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Investment Crowding-Out: Firm-Level Evidence from Germany¹

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Abstract: The main objective of the present paper is to estimate the extent to which firm investment is substituted (crowded-out) by investment support policies granted under the EU Rural Development Programme (RDP). In the empirical analyses we employ the difference-in-difference propensity score matching approach, which allows us to address several important sources of bias, such as selection bias, the simultaneity bias, and functional form misspecification, from which many previous studies suffer. Using panel data of 1,333 firms from the Schleswig-Holstein region in Germany, we find that the crowding-out effect of the RDP is close to 100%, implying that firms use public support to substitute for private investments. Furthermore, no evidence was found that, due to RDP programme support, firms would have brought forward their investments planned originally in a later period, rejecting the f inter-temporal substitution of investments.

Keywords: Investment subsidy, crowding-out, substitution effect, additionality, subsidy leverage, propensity score matching.

JEL classification: F1, O1, R3, R4.

¹ The authors are solely responsible for the content of the paper. The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

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INTRODUCTION

Investment support to firms is one of the main measures within the Rural Development Programme (RDP) and an essential component of the productivity enhancement strategy within the Common Agricultural Policy (CAP) in the EU. As part of the RDP, more than 11 billion Euro (representing 11.5 percent of the total RDP budget) was spent for supporting firm investment in the financial programming period (FPP) 2007-2013. The 2013 CAP reform extended the availability of the RDP investment support to the current 2014-2020 FPP (EC, 2012; EU, 2013). One of the key objectives of the EU investment support is to trigger additional investments that otherwise would not have been undertaken, which in the EU policy implementation guidelines (EC, 2006a) is referred to as the principle of additionality.³

A key question related to public support in general, and to the EU investment support in particular, is the extent to which such policies actually stimulate private investment, and what are the second order induced effects on productivity, employment, environment, etc. Despite the fact that additionality is an important condition for public support and a measure of public support's success, the available empirical evidence is not conclusive yet. According to the existing literature, investment support can have either a complementary or a substitutionary effect on firm investment. Some studies find that investment support induces additional investment of supported firms (HARRIS and TRAINOR, 2005; PELLEGRINI and CENTRA, 2006; DUCH et al., 2009; GADD et al., 2009; KIRCHWEGER and KANTELHARDT, 2012; ORTNER, 2012). Other studies do not find positive effects of investment support programmes (BRONZINI and de BLASIO, 2006; Koester and Senior, 2010), implying that the investment support crowds-out of private investments by triggering either intra-firm or inter-firm adjustments in firm investments but with no impact on the overall investment level. Similarly, the job creation effect of capital subsidies is often found to be insignificant (GABE and KRAYBILL, 2002), as the impact on efficiency and productivity is found to be negligible or even negative (BEASON and WEINSTEIN, 1996; LEE, 1996; BAGELLA and BECCHETTI, 1998; BERGSTRÖM, 2000; HARRIS and ROBINSON, 2004; BERNINI and PELLEGRINI, 2011).

Similarly, studies focusing specifically on RDP investment support find mixed evidence. Most studies focus on the second order induced effects of the RDP investment support such as on productivity, profitability, income, employment and financial indicators. Among others, they find positive impact of investment support on and added value, farm profitability, productivity and income level (KIRCHWEGER and KANTELHARDT, 2012; SALVIONI and SCIULLI, 2011; MEDONOS et al., 2012; SPICKA and KRAUSE, 2013), but no impact on labour employment and return on assets and equity

³ Additionality is one of the key principles of the EU funding. Three types of potential additionality can be identified: project-level, programme-level and at MS-level. Although, additionally is a more general concept, in this paper we consider financial additionality at firm level; that is, whether it stimulates investment expenditure at a firm level relative to the situation without the support.

(SALVIONI and SCIULLI, 2011). With the exception of MEDONOS et al. (2012), none of the studies estimate the crowding-out effect of investment support.

From a policy perspective, one of the key targets of investment support depends on the concept of additionality, which means that the EU investment support should add on but not replace the equivalent expenditure undertaken in the absence of the support. Given that the previous evidence about the RDP impact on farm investment is inconclusive, further research is needed in this area, to better understand the investment response of firms and the implications for complementary/substitutionary effect of policy interventions.

The present paper attempts to close this research gap and estimates the extent to which the RDP investment support has a complementary or a substitutionary effect on firm investments. In order to answer this question, we attempt to quantify the potential crowding-out effect by estimating the extent to which the RDP beneficiaries would have undertaken comparable investments also without the RDP support. As a robustness check, we also estimate the impact of the RDP on private off-farm spending (the so called leverage effect), and the inter-firm substitution effects of the RDP investment support, by attempting to account for the potential impact of the support on non-treated farms. Building on recent advances in the counterfactual impact evaluation, in the present paper we employ the difference-in-difference propensity score matching (DID-PSM) approach, which allows us to address several important sources of bias, from which many previous studies suffer. In particular, by employing the DID-PSM estimator we are able to address the selection bias, the simultaneity bias, and the functional form misspecification. We base our empirical analysis on a sample of 1,333 firms from Schleswig-Holstein region (Germany) for the period 2001-2007. Using an improved econometric approach and a balanced panel of firm level data allows us to obtain more precise results, and hence more valuable for policy makers. We find that the crowding-out effect of the RDP is nearly 100%, implying that firms use public support to substitute for private investments. Furthermore, no evidence was found that, due to RDP programme support, firms would have brought forward their investments planned originally in a later period, rejecting the inter-temporal substitution of investments.

FARM INVESTMENT SUPPORT IN THE EU AND IN THE STUDY REGION

The ultimate objective of the RDP is to promote growth, employment, environment, output diversification in rural areas and to reduce disparities vis-à-vis non-agricultural sectors in terms of regional income per capita and rates of employment. The RDP support is not automatically granted to all farms but is subject to a project approval. Only those farms, which submit a project and are selected according the selection criteria, are granted the RDP. This has important implication for our empirical analysis. First, because not all farms receive the RDP, we can build a counterfactual of non-supported farms. Second, a selection bias may emerge, because farms self-select themselves into those who

apply for the RDP, and those who do not. Similarly, the selection procedure may favour certain types of farms. Both selection effects favour more dynamic and productive farms, because the selection criteria include economic viability, adequate occupational skills and competences, and minimum thresholds of supported investment, etc. In addition, beneficiaries need to comply with minimum standards regarding the environment, hygiene and animal welfare (EC, 2006b; KANTOR, 2012).

In general, the RDP support can be grouped into three main areas of rural development: restructuring and competitiveness (representing 38% of the total RDP expenditures); environment and land management (representing 52% of the RDP expenditures); and rural economy and communities (representing 10% of the RDP expenditures) (KANTOR, 2012). In this paper we focus on the RDP granted in the 2000-2006 FPP and we cover the investment support provided under the restructuring and competitiveness measures. The main objective of the investment support is to support investments aiming at improving the economic performance of farms. More specifically, the support aims at promoting investments in farm capital and technology, adding value to agricultural production and improving the quality of agricultural products. Investment support was the third largest item within the 2000-2006 RDP (after agri-environment measure and less favoured area payments), representing 9% of the total expenditures (EC, 2006b; KANTOR, 2012; MICHALEK, 2012).

In Schleswig-Holstein (SH) the investment support for modernisation of agricultural farms was implemented under the Agrarinvestitionsförderungsprogramm (AFP). The main mechanism of the AFP was a subsidy of the commercial interest rate for loans on firm investment (175,000 EUR to 500,000 EUR) carried out in the milk, beef, pork, horticultural and the agro-tourism sectors. The subsidy of the commercial interest rate (approximately 13% of the eligible investment volume) was provided to eligible farms for the period of 10 to 20 years of an average amount of 23,000-30,000 EUR per farm. During the 2000-2006 FPP, the total subsidies provided under the AFP reached approximately 29.7 Million EUR distributed between 1513 farms (for a net investment volume of 250 Million EUR). The largest part of the programme budget (approximately 80%) was provided for farm inventory (buildings) investment support, mainly in the milk and beef sectors. The rest was split up for investment support (including purchases of machinery or investments in alternative sources of energy) among the pork sector, the agro-tourism sector and the horticulture sector. The sub-regions Nordfriesland (NF) and Schleswig-Flensburg (SF) received by far the largest share of the total AFP with most of it being granted to the milk and beef sectors. Specific eligibility criteria, such as investment volume higher than 175,000 EUR, and personal income up to 90,000 EUR per person or 120,000 EUR per couple, excluded the smallest and the largest agricultural farms from this programme (TI, 2008).

TESTABLE HYPOTHESES

Investment support can have either complementary (additional) or substitutionary (crowding-out) effect on firm investment. To identify these effects, one needs to investigate intra-firm and inter-firm adjustments to investment support. Whereas intra-firm adjustments capture channels in investment decision at firm level, inter-firm adjustments reflect changes in investment patterns across firms as, due to general equilibrium effects, investment support may cause a substitution of investments from non-subsidised firms to subsidised firms. The inter-firm substitution results from relocation of investment among firms, i.e. it may cause a crowding-out of investment of non-subsidised firms. The intra-firm substitution reflects changes in investment behaviour within firm, e.g. improved access to financial resources of credit constrained firms, and by inter-temporal relocation of investments.

