address the credit market imperfections directly.

A second important finding of this paper is that we cannot completely exclude the crowding out effect of agricultural subsidies on bank loans. The crowding out tends to be stronger for small farms and for short-term loans. Therefore, different policy measures have varying impacts depending on the structure of farms and the type of financial instruments used. Based on these results agricultural policies can be better targeted. Subsidies can be designed in such a way that the crowding out effect is reduced to minimum and only credit constrained farms are supported. This would result in a more efficient use of public money.

Our results are subject to several limitations. We test the relationships between the value of subsidies received by farmers and the amount of loans extended to farmers by banks. Estimation of these relationships with more detailed data on bank loans (e.g. type of collateral used) may improve the results. The availability of data on non-bank loans such as futures, derivatives or informal credit may further improve the estimates. Additionally, the GMM method employed in this paper may suffer from the weak instruments problem when time series are persistent and the number of time series observations is small. Addressing these issues is a promising avenue for future research.

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Figure 1: Credit market and subsidies

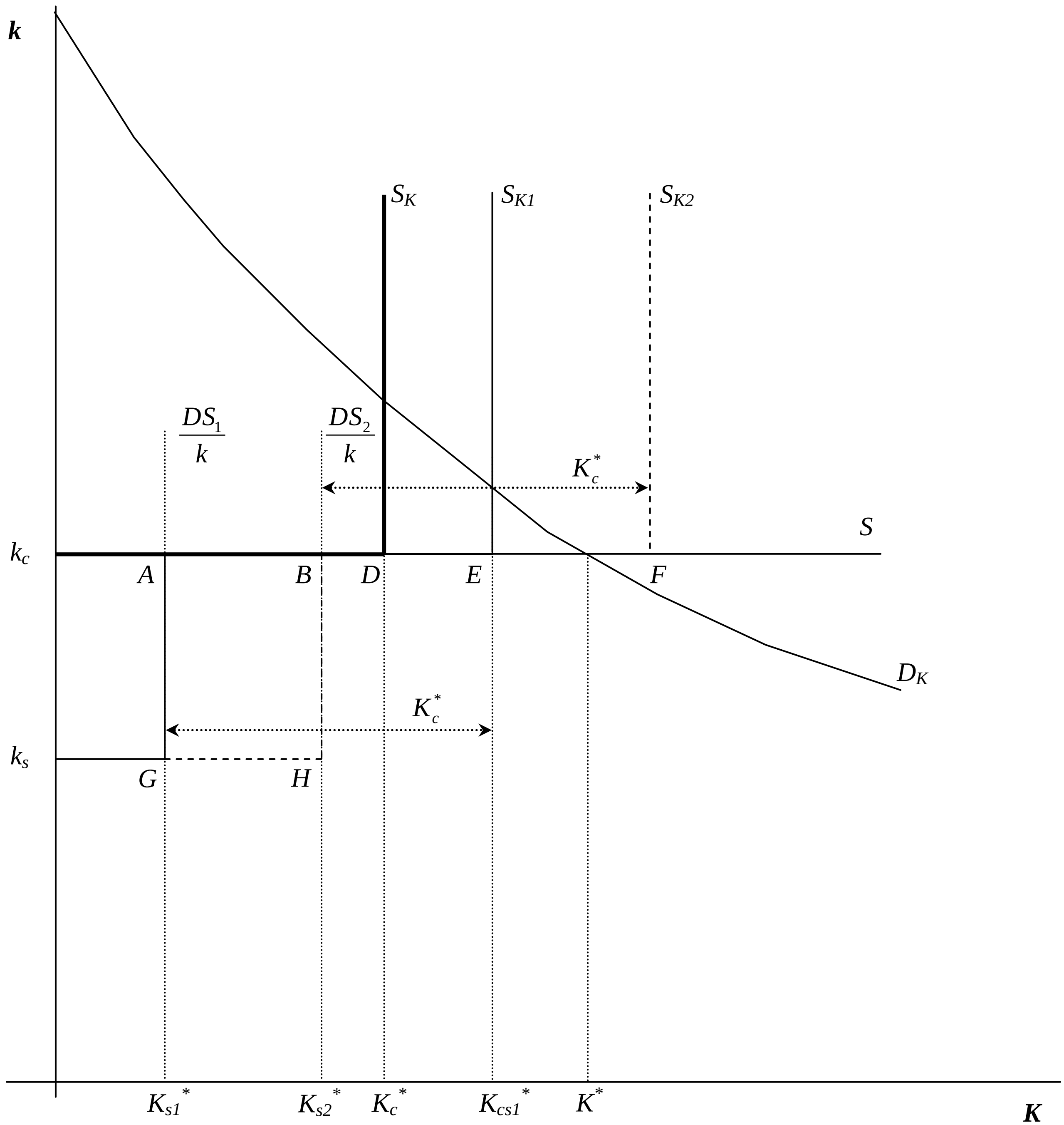

Figure 2: Credit constraint and subsidies used as collateral for bank loans

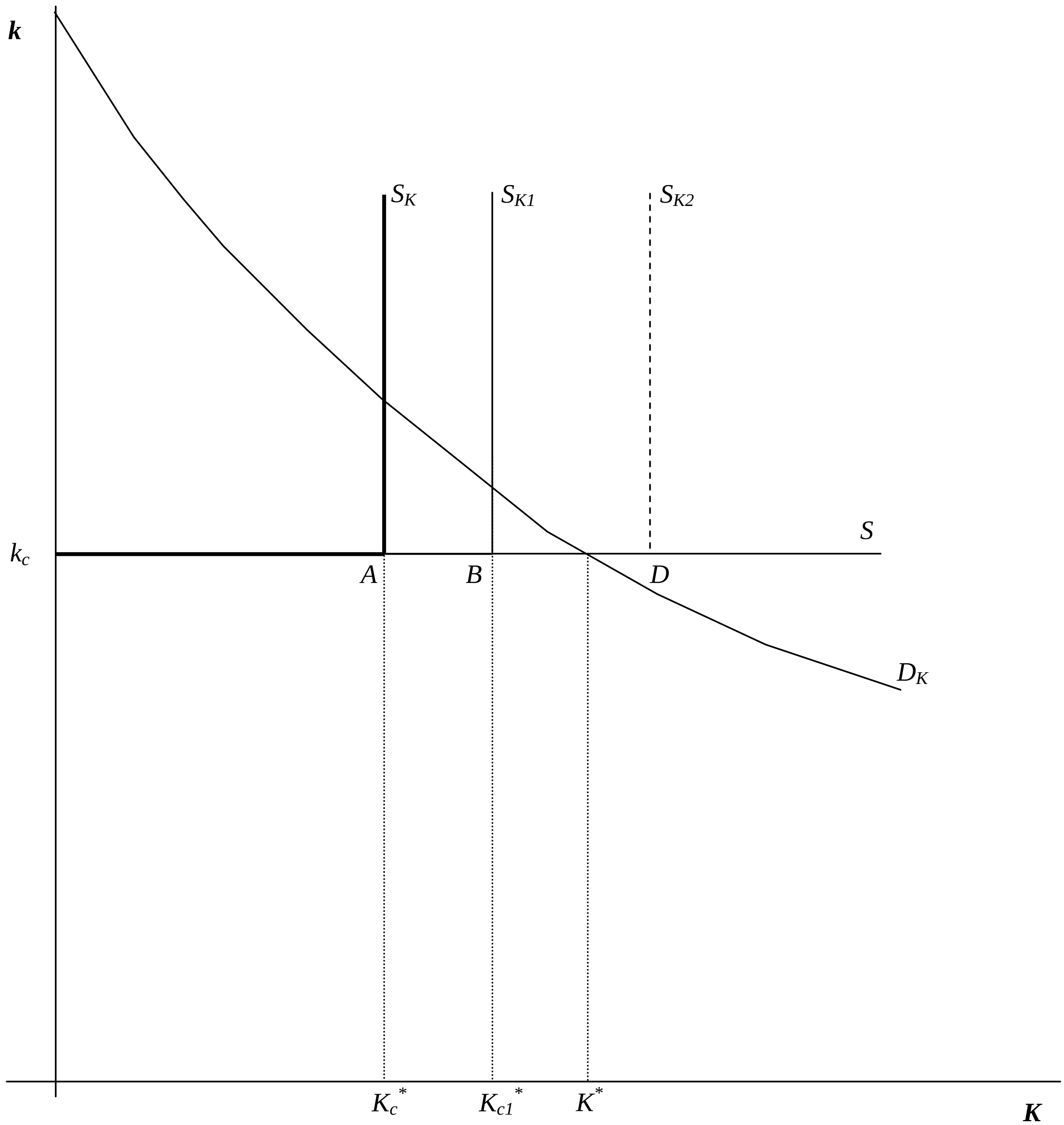

Table 1: Description of variables

Variable name	**Description**
Dependent variables	
Total loans	Long, medium and short-term loans per UAA
Long run loans	Long & medium-term loans per UAA
Short run loans	Short-term loans per UAA
Explanatory variables	
sub_total_ha	Hectare value of farm subsidies
sub_coupled_ha	Hectare value of all coupled subsidies on crops, livestock and livestock products and rural development payments
sub_decoupled_ha	Hectare value of SPS and SAPS
sub_total_ha_sq	Square value of subsidies
sub_coupled_ha_sq	Square value of coupled subsidies
sub_decoupled_ha_sq	Square value of decoupled subsidies
sub_total_fsize	Interaction variable between subsidies and total loans (=sub_total_ha * farm size)
sub_coupled_fsize	Interaction variable between coupled subsidies and total loans (=sub_coupled _ha * farm size)
sub_decoupled_fsize	Interaction variable between decoupled subsidies and total loans (=sub_decoupled _ha * farm size)
assets_ha	Hectare value of farm assets
income_net_ha	Cash flow: farm revenues from production sales minus payments for inputs (excluding depreciation and interest costs)
income_net_ha_l	Lagged value of income_net_ha
year	Trend variable
land_rented_ratio	Ratio of rented area to UAA
labor_own_ratio	Ratio of unpaid input to total labour
Farm size	Economic size of holding expressed in European size units (ESU)
irrigated_land	Ratio of irrigated land to UAA
glass_land	Ratio of the area under glass or plastic land to UAA
land_unused_ratio	Ratio of fallow and set-aside land to UAA
land_woodland_ratio	Ratio of woodland area to UAA
output_livestock_ratio	Ratio of total livestock output to total farm output
output_owncons_ratio	Ratio of farmhouse consumption and farm use to total output
lu_ha	Total livestock units per UAA

Note: All variables are calculated from the FADN data.

Table 2: Fixed effects estimates for bank loans (total subsidies)

