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FIRM-LEVEL EVIDENCE OF DEADWEIGHT LOSS OF INVESTMENT SUPPORT POLICIES: A CASE STUDY OF DAIRY FARMS IN SCHLESWIG-HOLSTEIN[1]

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ABSTRACT

The main objective of the present study is to estimate the extent to which the RDP investment support has a complementary or a substitutionary effect on farm investments. In order to answer this question, we attempt to quantify the potential deadweight loss by estimating the extent to which the RDP beneficiaries would have undertaken comparable investments also without the investment support. We find that the deadweight loss of the RDP is close to 100%, implying that firm investment would have been undertaken also without the support. These results suggest that capital market distortions are not significant in Schleswig-Holstein. Similarly, no evidence was found that, due to programme support, farms would have brought forward their investments planned originally in a later period, suggesting no evidence of inter-temporal substitution of investments. These results are new, as the deadweight loss and its conditionality have not been studied in the context of the RDP in Germany before.

Keywords: Rural development policies, investment subsidy, crowding out, substitution effects, additionality, subsidy leverage, deadweight loss, propensity score matching.

[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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1 INTRODUCTION

Investment support to farms is one of the main measures within the Rural Development Programme (RDP) and an essential component of the productivity enhancing strategy within the Common Agricultural Policy in the EU. As part of the RDP, more than 11 billion Euro (representing 11.5 percent of the total RDP budget) have been spent for supporting farm investment in the current financial programming period (FPP) 2007-2013. The RDP investment support grants are used to support private investment for improving farm productivity and competiveness, e.g. through innovation and adaption of new technologies (European Commission 2012). One of the key objectives of the EU investment support is to promote investments that otherwise would not have been undertaken, which in the EU policy implementation guidelines (European Commission 2006) is referred to as the principle of additionality.

A key question related to public support in general, and to the EU investment support in particular, is the extent to which the public support actually stimulates private investment, and what are the second order induced effects on productivity, employment, environment, etc. Investment support can have either a complementary or a substitutionary effect on firm investment. In the former case, investment support policies would increase the total farm investment compared to no policy support scenario. Several studies find that investment support induces additional investment of supported firms (Harris and Trainor 2005; Pellegrini and Centra 2006; Duch, Montolio and Mediavilla 2009; Gadd, Hansson and Månsson 2009). In the latter case, investment support would trigger either intra-firm or inter-firm adjustments in firm investment behaviour but with no impact on the overall investment behaviour. Indeed, several studies do not find positive effects (Bronzini and de Blasio, 2006; Koester and Senior, 2010). Similarly, the job creation effect of capital subsidies is found to be insignificant (Gabe and Kraybill, 2002), and 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). Thus, 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.

The main objective of the present paper is to estimate the extent to which the RDP investment support has a complementary or a substitutionary effect on farm investments. In order to answer this question, we attempt to quantify the potential deadweight loss 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, attempting to account for the potential impact of the support on non-beneficiaries.

In the empirical analyses we employ the propensity score matching (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. We base our estimation on a sample of 1333 farms from Schleswig-Holstein region (Germany) for the period 2001-2008.

We find that the deadweight loss of the RDP on farm investment is around 100%, implying that firm investment would have been undertaken also without the support. According to the theoretical hypothesis, these results suggest that farms in Schleswig-Holstein are not credit constrained, and hence do not significantly increase their investment level, when investment support becomes available. These results imply that credit market distortions are not significant. 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 7 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 deadweight loss has not been studied in the context of the RDP in Germany before.

2 FIRM-LEVEL INVESTMENT SUPPORT

2.1 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 represents the second pillar support measures within the CAP. The RDP grants are not automatically granted to all farms but are subject to a project approval. Only those farms, which submit a project and are selected according the selection criteria (including additionality), 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.

The RDP support can be regrouped 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 the present study, we focus on the restructuring and competitiveness measures of the RDP, provided for investment support, the main objective of which is to support investments aiming at improving the economic performance of farms. Investment support was the third largest item within the 2000-2006 FPP (after agri-environment measure and less favoured area payments), representing 9% of the total expenditures (Kantor 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 on an average amount of 23 000-30 000 EUR/farm. During the years 2000-2006, the total subsidies provided under the AFP reached approximately 29.7 Mill EUR distributed between 1513 farms (net investment volume of 250 Mill 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. 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.

2.2 RDP investment support in the literature

The sizable amount of firm level investment support has generated large interest between policy makers and researchers. Kirchweger and Kantelhardt (2012) apply the PSM estimator to estimate the effects from the agricultural investment support programme in Austria on the farm income. Their results suggest that farm income of treated dairy farms increases by about 1,200 Euros compared to the control group.

Ortner (2012) estimate the effects of investment support measures in Austria. Using farm-level data, and PSM and DID estimators, they estimate the impact of farm modernisation (measure M121), diversification (excluding bio-energy projects, measure M311b), and small and medium enterprises (SMEs, measure M312). They find that due to its positive effect on Gross Value Added, investment support renders private investments profitable.