Intra-firm substitution hypothesis

BRANDSMA et al. (2013) provide a theoretical analysis of *intra-firm* adjustment mechanisms to investment support. According to their theoretical results, the main factors determining the impact of investment support on firm performance are competition on input (and output) markets and market imperfections. Under perfect competition, investment support does not increase firm investment, because the support cannot improve investment opportunities of firms. In this case, public investment support fully substitutes private investment and hence represents a pure income transfer from taxpayers to firms, i.e. private investment is crowded-out by public investment support. In contrast, in imperfectly competitive markets, the support may be complementary to firm investments. For example, if firms are credit constrained, they do not have sufficient financial resources to fully exploit all investment opportunities in the absence of the support. Investment support allows firms to expand investment, and to exploit the otherwise unused profitable investment opportunities.

Empirical evidence for intra-firm adjustment in a static setting is provided e.g. by BARRY and ROBINSON (2001). Due to the nature of production and agriculture specific risks, the agricultural sector is perceived to have significant credit constraints (including in developed countries such as EU and the USA) which potentially may interact with the investment support (BLANCARD et al., 2006; FÄRE et al., 1990). In light of the findings of BRANDSMA et al. (2013), investment support policies will likely increase firm investment in those agricultural markets, which are imperfectly competitive.

BRANDSMA et al. (2013) use a static framework. However, the investment support policies may have a substitutionary effect on investments within firm even in competitive markets, if one considers a dynamic context. According to BERGSTRÖM (2000), investment support may displace private investments due to inter-temporal substitution. I.e., firms may bring forward investments originally planned for the post intervention period. As shown by ABEL (1982), a temporary investment subsidy

gives firms strong incentives to invest during the investment support period (AUERBACH and HINES, 1988; ADDA and COOPER, 2000).

Empirical evidence for intra-firm adjustment in a dynamic setting is provided e.g. by BRONZINI and de BLASIO (2006), who show that inter-temporal substitution considerably affects the pattern of supported firm investment in Italy. They find that a potential effect of investment support may boost investment during the support period, at the cost of reducing investment subsequently. In this case, a positive effect of investment subsidies is not a proof of complementarity effect as, without the support, the same investment may have been undertaken in the following period.

Similarly, CANNARI et al. (2006) find that inter-temporal substitution is significant: 64.2 percent of firms that would have invested less without subsidies reported that they would have invested in the following periods. CANNARI et al. also find that inter-temporal substitution is more important for firms in traditional sectors.

Inter-firm substitution hypothesis

Inter-firm adjustments to investment support occur when a given programme affects (positively or negatively) non-supported firms (DAVID et al. 2000). The inter-firm substitution belongs to an indirect general equilibrium or macro-economic effect, and is defined as the effect occurring in favour of supported firms at the expense of firms that do not participate in a given programme. For example, due to the RDP support, factor prices (e.g. land rents, loan interest rate) may increase, or regional producer prices may decrease, which increases costs or decrease revenues, respectively, of non-treated firms. Subsidised firms may receive some of the investment opportunities that non-subsidised firms would have had in absence of the investment support (HARRIS and TRAINOR, 2005; LEE, 1996).

Empirical evidence of the inter-firm crowding-out of investment support is provided for example by BRONZINI and de BLASIO (2006). Adopting the difference-in-difference estimation approach, they find that the supported firms have increased their investments in detriment of unsubsidised firms. The empirical evidence of capital price increase due to investment support programmes is provided e.g. by GOOLSBEE (1998), who finds that at the aggregate level investment incentives have little impact because, through higher prices, a significant share of programme support leaks to the suppliers of capital. Inter-firm substitution is particularly important when the market is small, and when firms demand similar inputs and supply similar outputs (ROSENTHAL and STRANGE, 2004). BRONZINI and de BLASIO (2006) find that inter-firm substitution is more pronounced for firms located in the same area and competing in the same sector.

ECONOMETRIC APPROACH

Propensity score matching

The causal effect of treatment (investment support) is the difference between the potential outcome (investment level) with treatment, Y_1 , and the potential outcome without treatment, Y_0 : $Y_1 - Y_0$. The expected value of potential outcome without treatment is not directly observed. In most non-experimental settings the estimation of the causal effect of a programme is based on non-treated farms as a control group which. However, this may result in a selection bias, because the selection in or out of the programme is usually not random, implying that means of Y_0 for treated farms ($D=1$) and Y_0 for non-treated farms ($D=0$) may differ systematically, even in the absence of the programme (HECKMAN and ROBB, 1985; HECKMAN, 1997; SMITH, 2000; SMITH and TODD, 2003). The selection bias is particularly relevant for investment support granted under the RDP. First, farms self-select themselves into those who apply for the support. Second, the criteria used in the selection procedure may favour granting the support to certain types of farms. To address the selection bias, we define the average treatment on the treated (ATT) conditional on probability distribution of observed covariates:

$$(1) \text{ ATT}(Z) = E(Y_1 - Y_0 | X = Z, P(Z) = p, D = 1)$$

where X is a set of variables representing the pre-exposure attributes (covariates) of farms, Z is a subset of X representing a set observable covariates, P is a probability distribution of observed covariance Z .

The estimation of the ATT using the matching estimator (HECKMAN and NAVARRO-LOZANO, 2003) may be difficult due to the “curse of dimensionality” of the conditioning problem (ZHAO, 2005; TODD, 2006; BLACK and SMITH, 2004). ROSENBAUM and RUBIN (1983) have shown that the dimensionality of the conditioning problem can be significantly reduced by implementing matching methods through the use of balancing scores $b(Z)$ such as propensity score. For random variables Y and Z and for discrete variable D , the propensity score can be defined as the conditional probability of participating in a programme given pre-programme characteristics, Z : $p(Z) = \Pr(D = 1|Z) = E(D|Z)$. According to ROSENBAUM and RUBIN, if participation in a programme is random conditional on Z , it is also random conditional on $p(Z)$:

$$(2) \ E[D|Y, \Pr(D = 1|Z)] = E[E(D|Y, Z|Y, \Pr(D = 1|Y))]$$

so that $E(D|Y, Z) = E(D|Z) = \Pr(D = 1|Z)$, which implies that $E[D|Y, \Pr(D = 1|Z)] = E[D|\Pr(D = 1|Z)]$, where $\Pr(D = 1|Z)$ is a propensity score. This implies that, when outcomes are *independent of programme participation* conditional on Z , they are also *independent of participation* conditional on the propensity score, $\Pr(D = 1|Z)$. Hence, the conditional independence remains valid, if we use the propensity score $p(Z)$ instead of covariates Z or X .

Estimating a conditional participation probability by employing a parametric method, such as *probit* or *logit*, or *semi-parametrically* reduces dimensionality of the matching problem substantially to one dimension only, i.e. univariate propensity score. An important feature of this method is that after individuals have been matched, the unmatched comparison individuals can be easily separated out and are not directly used in the estimation of programme effects.

The Propensity Score Matching (PSM) estimator for the ATT can be written as:

$$(3) \tau^{PSM} = E[p(Z)|D=1][E(Y_1|D=1, p(Z)) - E(Y_0|D=0, p(Z))]$$

which corresponds to the mean difference in outcomes over the common support, appropriately weighted by the propensity score distribution of treated firms (CALIENDO and KOPEINIG, 2008).

Difference-in-Differences PSM estimator

Whereas the PSM can be applied to control for selection bias on observables at the beginning of the programme, a combination of the PSM with DID methods (conditional DID estimator) allows for controlling of selection bias in both observables and unobservables. The PSM-DID measures the impact of the RDP support by using differences between comparable treated firms ($D=1$) and control group (non-treated) ($D=0$) in the period before, t' , and after, t , the support implementation :

$$(4) \text{PSM - DID} = \left\{ \sum_i [Y_{it}|(D=1) - Y_{it}|(D=0)] - \sum_i [Y_{it'}|(D=1) - Y_{it'}|(D=0)] \right\} / n$$

where $Y_{it}|(D=1) - Y_{it}|(D=0)$ is the difference in mean outcomes between i treated firm and i *matched* non-treated firm *after* the access to the RDP, and $Y_{it'}|(D=1) - Y_{it'}|(D=0)$ is the difference in the mean outcome between i treated firm and i *matched* non-treated firm in *prior* period to the programme implementation.

The PSM-DID estimator thus eliminates differences in the initial conditions (observable heterogeneity) and differences between both groups (treated and non-treated) of firms. The first difference in the PSM-DID estimator, which is the change over time within firms, eliminates the influence of time-invariant unobserved individual heterogeneity. The second difference, between treated farms and control group, eliminates general changes in investments common to all firms (treated and non-treated).

Two-stage approach to estimate the crowding-out effect

The direct applicability of the standard PSM method requires an absence of inter-firm adjustments (or general equilibrium effects) to investment support. In other words, the standard PSM estimates are

only valid under the assumption of *no indirect effects* of a given RDP on non-treated farms. The presence of inter-firm adjustments would bias the estimated crowding-out effect of the support, as non-treated farms (i.e. the control group) might also be affected, thus potentially distorting the performance of the control group relative to a situation without the support. To address this issue, we employ a two-stage approach: (i) first, we estimate inter-firm effects of the investment support, where we check whether non-treated farms are affected by the support; and (ii) second, we estimate the potential crowding-out effect by dropping all programme affected non-supported firms from the sample.