	Total loans			*Long-term loans*			*Short-term loans*		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
sub_total_ha	0,066	-0,99**	-1,07***	0,076	-1,94***	-1,66***	0,0081	-0,14	-0,14
sub_total_ha_sq			0,0001**			0,0002**			0,0000
sub_total_fsize		0,142*	0,0967		0,255**	0,158**		0,0204	0,0206
assets_ha	0,42***	0,42***	0,42***	0,41***	0,41***	0,41***	0,052***	0,052***	0,052***
income_net_ha	0,246	0,246	0,247	0,301	0,302	0,303	-0,0726*	-0,0726*	-0,0726*
income_net_ha_l	-0,136	-0,136	-0,135	-0,149	-0,148	-0,147	0,0005	0,0005	0,0005
year	24,94**	24,94**	25,59**	19,89**	19,81**	20,66**	-7,654***	-7,664***	-7,667***
farm size	85,82	28,93	48,96	99,07	0,353	40,88	17,50	9,233	9,125
labor_own_ratio	-251,4***	-249,8***	-256,5***	-253,1**	-253,1**	-260,0**	-51,85	-51,54	-51,50
land_rented_ratio	3780**	3778**	3779**	3258**	3251**	3253**	470,0***	470,0***	470,0***
land_unused_ratio	297,1	279,2	279,9	200,5	175,1	179,4	-70,19	-72,55	-72,62
land_woodland_ratio	-2209***	-2166***	-2148***	-2598**	-2546**	-2529**	-179,9*	-173,4	-173,5
output_livestock_ratio	-3,075	-3,078	-2,473	1,655	1,843	2,441	-4,268	-4,270	-4,272
output_owncons_ratio	436,9	436,4	448,5	436,7	439,9	451,7*	-43,92	-44,00	-44,09
irrigated_land	-13,49	-13,45	-13,01	32,17	32,65	39,00	5,168	5,170	5,169
glass_land	28,15	28,16	30,58*	49,48***	50,20***	52,75***	-9,384*	-9,382*	-9,395*
yield_wheat	-0,194**	-0,195**	-0,190**	-0,236***	-0,234***	-0,230***	0,0405**	0,0405**	0,0405**
lu_ha	91,61	91,28	90,70	34,18	33,57	32,81	48,59**	48,57**	48,58**
Constant	-54495**	-54088**	-55396**	-44250**	-43310**	-45192**	15011***	15091***	15098***
Observations	237372	237372	237372	195496	195496	195496	206108	206108	206108
R-squared	0,489	0,489	0,490	0,484	0,484	0,485	0,106	0,106	0,106
Number of individual farms	60904	60904	60904	51360	51360	51360	54382	54382	54382

*** p<0,01; ** p<0,05; * p<0,1

Table 3: Fixed effects estimates for bank loans (disaggregated subsidies)

	Total loans			*Long-term loans*			*Short-term loans*		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
sub_decoupled_ha	-0,0325	-2,712***	-2,182**	0,131	-6,451***	-5,383***	-0,164***	1,120***	1,183***
sub_decoupled_ha_sq			-0,0004			-0,0009*			-0,0001
sub_decoupled_fsize		0,339**	0,260		0,801***	0,676***		-0,153***	-0,155***
sub_coupled_ha	0,070	-0,945**	-1,046***	0,074	-1,731**	-1,450***	0,0139	-0,196	-0,198
sub_coupled_ha_sq			0,0001**			0,0002**			0,0000
sub_coupled_fsize		0,136*	0,096		0,229**	0,136**		0,0282	0,0297
assets_ha	0,42***	0,42***	0,42***	0,41***	0,41***	0,41***	0,052***	0,052***	0,052***
income_net_ha	0,247	0,247	0,247	0,301	0,302	0,303	-0,072*	-0,073*	-0,072*
income_net_ha_l	-0,136	-0,135	-0,135	-0,149	-0,148	-0,147	0,00067	0,00078	0,00076
year	27,46*	28,34*	26,50*	18,55	20,71	18,22	-3,072	-3,549*	-3,809*
farm size	84,51	15,31	38,08	99,77	-26,67	16,71	15,01	17,02	16,87
labor_own_ratio	-252,3***	-243,6***	-251,3***	-252,7**	-232,3**	-239,1**	-54,60	-60,46*	-60,39*
land_rented_ratio	3779**	3779**	3781**	3258**	3258**	3261**	469,0***	468,2***	467,9***
land_unused_ratio	292,3	275,0	276,2	204,1	177,2	185,8	-81,02	-91,46	-91,89
land_woodland_ratio	-2208***	-2146**	-2129**	-2598**	-2556**	-2544**	-176,4*	-190,4*	-191,1*
output_livestock_ratio	-2,842	-2,693	-2,154	1,535	2,463	3,166	-3,852	-4,012	-4,002
output_owncons_ratio	448,2	443,1	445,3	430,9	427,0	426,8	-9,337	-0,244	-1,678
irrigated_land	-13,71	-14,51	-14,00	34,17	25,43	30,25	5,128	5,680	5,685
glass_land	24,32*	25,83*	32,41**	51,57***	55,21***	64,12***	-15,99***	-17,37***	-16,98***
yield_wheat	-0,187**	-0,189**	-0,191**	-0,239***	-0,242***	-0,247***	0,0532***	0,0551***	0,0545***
lu_ha	91,60	91,32	90,68	34,19	33,70	32,86	48,60**	48,46**	48,47**
Constant	-59533*	-60790*	-57152*	-41584	-44903	-40130	5857	6794	7310*
Observations	237372	237372	237372	195496	195496	195496	206108	206108	206108
R-squared	0,489	0,489	0,490	0,484	0,484	0,485	0,106	0,107	0,107
Number of individual farms	60904	60904	60904	51360	51360	51360	54382	54382	54382