Ratinger et al (2012) estimate the economic and other effects of the measure 121 “Modernisation of Agricultural Holdings” of the RDP 2007-2013 on the Czech farms. Employing the PSM estimator they attempt to assess what would have happened if the supported producers did not participate in the programme and then comparing the result indicators? The quantitative analysis of programme effects is complemented by a qualitative survey on 20 farms, which received the investment support between 2008 and 2010. The quantitative assessment showed significant benefits of the investment support in terms of business expansion and productivity improvements. They also find a significant deadweight loss of the RDP support. However, since it does not take into account post accession restructuring of the sector and multiannual and multi-enterprise character of investment at the farm level, these latter results may be incomplete.

Salvioni and Sciulli (2011) use a conditional difference-in-difference PSM estimator, and a balanced panel for 2003-2007 drawn from the FADN Italian sample to evaluate the impact at the farm level of the implementation of the first Italian RDP. They find that, on average, farms receiving at least some RDP increased the employment of family labour, while they did not increase the total labour on-farm employment. In addition, they experienced an increase in labour profitability and in added value, even though the estimate significance varies across alternative matching methods. Their findings suggest that the implementation of the RDP in Italy produced a positive direct impact on rural GDP, while it did not prove to be effective in terms of rural employment growth.

As noted above, from a policy perspective, one of the key targets of investment support is the concept of additionality. The principle of additionality means that the EU investment support should add on but not replace the equivalent expenditure undertaken in the absence of the support. However, the previous evidence about the RDP impact on farm investment is inconclusive, and 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. Therefore, we start with a theoretical analysis, which allows us to better interpret, structure and understand the empirical results.

3 THEORETICAL HYPOTHESIS

Investment support can have either a complementary or a substitutionary effect on firm investment. To identify the additionality effect, one needs to investigate intra-firm and inter-firm adjustments to investment support. Whereas intra-firm adjustments capture adjustments 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 intra-firm substitution reflects changes in investment behaviour within firm, which might be caused by interaction of support with firms' access to financial resources (e.g. credit constraint), and by inter-temporal relocation of investments. 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.

3.1 Intra-firm substitution of investment support

Brandsma, Kancs and Ciaian (2013) provide a theoretical analysis of intra-firm adjustment to investment support. According to their theoretical results, the main factors determining the impact of investment support on farm performance are the level of competition and market imperfections. Under perfect competition, investment support does not increase firm's investments, because the support cannot improve investment opportunities of firms. The public investment support fully substitutes private investment and hence represents a pure income transfer from taxpayers to firms, i.e. public investment support results in a deadweight loss; firms undertake the same level of investments with and without the 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. The investment support allows firms to expand investment, and to exploit the otherwise unused profitable investment opportunities. The results of Brandsma, Kancs and Ciaian (2013) suggest that investment support policies will more likely increase firm investment in imperfectly competitive markets. Due to the nature of production and agriculture specific risks, the agricultural sector is perceived to have significant credit problems (Barry and Robison 2001). Studies show that this may also be the case in developed countries such as EU and the USA (Blancard et al. 2006; Lee and Chambers 1986; Färe, Grosskopf, and Lee 1990).

Brandsma, Kancs and Ciaian (2013) use a static framework. However, the investment support policies may have substitutionary effect on investments within firm even in perfectly 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 and Adda and Cooper 2000). Bronzini and de Blasio (2006) 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 would have been undertaken in the following period. Similalry, Cannari, D'Aurizio and de Blasio (2006) find that inter-temporal substitution is significant: 64.2 percent of firms that would have invested less without subsidies declared that they would have invested in the following periods. Cannari, D'Aurizio and de Blasio also find that inter-temporal substitution is more important for firms in traditional sectors.

3.2 Inter-firm substitution of investment support

Inter-firm adjustments to investment support occur when a given programme affects (positively or negatively) also others than the supported farms. The inter-firm effect belongs to the indirect general equilibrium or macro-economic effects, and is defined as the effect occurring in favour of supported farms at the expense of farms 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, by crowding out non-participants. 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 and Lee 1996). Empirical evidence of inter-firm crowding out of investment support is provided e.g. by Bronzini and de Blasio (2006). Adopting the difference-in-difference estimation approach, they find that the supported firms have substantially increased their investments compared to firms, whose applications have been rejected.

Firm-level investment support may affect both regional input, factor and output prices. The empirical evidence of capital price increase due to investment support programmes is provided e.g. by Goolsbee (1998), who finds that 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 that inter-firm substitution is more pronounced for firms located in the same area and competing in the same sector.