In the first stage, we estimate the *inter-firm effect* by applying the standard PSM estimator, and by comparing the performance of non-treated farms in sub-regions where the intensity of the AFP exposure was high (high probability of positive/negative effects from a given programme, $P=1$) with the performance of comparable non-treated farms in other sub-regions characterised by a very low AFP intensity ($P=0$). The first group of firms in high AFP sub-regions represents those “unintentionally exposed” whereas the second group (in other sub-regions) captures non-affected firms. The obtained differences in performance of both groups (non-treated farms) are statistically tested. As a measure of firm performance we use a set of commonly applied result indicators suggested in European Commission guidelines (i.e. Gross Value Added, employment, profits, etc.) (EC 2006b). A significant difference in the estimated ATT-DID between both groups of farms would indicate the existence of inter-firm adjustments to investment support. Insignificant difference would indicate an absence of inter-firm adjustments to investment support. Given results from the first stage, we correct our sample by excluding non-treated firms found to be affected by the AFP.

In the second stage, i.e. after dropping all non-treated farms affected by the programme, we analyse potential *crowding-out effect* of the AFP. The crowding-out effect is measured by comparing the performance of treated farms vis-à-vis non-affected non-treated farms. Similar as in the first stage, we apply a standard PSM method, whereby a logit function is re-estimated using the same covariates as in Stage 1 but with the adjusted sample. The ATT is estimated before the programme and after the programme using farm asset value as a relevant result indicator measuring the crowding-out effect. It is expected that in the case of zero or small crowding-out effect the asset value of the treated farms would increase significantly stronger compared to the control group,⁴ i.e. differences in the DID-ATT would be significant. In contrast, the presence of crowding-out effect would result in similar differences in the DID-ATT between the treated farms and control group.

⁴ For empirical estimations it is important to identify a control group as similar as possible to treated farms. Yet, some farms (control farms) irrespectively on whether support is provided or not, may not be willing to invest, due to a number of reasons, e.g. lack of farm successor. As the latter factor is usually an unobservable, i.e. cannot be derived from micro data, it would be inappropriate to compare farms which received investment support with *all* those others which did not invest. In order to circumvent this problem we selected into potential control group only those farms which were “willing to invest”, i.e. those which in a given period undertook analogous investment (i.e. modernisation of buildings) yet, at various intensity levels.

RESULTS

Data

The balanced panel we employ in this paper covers seven years (2001-2007)⁵ for the Schleswig-Holstein region in Germany. The choice of the period 2001-2007 is determined by the availability of data, which cover the period at the start of the 2000-2006 programme and one year after (i.e. 2007) the programme.⁶ The main data source is farm bookkeeping data comprised of approximately 10,500 farms for the bookkeeping year 2000/2001 and 3,900 farms for 2007/2008. In addition, for specific comparisons data from the “Testbetriebe” (part of the German FADN (Farm Accountancy Data Network) data set)⁷ are used.

Using information about general- and measure-specific conditions of programme participation, the potentially eligible farms are identified and selected. This group of farms is divided into treated farms and non-treated farms (control group). A balanced panel for both sub-groups is constructed for 2001 and 2007. Given that the main focus of the AFP are milk and beef sectors, 1,333 bookkeeping farms specialising in milk/beef production are selected. The balanced panel we employ in the empirical analysis consists of 101 milk/beef farms supported by the AFP and 1,232 non-treated farms, of which 526 were located in high intensity AFP regions (Nordfriesland and Schleswig-Flensburg), and 706 were located in low intensity AFP regions.⁸

A list of variables that determine both programme participation and outcomes and are included as relevant covariates in the PSM estimator is provided in Table 1.⁹ Following the specific AFP eligibility criteria covering, among others, farm economic viability requirement, size of investment volume, size of personal income, the exclusion of the smallest and the largest agricultural farms from the programme, we follow previous studies (e.g. CIAIAN ET AL, 2012) and include in the econometric model covariates linked to asset value of farm (e.g. value of buildings, machinery, capital stock), heard size (e.g. cattle, slaughter cows, breeding bulls), income and production level (e.g. milk production, profit per farm), input use (e.g. labour, purchased concentrated feed), financial indicators (e.g. equity

⁵ Note that the 2000-2006 refers to the 2000-2006, whereas the period of our analysis is 2001-2007 (see further).

⁶ Given that the RDP support is project-based, the start of granting actual support usually does not correspond with the actual start of the financial period (i.e. 2000), and often is delayed because of the time needed to setup the granting system and to implement the actual selection of the submitted projects.

⁷ The FADN is a European system of farm surveys that take place every year and collects structural and accountancy information on farms. Farms are selected to take part in the survey based on stratified sampling of farms.

⁸ For specification test results see Appendix A1.

⁹ There is not available in the literature a specific rule with respect to which covariates should be selected in the estimation of the PSM function. In general, besides applying economic theory and using empirical evidence, there are three possible strategies for selection of covariates (CALIENDO and KOPEINIG, 2008): (i) hit or miss method (HECKMAN et al., 1997); (ii) statistical significance method; (iii) leave-one out-cross validation (BLACK and SMITH, 2004). In our paper we have followed the empirical evidence on the implementation of AFP to select the covariates. More precisely, the selection of covariates was based on expertise of branch specialists (beef and milk production) by taking into consideration a prerequisite that selected covariates have to simultaneously affect a farm’s decision to participate in programme as well as outcome variables.

capital formation, interest subsidy to investment), and other covariates (e.g. labour productivity). An important variable considered is the level of support obtained from the past RDP (*obtained level of support from the previous programmes*). Inclusion of this variable allows us to increase comparability and to overcome the problem mentioned in many evaluation studies concerning the non-existence of non-treated farms (from the current and previous RDP) in a specific programme area.

Table 1 provides descriptive statistics for the sub-sample of excluded programme affected non-treated farms. According to Table 1, farms have solid capital endowment. For example, the average value of farm buildings represents EUR 69,569 per farm, machinery EUR 28,903 and total capital EUR 650,984. On the other hand, the labour intensity per farm is relatively high. On average farms use 1.68 units of labour (family or/and hired labour) while the maximum represents only 6 persons per farm. The average yearly revenue of beef/cattle/milk related sales represents EUR 179,776 per farm. The number of milk cows per farm varies between 2 and 223 heads and the number of suckler cows between 0 and 50 heads. Besides adult cows, farms have also other type of livestock categories varying between 0 and 170 heads. The agricultural area of farms varies between 19 and 393 hectares. The average profitability per farm is EUR 43,888.

Inter-firm substitution effects

As mentioned above, to estimate the inter-firm effects, we exploit information of non-treated farms located in high and low AFP intensity sub-regions. The intensity of the AFP was the highest in two neighbouring sub-regions of Schleswig-Holstein: NF and SF (TI, 2008). We expect that the probability of positive/negative indirect inter-firm programme impact on non-treated farms would also be the highest in these two sub-regions. Should this be the case, the economic performance of non-treated farms in NF and SF regions can be therefore described as a result of a “non-intended selection into programme” implemented in a given region. We measure the economic performance of farms using the following variables: profit per farm, economic corrected profit,¹⁰ milk production, corrected profit per person fully employed, corrected profit per family labour, standard profit per fully employed, and standard profit per family labour.

Estimates of the first-stage analysis are presented in Table 2. The estimated results show that profits per farm among programme *non-treated farms* located in regions with low AFP intensity increased by EUR +41,371 between 2001 and 2007, whereas in the group of matched non-treated farms in high AFP intensity regions it increased by EUR +37,824 (Table 2). The DID-ATT estimates suggest a slight deterioration in the economic performance of those farms, which did not receive

¹⁰ Expression “corrected” is specific to the variable “profit per farm”. Corrected/adjusted profit per farm means current profits corrected for specific revenues and expenses linked to other periods (current profits minus specific revenues generated in other periods plus specific costs related to other periods). Corrected profits include also adjustment for taxes and other payments pre-paid or received in relation to other periods.

programme support, but were located in a close neighbourhood of those who received support, i.e. through a reduction of profit by EUR -3,547 (-3%) per farm on average. A similar negative general equilibrium effect of the AFP affecting non-treated farms located in high AFP regions was found also for other variables: corrected profit, milk production, corrected profit per person fully employed, corrected profit per family labour, standard profit per fully employed, and standard profit per family labour.

The negative inter-firm effects on the economic performance of farms could have occurred due to several factors. One possible explanation is that agricultural farms, which were directly supported by the AFP, considerably increased their demand for specific inputs, e.g. land (pastures or arable land), thus leading to an increase in input (e.g. land) prices. Indeed, while the lease price for agricultural land remained at the same level in regions where the AFP support was very intensive, the land price dropped by 7.3% in regions with low AFP intensity or where the programme was not implemented. Other possible channel, through which the AFP may have affected non-treated farms, is by crowding-out their funding opportunities (e.g. bank loans). First, funds available on the market may relocate from non-treated farms to treated farms. Second, when the crowding-out effect of support is high, the support may stimulate treated farms' private spending on off-farm assets (leverage effects), and under certain conditions increase price of those assets for non-treated farms. Both effects may reduce non-treated farms investment activity (either on- or off-farm), thus leading to a lower performance. Other factors, which potentially may cause inter-firm substitution effects, could be due to an increase of labour costs, milk price changes¹¹ and increase in prices of dairy-specific equipment and machinery triggered by a fiercer competition on regional/local markets.