*** p<0,01; ** p<0,05; * p<0,1

Table 4: Arellano and Bond estimates for bank loans (disaggregated subsidies)

	Long-term loans			*Short-term loans*		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
sub_decoupled_ha	2,434***	-4,792	0,294	0,328	-0,677	-0,415
sub_coupled_ha	2,471***	-1,644	-0,214	0,279	-0,101	-0,189
sub_decoupled_fsize		0,861**			0,118	
sub_coupled_fsize		0,482			0,0449	
sub_decoupled_ha_sq			-0,0006			0,0008
sub_coupled_ha_sq			0,0003***			0,0002***
assets_ha	0,21***	0,22***	0,21***	0,043***	0,040***	0,043***
income_net_ha	0,468***	0,477***	0,431***	0,0628**	0,0511*	0,0489*
investment_ha	0,766***	0,756***	0,747***	-0,0786	-0,0593	-0,0579
L.investment_ha	0,243***	0,242***	0,260***	0,0797***	0,0886***	0,0782***
farm size	-82,65***	-292,0**	-83,61***	-13,58	-41,48	-16,61
labor_own_ratio	-90,20	-74,66	-86,22	-54,90	-45,12	-49,75
land_rented_ratio	1760***	1690***	1617***	281,5***	275,8***	294,3***
land_unused_ratio	416,1***	397,7***	210,4*	-75,45	-88,65	-73,07
land_woodland_ratio	-4758***	-3836***	-3190***	-151,6	-131,5	-123,8
output_livestock_ratio	13,87	14,68	14,46	0,304	0,450	-0,0605
output_owncons_ratio	545,7***	441,0***	519,2***	48,86	43,17	60,15
irrigated_land	-192,7	-193,7	-219,0	-17,68	-29,78	-36,60
glass_land	59,32***	60,47***	46,79***	1,185	1,128	0,925
yield_wheat	-0,258***	-0,270***	-0,267***	-0,020	-0,023	-0,0065
lu_ha	167,0***	151,3**	175,9***	35,31	41,42	33,86
L.loan_total_ha_adj						
L2.loan_total_ha_adj						
L.loan_long_run_ha_adj	-0,0368*	-0,0298	-0,0357*			
L2.loan_long_run_ha_adj	-0,0407***	-0,0436***	-0,0269*			
L.loan_short_run_ha_adj				0,146***	0,160***	0,141***
L2.loan_short_run_ha_adj				-0,0233	-0,0233	-0,0305
Constant	-1948***	-172,0	-907,7***	-94,81	142,6	72,89
Observations	92328	92328	92328	95448	95448	95448
Number of individual farms	26792	26792	26792	28380	28380	28380

*** p<0,01; ** p<0,05; * p<0,1

Table 5: Summary of empirical results: Impact of subsidies on bank loans

	Fixed effect estimates		GMM estimates	
	Long-term	Short-term	Long-term	Short-term
Decoupled subsidies				
Small farms	Negative	Positive	Positive	Zero
Big farms	Positive	Negative	Positive	Zero
Coupled subsidies				
Small farms	Negative	Zero	Non-linear	Non-linear
Big farms	Positive	Zero	positive	positive