As a robustness check and to identify the role of potential spill-over effects, we have also estimated the inter-firm effect of investment on the value of non-treated farm assets: (i) value of commercial farm buildings, and (ii) value of farm machinery. The results of this robustness check fully confirm previous results of a negative impact of the AFP on non-supported farms located in a close neighbourhood of supported farms. The value of commercial farm buildings has decreased in non-treated farms between 2001 and 2007 (i.e. because the gross investments in farm buildings were lower than depreciation, the net value of buildings decreased). However, the value of commercial farm buildings in the group of non-treated farms located in a close neighbourhood of highly supported farms decreased much stronger (-5,465 EUR/farm) than in the matched group of non-treated farms located in regions where the AFP intensity was low (-3,747 EUR/farm). Similarly, the AFP impact on the value of farm machinery was negative. Although, between 2001 and 2007 the value of farm machinery in both groups of farms increased significantly (net investments were positive and substantial), in the group of non-treated farms located in regions with high AFP intensity, the increase

¹¹ The perishability of milk, the need to maintain strict sanitary control and the relatively high transportation costs of fluid milk leads to regional differentiated adjustments of milk prices.

of investments in farm machinery was much lower (+9,536 EUR/farm or 39%) compared to investment in non-treated farms located in regions where intensity of AFP was low (+11,877 EUR/farm or 45%). These results confirm that a negative impact of the AFP on profits of farms located in regions with high AFP intensity also reduced the willingness to undertake additional investments in farm assets (farm buildings and machinery).

Although, the investment support programme could have also induced some positive effects, e.g. leading to positive knowledge spillover effects and to an increase in attractiveness and competitiveness of the region as a whole, our results show that such effects were minimal or almost zero. All major micro-economic performance indicators have deteriorated for farms which were *not* supported by the programme (non-treated farms) located in high-support regions compared with indicators of matched non-treated farms located low-support regions.

These results provide empirical evidence of inter-firm crowding-out effect of investment support. Although, the support may improve performance of treated farms, it has a negative impact on non-treated farms. A second conclusion of these results is that the direct estimation of the crowding-out effect is biased, if we do not control for the affected firms in the counterfactual non-treated group.

Crowding-out effect

Results from the previous section suggest considerable inter-firm substitution effects, which would yield biased estimates of crowding-out effects when using the full sample. In order to eliminate this bias, all programme non-treated farms (control group) located in regions with high programme intensity, i.e. NF and SF, were dropped from further analysis. The adjusted panel consists of 244 farms,¹² 83 of which were treated farms and 161 non-treated farms (control group). For comparison purposes, we also include results for the full sample (376 farms). This will allow us to quantify the potential underestimation of the crowding-out effect when not controlling for the bias. We estimate the crowding-out effect using variable farm assets as, according to the theoretical literature (TI, 2008), any change in farm assets should be a result of investment undertaken by a farm; i.e. an increase in the asset value implies that the depreciation and sales are lower than the investment level, whereas a decrease in the assets implies the reverse.

According to the results reported in Table 3, there is a substantial crowding-out effect linked to farm assets of the AFP implemented in Schleswig-Holstein.¹³ For the full sample, where we do not control for inter-firm substitution effect, the value of farm assets in the matched (control) group of non-treated farms increased by 86% compared with the base year (prior to the programme). At the

¹² Due to dropping of programme non-treated farms located in regions with the highest programme intensity from the data base, i.e. regions NF and S-F, and those farms where modernisation of farm buildings did not take place, only 161 non-treated (control) farms were left to re-estimate crowding-out effects.

¹³ For specification test results see Appendix A2.

same time, the value of farm assets in the group of programme treated farms increased by 92%, implying that the estimated crowding-out effects were as high as 82% (the ratio of 60,552 EUR/73,487 EUR).

When controlling for the inter-firm substitution effect, the crowding-out effect increases to 99% (or the ratio of 71,939 EUR/72,329 EUR). In the control group of the matched non-treated farms, the value of farm assets increased over-proportionally by 71,939 EUR (i.e. by 126.8%), compared to the group of treated farms (72,329 EUR; +93.2%). This implies that, due to prevailing economic conditions affecting the performance of all milk producers, similar investments in the examined period would have been undertaken also without the AFP support. These results also suggest that, if we would not have controlled for the bias, the crowding-out effect would be underestimated by around 17 percent.

Theoretical expectations imply that the crowding-out effect may occur either in the absence of any market imperfections or due to inter-temporal substitution of investments. The presence of crowding-out effect may imply that farms in the Schleswig-Holstein region do not face significant market imperfections, such as credit constrain. Our results support the hypothesis that farms are able to undertake all profitable investment opportunities also without the RDP, as they do not significantly increase their investment level, when policy support becomes available. Our findings are consistent with MEDONOS et al. (2012), who also find a significant evidence of crowding-out effect of investment support among Czech farms.

Further, given that we cover a seven year period, farms may have changed the timing of investments within the study period. To comply with programme requirements and application procedure, farms may have shifted forward or backward investment *within* the study period. However, due to insufficient number of observations, we cannot directly control for time variation of investments and hence quantify this effect. On the other hand, our results do not support the hypothesis that farms inter-temporally substitute investments beyond the study period (i.e. after 2007). To have a shift in investments from the post-study period to the study period, we would need to observe an increase in treated farms' investments relative to non-treated farms investments over the study period. As reported in Table 3, the assets of non-treated farms increased by 126.8% over the period of 2001-2007, whereas for treated farms the increase in asset value was 93.2%, rejecting the hypothesis of inter-temporal investment substitution.

Overall, our results imply that distortions in the agricultural capital markets are minimal and, de facto, the AFP investment support represents an income transfer to farms. As discussed in the next section, an indirect consequence of the support is an increase in off-farm related spending.

Robustness tests

To check the robustness of the crowding-out effect, we estimate the leverage effect, which occurs when public funding induces off-farm spending of treated farms. Overall, the support should be reflected either as an increase in farm assets or as a change in other farm household expenditures which are not linked to farm activities. Thus, the leverage effect is an indirect test of the crowding-out effect, because in its presence the AFP is diverted from farm investments to off-farm investments and private consumption. It can be expected that in the case of significant crowding-out effect, the leverage effect would be positive and significant. Given the fact that we found a significant crowding-out effect, we expect that the AFP would have a substantial impact on private off-farm spending.

We use three indicators to measure private off-farm spending: (i) money transfer from farm to farm households for living expenses, (ii) money transfers from farm to building of private non-farm assets and (iii) total money transfers from farm to farm household (i.e. total leverage effect). As above, for comparison purposes we also include the results for the full sample and for the subsample, where we control for the inter-firm effect bias.

The results reported in Table 4, Table 5 and Table 6 indicate considerable leverage effects.¹⁴ For the full sample, the AFP brought about significant transfers to farm households. On average, additional money transfers from farm to farm households for living expenses for treated farms increased by EUR +4,653 (12.8%) (Table 4) compared to control group; for building of private non-farm assets to EUR +3,178 (9.4%) (Table 5), while additional total money transfers from farms to farm households increased by EUR +14,550 (19.9%) (Table 6). These results suggest that the propensity to consume among farms that received support from the AFP was much higher compared to control group.

As expected, the results, which are based on a reduction of the bias originating from inter-firm substitution effects, show that the AFP has a slightly higher leverage effect compared to former outcomes, in particular, for money transfers from farm to building of private non-farm assets and total money transfers from farm to farm households. Indeed, the AFP was found to substantially induce private off-farm spending among programme treated farms, i.e. participation in the AFP led to: (i) an increase in money transfers from farm to farm household for living expenses compared to non-treated control group by approximately +4,659 EUR (13.2%) per farm (Table 4); (ii) an increase in money transfers from farm to farm household for building of private non-farm assets by approximately +9,526 EUR (27.7%) per farm (Table 5); and (iii) an increase in the total money transfer from farms to farm households by approximately +22,702 EUR (27.0%) (Table 6). These results confirm the presence of the crowding-out effect of the AFP implemented in Schleswig-Holstein. The AFP

¹⁴ For specification test results see Appendix A3.

significantly increases off-farm household spending boosted by resources freed from the substitution of on-farm private investments with the public support.¹⁵

Sensitivity analysis

Due to unobserved variables, which simultaneously affect both the assignment to treatment and outcome, a hidden bias may arise. Unobservable heterogeneity can substantially affect the estimated results of programme effects. While the propensity score matching assumes conditional independencies to exclude the problem of unobservable heterogeneity, the unconfoundedness assumption holds even when two units with the same values for observed characteristics differ in their treatment choices (treated or non-treated farms). The difference in their choices may be driven by differences in the unobserved characteristics that themselves are unrelated to the outcomes of interest (IMBENS, 2003). Yet, if there are unobserved variables that simultaneously affect the assignment into the programme and the outcome variable, a hidden bias might arise to which matching estimators are not robust (ROSENBAUM, 2002; CALIENDO and KOPEINIG, 2008).

In our paper the possibility of hidden bias is addressed by conducting sensitivity analysis by employing the bounding approach proposed by ROSENBAUM (2002). It allows to determine how much hidden bias would need to be present to render plausible null hypothesis of no effect or, in another words, how strongly an unmeasured variable must influence the selection process in order to undermine the implications of matching analysis (CALIENDO and KOPEINIG, 2008). Hence, the bounding approach does not test the unconfoundedness assumption itself, because this would amount to testing that there are no (unobserved) variables that influence the selection into the programme, but instead, this approach provides evidence about the degree to which any significant results hinge on this untestable assumption. We perform sensitivity analysis using the MANTEL and HAENSZEL (1959) test statistics as proposed by AAKVIK (2001).

We also conduct other sensitivity analysis to test the stability of the obtained results. With respect to the specification of the propensity score, the number of selected companies, changes in covariates, changes in parameters of balancing properties, etc. Given a standardised set of variables describing the characteristics of agricultural enterprises, one of the most important sensitivity tests was to find the minimal/optimal set of conditional variables to be included in the estimations.

¹⁵ To further check the robustness of the results we have estimated the leverage effects for the same group of farms that was included in the computation of crowding-out effects (i.e. the sub-sample of only those farms who were willing to invest and excluding programme affected non-treated farms as reported in Table 3). The results show that (ii) additional money transfers from farm to farm households for living expenses increased by EUR 2,575 EUR compared to control farms; for (ii) for building of private non-farm assets decreases by -6,253 EUR; and (iii) the total leverage effect increased by 5,291 EUR. Apparently treated farms in comparison to similar control farms, who were also willing to invest, did not have a preference for transfers from farm aiming at increasing private non-farm assets (negative value) yet, transfers to farm household for living expenses were positive (+2,575 EUR) and also the total leverage effect was strongly positive (+5,291 EUR).

We perform sensitivity analysis using the Rosenbaum bounding approach methodology as described above. The sensitivity analysis results suggest that the estimated AFP effects are rather sensitive to hidden bias (Table 7). A presence of a hidden bias of the magnitude of 5-10%, i.e. increasing the odds ratio from 1 to 1.05-1.10, would make the obtained results statistically insignificant. This relatively high sensitivity of the obtained results could have been caused by a relatively small number of observations used in these tests (99 matched pairs). Yet, the sensitivity tests provide only additional information regarding effects' stability, but do not question the overall validity of the obtained results.

POLICY IMPLICATIONS

Our results have important policy implications. One of the key priorities of the EU agricultural policy, as outlined in the European Commission's strategic document for the future CAP, 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 rural areas (EC, 2010). Farmers' investment, especially during the financial crisis, may play a prominent role in achieving some of these policy objectives.

Our results indicate that the investment support does not necessary stimulate farm investments and hence it does not promote productivity growth in rural areas. Second, our estimates indicate that the support indirectly improves non-farm related expenditures of farm households boosted by resources freed from the substitution of on-farm private investments with the public support. These results suggest that granting policy support in form of a lump-sum transfer would induce the same effect as the investment support. Given that from the implementation point of view the investment support is more expensive than a lump-sum transfer (CAHILL and MOREDDU, 2005), the later instrument may be preferred from the social welfare perspective.

Despite the comprehensiveness of our analysis, one should interpret the results with care, as several factors prevent us from generalising our findings to other regions. Given the specific region considered in the paper, our results cannot be straightforwardly extended to other regions and countries. The economic conditions and credit access of farms vary strongly between EU regions, which likely would cause heterogeneous effects of the investment support depending on the economic context. Further, our analysis covers the period before the financial crises. The credit-tightening accompanying the financial crisis reduced access to capital of private sector and thus it may have changed the investment behaviour of farms and potentially altering also the actual impact of farm investment support. In the presence of tighter credit markets, the investment support may have improved creditworthiness of supported farms which may have improved their access to capital thus

leading to higher investment levels relative to non-supported farms. In such macro-economic context, the estimated policy effects may have been different and further research is necessary to be carried out to answer these policy-relevant questions.

CONCLUSIONS

The main objective of this paper is to estimate the extent to which the EU RDP investment support has complementary or substitutionary effect on firm investments. In order to answer this question, we attempt to quantify the potential crowding-out effect by estimating the extent to which the RDP beneficiaries would have undertaken comparable investments also without the RDP support. As a robustness check, we also estimate the impact of the RDP on private off-farm spending (the so called leverage effect), and inter-firm substitution effects of the RDP investment support, attempting to account for a possible impact on non-treated farms.

In the empirical analyses we employ the difference-in-difference propensity score matching (DID-PSM) approach, which allows us to address several important sources of bias, from which many previous studies suffer. In particular, by employing the PSM estimator we are able to address the selection bias, the simultaneity bias, and functional form misspecification. Estimation of a crowding-out effect is performed on the basis of the DID-PSM approach in 2-stages by correcting for the inter-firm substitution effect, i.e. by dropping the programme affected non-treated firms from the sample. We base our estimation on a sample of 1,333 farms from Schleswig-Holstein region (Germany) for the period 2001-2007.

We find that the crowding-out effect of the RDP on farm investment is nearly 100%, implying that firm investment would have been undertaken also without the RDP support. According to the theoretical hypothesis, these results suggest that farms in Schleswig-Holstein are likely not to be credit constrained, and hence do not significantly increase their investment level, when investment support becomes available. In contrast, the RDP investment support represents an income transfer to farm households by significantly increasing private off-farm spending. Further, given that we cover a seven year period from 2001 to 2007, farms may have brought forward their investments. However, our results do not support the inter-temporal investment substitution hypothesis. These results are new, as the crowding-out effect has not been studied in the context of the RDP in Germany before. However, given the specific region of the empirical analysis, our results cannot be straightforwardly generalised to other regions in the EU. Further, our results indirectly imply that the high level of the estimated crowding-out effect is likely due to the fact that farms do not face significant credit constraints. However, in order to confirm this hypothesis, the interaction between credit, investment and policy support uptake would need to be investigated in-depth. These issues are promising avenues for future research.

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Table 1: List of covariates and descriptive statistics*

	Mean	Standard deviation	Min	Max
Value of fixed assets – buildings	69569.17	54548.06	0	631047.6
Operating facilities (value)	15595.69	18551.79	0	210755
Machinery (value)	28903.34	23102.65	0	185988.7
Cattle (value)	97013.16	41118.18	18590	377486.8
Inventory stock	76.67037	1567.524	0	50538.2
Capital stock (value)	650983.8	357672.4	0	3004102
Revenues beef/cattle/milk sales	179775.6	82240.91	21198.5	629046.9
Purchased concentrated feed for cattle	-25978.03	17395.87	-136908.6	0
Labour costs (total)	-5298.846	7781.244	-92259.44	0
Milk yield (per cow)	6789.374	1318.223	2630.01	10706.05
Fem. Calves > 0.5 year	14.22281	9.804195	0	73
Fem. Calves > 0.5 and < 1 year	18.69167	11.48515	0	115
Fem. Cattle > 1 and < 2 years	30.44636	15.21116	0	170
Breeding Heifer	17.99775	12.05994	0	97
Heifer	0.288072	2.047371	0	47
Milk cows	61.4171	25.91619	2	223
Suckler cows	0.3068267	2.578426	0	50
Slaughter cows	2.317329	5.441662	0	67
Male calves > 0.5	12.35709	11.68178	0	96
Male cattle > 0.5 and < 1 year	15.40285	14.8271	0	106
Male cattle > 1 and < 1.5 years	12.47787	15.04769	0	141
Male cattle > 1.5 and < 2 years	4.443361	8.604375	0	67
Male cattle > 2 years	0.5288822	4.093148	0	121
Breeding bulls	0.603901	0.7878868	0	8
Pasture area	43.24649	24.67204	0	202.57
Agricultural area (total)	84.42382	36.27911	18.97	393.59
Non-family labour	0.1529407	0.4041605	0	4
Labour total	1.678342	0.6727812	0.29	6
Milk production	419767.3	201117.9	15371.42	1624277
Excess milk quota	14808.38	30720.74	0	306254
Equity capital formation	132903.1	110220.2	-39965.83	1685936
Adjusted costs of labour employed	-4004.219	7523.779	-89808.26	846.99
Labour productivity (cattle/beef/milk per total labour)	114804.2	53714.13	13475.11	578509.6
Labour productivity (milk per total labour)	2654.599	1265.577	298.8889	13103.33
Farm profit	43888.28	28660.5	-74043.2	173640.8
Adjusted equity capital formation	3412.253	51986.09	-199468.8	1127032
Profit per farm (adjusted)	29795.8	34509.47	-461853.8	172493
Earnings from self-employment	76.90959	903.787	0	23337.49
Earnings from non-self-employment	425.3179	2801.125	0	37425.55
Obtained level of support from previous programmes	8290.527	9950.762	0	86916.73

Note: *The descriptive statistics is for the whole sample, i.e. the number of observations for all variables is 1,333.

Table 2: Inter-firm substitution effect: the impact of the AFP on farm profits

	No. of observations	DID (change in 2007 relative to 2001)	
		EUR	%
Unmatched ($P=1$)	526	38,354	83
Unmatched ($P=0$)	706	42,503	105
Matched ($M=1$)	517	37,824	82
Matched ($M=0$)	677	41,371	85
ATT		-3,546	-3

Notes: $P=0$: unmatched non-treated farms located in regions with low AFP intensity; $P=1$: unmatched non-treated farms located in high AFP intensity regions, $M=0$: matched non-treated farms located in regions with low AFP intensity; $M=1$: matched non-treated farms located in high AFP intensity regions

Table 3: Crowding-out effect of the AFP on farm assets

	Full sample		Sub-sample with excluded programme affected non-treated farms	
	No. of observations	DID (change in 2007 relative to 2001)	No. of observations	DID (change in 2007 relative to 2001)
		EUR (%)		EUR (%)
Unmatched treated farms ($P=1$)	83	73,487	83	73,487
Unmatched control group ($P=0$)	293	51,160	161	55,658
Matched treated farms ($M=1$)	83	73,487 (+92%)	78	72,329 (+93.2%)
Matched control group ($M=0$)	263	60,552 (+86%)	155	71,939 (+126.8%)
ATT (crowding-out effect)		93%		100%

Notes: $P=0$: unmatched control group; $P=1$: unmatched treated group, $M=0$: matched control group; $M=1$: matched treated group.

Table 4: Leverage effects of the AFP to farm household living expenses

	Full sample			Sub-sample with excluded programme affected non-treated farms		
	No. of observations	DID (change in 2007 relative to 2001)		No. of observations	DID (change in 2007 relative to 2001)	
		EUR	%		EUR	%
Unmatched treated farms ($P=1$)	101	13,738	45.7	101	13,738	45.7
Unmatched control group ($P=0$)	1,232	7,824	31.9	706	7,956	32.1
Matched treated farms ($M=1$)	101	13,738	45.7	99	13,869	45.8
Matched control group ($M=0$)	1,067	9,085	32.9	662	9,209	32.5
ATT		4,653	12.8		4,659	13.2

Notes: $P=0$: unmatched control group; $P=1$: unmatched treated group, $M=0$: matched control group; $M=1$: matched treated group.

Table 5: Leverage effects of the AFP to building of private non-farm assets

	Full sample			Sub-sample with excluded programme affected non-treated farms		
	No. of observations	DID (change in 2007 relative to 2001)		No. of observations	DID (change in 2007 relative to 2001)	
		EUR	%		EUR	%
Unmatched treated farms ($P=1$)	101	29,855	161.8	101	29,855	161.8
Unmatched control group ($P=0$)	1,232	20,294	174.5	706	16,483	143.5
Matched treated farms ($M= 1$)	101	29,855	161.8	99	29,307	158.1
Matched control group ($M= 0$)	1,067	26,677	152.4	662	19,782	130.4
ATT		3,178	9.4		9,526	27.7

Notes: $P=0$: unmatched control group; $P=1$: unmatched treated group, $M=0$: matched control group; $M=1$: matched treated group.

Table 6: Total leverage effect of the AFP

	Full sample			Sub-sample with excluded programme affected non-treated farms		
	No. of observations	DID (change in 2007 relative to 2001)		No. of observations	DID (change in 2007 relative to 2001)	
		EUR	%		EUR	%
Unmatched treated farms ($P=1$)	101	62,471	82.8	101	62,471	82.8
Unmatched control group ($P=0$)	1,232	38,100	62.1	706	32,829	53.6
Matched treated farms ($M= 1$)	101	62,471	82.8	99	62,413	82.6
Matched control group ($M= 0$)	1,067	47,919	62.9	662	39,711	55.6
ATT		14,550	19.9		22,702	27.0

Notes: $P=0$: unmatched control group; $P=1$: unmatched treated group, $M=0$: matched control group; $M=1$: matched treated group.

Table 7: Rosenbaum bounds test results (2007, N = 99 matched pairs)

Gamma*	Significance level		Hodges-Lehmann point estimate		Confidence interval (95%)	
	Upper bound	Lower bound	Upper bound	Lower bound	Upper bound	Lower bound
1	0.070	0.070	38,324	38,324	-12,676	100,171
1.05	0.103	0.046	32,668	45,248	-16,715	105,753
1.1	0.143	0.029	26,536	50,671	-23,047	111,138
1.15	0.191	0.019	20,495	56,805	-28,464	118,174
1.2	0.244	0.012	15,767	63,807	-32,436	123,938
1.25	0.302	0.007	11,304	69,335	-36,879	129,455
1.3	0.362	0.004	7,545	74,079	-42,561	135,367
1.35	0.424	0.003	4,107	78,951	-47,675	140,823
1.4	0.485	0.002	838	83,388	-51,330	146,999
1.45	0.545	0.001	-3,442	87,392	-55,648	151,453
1.5	0.601	0.001	-7,665	91,733	-59,844	156,474
2	0.932	0.000	-35,916	128,711	-94,189	207,359
2.05	0.945	0.000	-38,845	131,215	-98,107	212,718
2.2	0.971	0.000	-48,007	141,362	-105,729	226,869
2.5	0.993	0.000	-62,006	158,358	-117,343	246,818
2.55	0.995	0.000	-65,351	161,662	-119,505	249,272
2.95	0.999	0.000	-79,928	183,363	-134,223	277,348
3	0.999	0.000	-81,039	187,673	-137,031	280,889

Note: * Gamma = log odds of differential assignment due to unobserved factors

Appendix A1: Specification test results

Estimation of a logit function

After cleaning the data base (by dropping from the set of potential control those agricultural farms which were found to be affected by the AFP) logit function was estimated using 807 observations on bookkeeping farms (Schleswig-Holstein) specialised in milk production, of which 101 were treated farms and 706 programme non-treated farms. The list of variables (40) is provided in Table 1.

Table A1-1: Results of a logit function estimation

	Coef.	Std. err.	z	P> z	[95% conf. interval]	
Value of fixed assets – buildings	2.02E-06	2.35E-06	0.86	0.39	-2.59E-06	6.63E-06
Operating facilities (value)	-4.51E-06	7.51E-06	-0.6	0.548	-0.0000192	0.0000102
Machinery (value)	-0.0000268	7.17E-06	-3.74	0	-0.0000408	-0.0000127
Cattle (value)	1.97E-06	0.0000146	0.13	0.893	-0.0000267	0.0000306
Inventory stock	0.0000383	0.0000487	0.79	0.432	-0.0000572	0.0001338
Capital stock (value)	-2.54E-07	3.65E-07	-0.69	0.488	-9.70E-07	4.63E-07
Revenues beef/cattle/milk sales	6.66E-06	9.42E-06	0.71	0.48	-0.0000118	0.0000251
Purchased concentrated feed for cattle	0.0000454	0.0000106	4.28	0	0.0000246	0.0000662
Labour costs (total)	0.0001077	0.0004719	0.23	0.819	-0.0008171	0.0010326
Milk yield (per cow)	-0.0000613	0.0002764	-0.22	0.825	-0.000603	0.0004805
Fem. Calves > 0.5 year	0.0186913	0.0178942	1.04	0.296	-0.0163807	0.0537632
Fem. Calves > 0.5 and < 1 year	0.0118835	0.0167657	0.71	0.478	-0.0209766	0.0447436
Fem. Cattle > 1 and < 2 years	-0.0121226	0.0153492	-0.79	0.43	-0.0422064	0.0179613
Breeding Heifer	-0.0060769	0.0137317	-0.44	0.658	-0.0329905	0.0208366
Heifer	-0.0134439	0.0618279	-0.22	0.828	-0.1346243	0.1077365
Milk cows	-0.0613138	0.0338315	-1.81	0.07	-0.1276224	0.0049947
Suckler cows	-0.016113	0.0720671	-0.22	0.823	-0.1573618	0.1251358
Slaughter cows	-0.0048062	0.0287148	-0.17	0.867	-0.0610862	0.0514739
Male calves > 0.5	0.0121035	0.0156262	0.77	0.439	-0.0185234	0.0427303
Male cattle > 0.5 and < 1 year	0.0165394	0.0131412	1.26	0.208	-0.0092169	0.0422956
Male cattle > 1 and < 1.5 years	0.014429	0.013428	1.07	0.283	-0.0118895	0.0407475
Male cattle > 1.5 and < 2 years	0.0051632	0.0197474	0.26	0.794	-0.0335411	0.0438675
Male cattle > 2 years	-0.285279	0.3196748	-0.89	0.372	-0.9118302	0.3412722
Breeding bulls	0.1216614	0.1539543	0.79	0.429	-0.1800836	0.4234063
Pasture area	0.0072186	0.0068231	1.06	0.29	-0.0061544	0.0205916
Agricultural area (total)	0.0050058	0.0079983	0.63	0.531	-0.0106706	0.0206822
Non-family labour	-0.581429	0.4297761	-1.35	0.176	-1.423775	0.2609166
Labour total	0.3884432	0.3904466	0.99	0.32	-0.376818	1.153704
Milk production	7.79E-06	5.58E-06	1.4	0.163	-3.15E-06	0.0000187
Excess milk quota	1.93E-06	3.32E-06	0.58	0.562	-4.59E-06	8.44E-06
Equity capital formation	8.19E-07	1.47E-06	0.56	0.577	-2.06E-06	3.70E-06
Adjusted costs of labour employed	-0.0001288	0.0004732	-0.27	0.786	-0.0010563	0.0007987
Labour productivity (cattle/beef/milk per total labour)	-3.84E-06	0.0000143	-0.27	0.787	-0.0000318	0.0000241
Labour productivity (milk per total labour)	0.0005672	0.0006534	0.87	0.385	-0.0007134	0.0018478
Farm profit	-4.90E-06	8.59E-06	-0.57	0.568	-0.0000217	0.0000119
Adjusted equity capital formation	2.55E-07	2.98E-06	0.09	0.932	-5.58E-06	6.09E-06
Profit per farm (adjusted)	1.37E-06	5.39E-06	0.25	0.8	-9.20E-06	0.0000119
Earnings from self-employment	-0.0005951	0.0013484	-0.44	0.659	-0.0032378	0.0020476

Earnings from non-self-employment	0.0000249	0.000037	0.67	0.5	-0.0000476	0.0000975
Obtained level of support from previous programmes	-1.32E-06	0.0000126	-0.1	0.917	-0.0000261	0.0000234
Constant	-3.443257	2.004407	-1.72	0.086	-7.371823	0.4853098

Note: estimations in this table are based on a sub-sample which excludes programme affected non-treated farms.

In the next step results of a logit function estimation were used to derive for all agricultural farms specialised in milk production their individual probability (propensity scores) of participation in the AFP measure.

Selection of a matching algorithm

As the quality of a given matching algorithm depends strongly on a data set, the selection of a relevant matching technique was carried out using three independent criteria: i) standardised bias (ROSENBAUM and RUBIN, 1985); ii) t-test (ROSENBAUM and RUBIN, 1985); and iii) joint significance and pseudo R² (SIANESI, 2004).

Similar to the cases of other assessments of programme impact we found that the best results were achieved by using an iterative procedure (e.g. linear search) aimed at minimisation of the calculated standardised bias¹⁶ (after matching) and applying *min[*min*]* as the main selection criterion. In all considered cases (various matching algorithms)¹⁷ an optimal solution could easily be found due to local/global convexity of the objective function with respect to function parameters under each matching algorithm (e.g. radius magnitude in radius matching; or number of nearest neighbours in nearest neighbour matching). An overview of results obtained using different matching algorithms for the case of re-estimation of effects of the AFP in Schleswig-Holstein is provided in Table A1-2.

Table A1-2: Selection of a matching algorithm

Matching method	Matching parameters	Estimated standardised bias (after matching)
Nearest neighbours	N (8)	4.30
	N (9)	3.90
	N (10)	4.02
Caliper	(0.08)	3.76
	(0.07)	Selected (min) => 3.70
	(0.06)	3.95
Kernel normal	bw (0.03)	4.22
	bw (0.04)	3.99
	bw (0.05)	4.13
Kernel biweight		4.65
Kernel epanechnikov	bw (0.11)	3.92
	bw (0.09)	3.76
	bw (0.08)	3.89

¹⁶ The standardised bias is the difference of the sample means in the treated and non-treated (full or matched) sub-samples as a percentage of the square root of the average of the sample variances in the treated and non-treated groups (ROSENBAUM and RUBIN, 1985).

¹⁷ This does not apply to local linear weighting function matching which first smoothes out the outcome and then performs nearest neighbour matching. In this case more controls are used to calculate the counterfactual outcome than the nearest neighbour only (LEUVEN and SIANESI, 2009).

The lowest estimated standardised bias (after matching) was found in the case of caliper matching (0.07). This matching algorithm was therefore used in the further work for assessment of the effect of the AFP on direct treated farms¹⁸.

The application of the above procedure and common support restrictions resulted in dropping 46 farms (2 treated and 44 non-treated farms) from further analysis, thus selecting *comparable* 761 farms of which: 99 were treated and 662 were non-treated farms (Table A1-3).

Table A1-3: Overview of the matched sample

Treatment	Common support		Total
	Off support	On support	
Non-treated	44	662	706
Treated	2	99	101
Total	46	761	807

Verification of the balancing property of matched variables

One of the important criteria applied for the assessment of the matching's quality can be the comparison of mean values of relevant covariates in both groups of farms (treated farms vs control group) before and after matching (using the selected matching algorithm). It is expected that application of the selected matching algorithm (here: caliper matching 0.07) will lead to a considerable reduction of original differences in mean values of each individual variable included as a covariate in the logit function, between treated and control farms.

The comparison of mean values for all variables included as covariates in the estimated logit function in both groups of farms before and after matching is presented in Table A1-4. The results show that for almost all variables (except for the variables: number of breeding heifers, non-family labour and earnings from non-self-employment) the selected matching procedure resulted in a significant reduction of differences in variables' means among both groups of farms, i.e. treated farms vs. controls thus making both groups of farms much more comparable. Furthermore, after the implementation of above matching procedure the estimated standardised selection bias could be reduced from 25.6 (before matching) to 3.70 (after matching), i.e. it dropped by 86%. At the same time pseudo R² decreased as expected, i.e. dropped from 0.201 to 0.119 respectively, i.e. by 41%.

¹⁸ The caliper matching algorithm (0.07) was also found to perform satisfactory concerning other important Selection criteria, i.e. balancing property and pseudo R² tests.

Table A1-4: Balancing property tests

Variable-Name	Sample	Treated	Control	% bias	% reduction bias	t-test	
						t	p> t
Long-term assets – buildings	Unmatched	78645	64423	26.4		2.33	0.020
	Matched	77665	77949	-0.5	98	-0.03	0.974
Operating facilities (value)	Unmatched	17355	16524	4.4		0.40	0.691
	Matched	17400	17474	-0.4	91.1	-0.03	0.977
Machinery (value)	Unmatched	28285	32066	-16.3		-1.44	0.150
	Matched	28410	28297	0.5	97	0.04	0.970
Cattle (value)	Unmatched	1.10E+05	93309	43.7		4.27	0.000
	Matched	1.10E+05	1.10E+05	4.8	89	0.33	0.744
Inventory stock	Unmatched	174.12	93.661	4.3		0.39	0.700
	Matched	177.64	115.81	3.3	23.2	0.21	0.834
Capital stock (value)	Unmatched	6.80E+05	6.60E+05	5.9		0.55	0.584
	Matched	6.80E+05	6.70E+05	2.8	52.3	0.20	0.844
Revenues beef/cattle/milk sales	Unmatched	2.30E+05	1.70E+05	63.7		6.39	0.000
	Matched	2.20E+05	2.20E+05	6.3	90.1	0.42	0.675
Purchased concentrated feed for cattle	Unmatched	-29362	-26278	-16		-1.70	0.090
	Matched	-29955	-30484	2.7	82.9	0.18	0.856
Labour costs (total)	Unmatched	-6808.1	-5562.6	-14.9		-1.39	0.164
	Matched	-6815.2	-6229.6	-7	53	-0.51	0.613
Milk yield (per cow)	Unmatched	7351.9	6572	64		5.67	0.000
	Matched	7340.2	7283.7	4.6	92.8	0.33	0.744
Fem. Calves > 0.5 year	Unmatched	17.089	13.544	35.7		3.38	0.001
	Matched	16.929	16.114	8.2	77	0.53	0.594
Fem. Calves > 0.5 and < 1 year	Unmatched	21.911	19.007	25.4		2.35	0.019
	Matched	21.788	21.116	5.9	76.9	0.42	0.678
Fem. Cattle > 1 and < 2 years	Unmatched	35.119	30.305	32.9		3.04	0.002
	Matched	35.03	33.67	9.3	71.7	0.65	0.519
Breeding Heifer	Unmatched	19.218	19.221	0		-0.00	0.998
	Matched	19.222	19.545	-2.6	-10189.4	-0.17	0.863
Heifer	Unmatched	0.18812	0.30028	-6.4		-0.48	0.631
	Matched	0.19192	0.15312	2.2	65.4	0.20	0.841
Milk cows	Unmatched	71.861	61.584	38.6		3.63	0.000
	Matched	71.404	70.437	3.6	90.6	0.25	0.806
Suckler cows	Unmatched	0.13861	0.25212	-6.8		-0.53	0.599
	Matched	0.14141	0.12746	0.8	87.7	0.07	0.941
Slaughter cows	Unmatched	2.4158	1.5312	20.9		2.00	0.045
	Matched	2.4646	2.2616	4.8	77	0.30	0.764
Male calves > 0.5	Unmatched	14.762	10.374	41.7		3.78	0.000
	Matched	14.525	14.631	-1	97.6	-0.06	0.952
Male cattle > 0.5 and < 1 year	Unmatched	19.465	13.006	44.7		4.20	0.000
	Matched	19.364	20.036	-4.7	89.6	-0.27	0.789
Male cattle > 1 and < 1.5 years	Unmatched	16.04	9.7578	43.3		4.20	0.000
	Matched	15.818	15.918	-0.7	98.4	-0.04	0.969
Male cattle > 1.5 and < 2 years	Unmatched	4.6337	2.6785	26.3		2.68	0.008
	Matched	4.5556	4.4296	1.7	93.6	0.10	0.923
Male cattle > 2 years	Unmatched	0.05941	0.2762	-15.4		-1.10	0.270
	Matched	0.0404	0.04363	-0.2	98.5	-0.08	0.936
Breeding bulls	Unmatched	0.63366	0.61331	2.4		0.24	0.814
	Matched	0.60606	0.60544	0.1	96.9	0.01	0.996
Pasture area (ha)	Unmatched	48.231	39.04	36.1		3.78	0.000
	Matched	47.908	45.685	8.7	75.8	0.59	0.554
Agricultural area (total) (ha)	Unmatched	94.335	83.954	26.9		2.69	0.007
	Matched	93.834	92.596	3.2	88.1	0.23	0.819
Non-family labour	Unmatched	0.17337	0.18493	-2.5		-0.24	0.810
	Matched	0.17586	0.14761	6.2	-144.3	0.47	0.637
Labour total	Unmatched	1.7463	1.7426	0.5		0.05	0.961
	Matched	1.7523	1.7325	2.7	-429.2	0.19	0.850
Milk production	Unmatched	5.30E+05	4.10E+05	59		5.83	0.000
	Matched	5.30E+05	5.10E+05	5.9	90.1	0.39	0.697
Excess milk quota	Unmatched	22801	15735	20.8		1.93	0.054
	Matched	23064	20533	7.4	64.2	0.48	0.634
Equity capital formation	Unmatched	1.60E+05	1.30E+05	23.5		2.08	0.038
	Matched	1.60E+05	1.50E+05	5.4	77.1	0.40	0.691
Adjusted costs of labour employed	Unmatched	-5374.4	-4303	-13.2		-1.24	0.216
	Matched	-5387.1	-4827.3	-6.9	47.8	-0.50	0.618
Labour productivity (cattle/beef / milk per total labour)	Unmatched	1.40E+05	1.10E+05	69.6		6.80	0.000
	Matched	1.40E+05	1.40E+05	0.5	99.2	0.03	0.977
Labour productivity (milk per total labour)	Unmatched	3303	2487.6	64.8		6.21	0.000
	Matched	3266.7	3255.9	0.9	98.7	0.05	0.961
Farm profit	Unmatched	54629	40518	48.8		4.65	0.000
	Matched	54634	52293	8.1	83.4	0.53	0.594
Adjusted equity capital formation	Unmatched	4818	2168.3	5.6		0.42	0.674
	Matched	4847.6	6284	-3	45.8	-0.24	0.808
Profit per farm (adjusted)	Unmatched	35728	23889	35.3		2.97	0.003
	Matched	35855	34159	5.1	85.7	0.36	0.722
Earnings from self-employment	Unmatched	9.8107	93.767	-10.2		-0.73	0.467
	Matched	10.009	11.991	-0.2	97.6	-0.18	0.858
Earnings from non-self-employment	Unmatched	466.01	534.24	-2.3		-0.20	0.845
	Matched	475	389.37	2.9	-25.5	0.22	0.827
Obtained level of support from previous programmes	Unmatched	9340	8685.3	5.8		0.55	0.583
	Matched	9206.3	8954.3	2.2	61.5	0.16	0.871

Note: estimations in this table are based on a sub-sample which excludes programme affected non-treated farms.

Appendix A2: Specification test results of the crowding-out effect

Given the previously calculated individual propensity scores for treated farms and control group, and after imposing restrictions on the common support region, a new relevant matching technique was selected (a truncated data base consisted of 244 observations of which 83 observations were on treated farms and 161 on non-treated farms), according to three independent criteria: i) standardised bias (ROSENBAUM and RUBIN, 1985); ii) t-test (ROSENBAUM and RUBIN, 1985); and iii) joint significance and pseudo R² (SIANESI, 2004). As a result, a kernel (normal kernel, b.w. 0.08) was found to be the “best” matching technique and was selected for calculation of the crowding-out effect effects of the AFP.

The comparison of mean values for all variables included as covariates in the estimated logit function in both groups of farms before and after matching is presented in Table A2-1. The results show that for almost all variables (except for the number of breeding heifers and total labour) the selected matching procedure resulted in a significant reduction of differences in variables’ means among both groups of farms, i.e. treated farms *versus* controls thus making both groups of farms much more comparable.

Table A2-1: Balancing property tests (crowding-out effect)

Variable-Name	Sample	Treated	Control	% bias	% reduction bias	t-test	
						t	p> t
Long-term assets – buildings	Unmatched	80059	51608	57.2		4.26	0.000
	Matched	77609	56705	42	26.5	2.51	0.013
Operating facilities (value)	Unmatched	16750	17352	-3.5		-0.25	0.800
	Matched	16952	17281	-1.9	45.3	-0.12	0.906
Machinery (value)	Unmatched	27561	35370	-36.9		-2.61	0.010
	Matched	27622	32227	-21.8	41	-1.34	0.182
Cattle (value)	Unmatched	1.10E+05	1.00E+05	23.1		1.74	0.083
	Matched	1.10E+05	1.10E+05	-7.8	66.1	-0.47	0.638
Inventory stock	Unmatched	211.8	0	15.5		1.40	0.164
	Matched	225.4	0	16.5	-6.4	1.00	0.320
Capital stock (value)	Unmatched	6.70E+05	6.20E+05	14		1.01	0.316
	Matched	6.60E+05	6.40E+05	4.4	68.6	0.28	0.782
Revenues beef/cattle/milk sales	Unmatched	2.20E+05	1.90E+05	37		2.81	0.005
	Matched	2.20E+05	2.20E+05	-6.3	83	-0.39	0.700
Purchased concentrated feed for cattle	Unmatched	-29142	-28927	-1.1		-0.09	0.931
	Matched	-30490	-31376	4.6	-313.5	0.29	0.776
Labour costs (total)	Unmatched	-6428.1	-5904.8	-6		-0.42	0.672
	Matched	-6232.8	-6232.2	0	99.9	-0.00	1.000
Milk yield (per cow)	Unmatched	7330.4	6846.9	38.4		2.77	0.006
	Matched	7244.4	7231.2	1.1	97.3	0.07	0.945
Fem. Calves > 0.5 year	Unmatched	17.181	14.012	31.2		2.33	0.021
	Matched	16.59	17.002	-4.1	87	-0.22	0.824
Fem. Calves > 0.5 and < 1 year	Unmatched	21.855	20.205	14.1		1.05	0.293
	Matched	21.372	21.056	2.7	80.9	0.17	0.867
Fem. Cattle > 1 and < 2 years	Unmatched	35.096	32.168	19.5		1.44	0.152
	Matched	34.385	33.672	4.7	75.7	0.30	0.767
Breeding Heifer	Unmatched	19.06	20.919	-14.2		-1.06	0.289
	Matched	19.205	21.536	-17.9	-25.4	-1.06	0.289
Heifer	Unmatched	0.22892	0.13043	12.1		0.94	0.347
	Matched	0.24359	0.07922	20.2	-66.9	1.31	0.193
Milk cows	Unmatched	71.096	64.745	23.6		1.76	0.079
	Matched	69.859	70.878	-3.8	84	-0.23	0.820
Suckler cows	Unmatched	0.16867	0.39752	-9.5		-0.63	0.529
	Matched	0.17949	0.2351	-2.3	75.7	-0.17	0.865
Slaughter cows	Unmatched	2.3253	1.4472	21.4		1.63	0.104

	Matched	2.2179	2.2264	-0.2	99	-0.01	0.990
Male calves > 0.5	Unmatched	14.735	11.708	26.8		1.91	0.058
	Matched	14.218	15.16	-8.3	68.9	-0.43	0.667
Male cattle > 0.5 and < 1 year	Unmatched	19.542	13.969	38.1		2.78	0.006
	Matched	19.359	18.654	4.8	87.3	0.25	0.805
Male cattle > 1 and < 1.5 years	Unmatched	16.06	11.143	30.4		2.19	0.029
	Matched	15.821	16.31	-3	90	-0.14	0.887
Male cattle > 1.5 and < 2 years	Unmatched	4.506	3.1615	18.3		1.35	0.177
	Matched	4.3974	4.686	-3.9	78.5	-0.22	0.826
Male cattle > 2 years	Unmatched	0.06024	0.34161	-14.1		-0.91	0.365
	Matched	0.03846	0.04948	-0.6	96.1	-0.26	0.798
Breeding bulls	Unmatched	0.61446	0.58385	3.7		0.28	0.779
	Matched	0.58974	0.57852	1.3	63.3	0.08	0.933
Pasture area (ha)	Unmatched	49.093	40.81	29.9		2.28	0.023
	Matched	48.201	44.891	11.9	60	0.75	0.456
Agricultural area (total) (ha)	Unmatched	93.311	89.865	9.2		0.69	0.490
	Matched	91.975	94.859	-7.7	16.3	-0.50	0.617
Non-family labour	Unmatched	0.15614	0.20634	-11.2		-0.79	0.429
	Matched	0.13923	0.18349	-9.9	11.8	-0.70	0.484
Labour total	Unmatched	1.6827	1.7401	-8.3		-0.62	0.539
	Matched	1.6683	1.785	-16.9	-103.1	-1.04	0.299
Milk production	Unmatched	5.20E+05	4.50E+05	36.4		2.75	0.006
	Matched	5.10E+05	5.10E+05	-2.5	93.3	-0.15	0.879
Excess milk quota	Unmatched	23110	18986	10.7		0.75	0.453
	Matched	21233	21270	-0.1	99.1	-0.01	0.995
Equity capital formation	Unmatched	1.60E+05	1.50E+05	7		0.49	0.627
	Matched	1.50E+05	1.40E+05	8.3	-18.3	0.71	0.479
Adjusted costs of labour employed	Unmatched	-5010.7	-4587.9	-5		-0.35	0.725
	Matched	-4834.9	-4826.6	-0.1	98	-0.01	0.995
Labour productivity (cattle/beef / milk per total labour)	Unmatched	1.40E+05	1.20E+05	49		3.77	0.000
	Matched	1.40E+05	1.30E+05	11.8	76.4	0.69	0.492
Labour productivity (milk per total labour)	Unmatched	3339.9	2746.1	47.6		3.56	0.000
	Matched	3269.4	3113.7	12.5	73.8	0.72	0.473
Farm profit	Unmatched	53271	44302	28.9		2.10	0.037
	Matched	50921	51098	-0.6	98	-0.04	0.971
Adjusted equity capital formation	Unmatched	5701.7	11245	-7.3		-0.48	0.632
	Matched	6079.4	5885	0.3	96.5	0.04	0.972
Profit per farm (adjusted)	Unmatched	34517	25450	28.9		2.07	0.040
	Matched	32722	32037	2.2	92.4	0.14	0.889
Earnings from self-employment	Unmatched	11.938	14.915	-3.1		-0.23	0.820
	Matched	12.704	11.316	1.5	53.4	0.10	0.919
Earnings from non-self-employment	Unmatched	540.52	758.7	-5.9		-0.41	0.683
	Matched	574.63	535.55	1.1	82.1	0.07	0.942
Obtained level of support from previous programmes	Unmatched	9207.8	8598	5.4		0.41	0.685
	Matched	9007.9	8587.9	3.7	31.1	0.23	0.817