4 ECONOMETRIC APPROACH

4.1 Propensity score matching

The impact of investment support is the causal effect of the support ('treatment') on an outcome variable of interest ('investment'). For each individual farm there is a potential outcome with treatment, denoted Y_1, and another potential outcome without treatment, denoted Y_0. The treatment causal effect of the support is the difference between these two quantities: $Y_1 - Y_0$. A common empirical application of the treatment effect consists of estimating the average impact of programme participation on farms that participated in the programme, the average treatment on the treated (ATT):

(1) $ATT = E(Y_1 - Y_0 | D = 1) = E(Y_1 | D = 1) - E(Y_0 | D = 1)$

where *D* is a binary variable (0-1) and indicates whether farm *i* participated (*D*=1), or did not participate (*D*=0) in the programme.

The ATT captures the effect of programme on participants (Heckman and Robb, 1985; Heckman, 1997; Smith, 2000; Smith and Todd, 2003). Although, the ATT is generally applicable to provide answers about support effects on firms that participated in the programme, the empirical estimation of the ATT is not straightforward. While $E(Y_1| D =1)$ can be easily identified from the data on programme participants, the expected value of potential outcome in case of non-participation, $E(Y_0|D =1)$, i.e. the counterfactual mean in outcome of those who participated in the programme, cannot be directly observed. For this reason, one has to choose a substitute for the unobservable $E(Y_0|D =1)$ in order to estimate the ATT.

One could use the non-participants directly as an adequate control group:

(2) $E(Y_1 | D = 1) = E(Y_0 | D = 0)$

However, condition (2) is likely to hold only in randomised experiments (Caliendo and Hujer, 2005). In most of non-experimental studies the estimation of the ATT using the differences in outcome means of programme participants and non-participants results in a selection bias. The selection bias arises because the means of Y_0 for programme participants (*D*=1) and Y_0 for non-participants (*D*=0) may differ systematically, even in the absence of the programme. The selection bias is particularly relevant for investment support granted under the RDP programme. Farms self-select themselves into those who apply for the support, as well as criteria used in the selection procedure may favour granting the support to certain types of farms.

The ATT can also be defined conditional on *P*(*Z*):

(3) $ATT(Z) = E(Y_1 - Y_0 | X = Z, P(Z) = p, D = 1)$

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.* Given that (1) and (3) are equivalent, the latter formulation will be used for calculating the effects of the RDP support.

The most suitable method used for estimation is the matching estimator (Heckman and Navarro-Lozano, 2004). Matching of comparable farms may be difficult, if the set of conditioning variables *Z* is large, due to the "curse of dimensionality**"** (problem of empty cells) of the conditioning problem (Zhao, 2005; Todd, 2006; Black and Smith, 2004): [2] as the number of observable characteristics in the group of programme participants increases linearly, the number of necessary observations in the control group increases exponentially. Moreover, matching on all the covariates using a

[2] For example with just 20 binary covariates there are 2^{20} covariate patterns (1.04 mill possibilities).

distance measure, which effectively regards all interactions among the *X* covariates as equally important, is not efficient (Gu and Rosenbaum, 1993; Rubin and Thomas, 1996).

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*), i.e. functions of the relevant observed covariates, *Z*, such that the conditional distribution of *Z* independent of the assignment into treatment. One possible balancing score is the propensity score, i.e. the probability of participating in a programme given observed characteristics *Z*.

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*:

(4) $p(Z) = \Pr(D = 1|Z) = E(D|Z)$

According to Rosenbaum and Rubin (1983), if participation in a programme is random conditional on *Z*, it is also random conditional on *p*(*Z*):

(5) $E\left[D|Y, \Pr(D = 1|Z)\right] = E\left[E(D|Y, Z|Y, \Pr(D = 1|Y)\right]$

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*.

According to Winship and Morgan, (1999), the propensity score contains all the information needed to create a balanced evaluation design. Estimating a conditional participation probability by employing a parametric method, such as *probit* or *logit*, or *semi-parametrically*, (which converges faster than the non-parametric), reduces the dimensionality of the matching problem substantially to one dimension only, i.e. the univariate propensity score. An important feature of this method is that after the individuals have been matched, the unmatched comparison individuals can easily be 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:

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

which corresponds to the mean difference in outcomes over the common support, appropriately weighted by the propensity score distribution of programme participants (Caliendo and Kopeinig, 2005).

4.2 Difference-in-Differences PSM estimator

While the PSM can be applied to control for selection bias on observables at the beginning of the programme, a combination of PSM with DID methods (conditional DID estimator) allows for a better controlling of selection bias in both observables and unobservables. The combined PSM and DID method serves as a feasible estimator in cases, where the outcome data on programme participants and non-participants are available for both "before" and "after" periods (*t*′ and *t*, respectively). The PSM-DID measures the impact of the RDP support by using differences between comparable to each other programme participants (*D*=1) and non-participants (*D*=0) before and after the support. The observed changes over time for the matched (using PSM) programme non-participants are assumed to be appropriate counterfactual for programme participants.

In general, the PSM-DID estimator can be described as:

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

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

Compared to a conventional DID estimator, the PSM-DID estimator eliminates differences in initial conditions (observable heterogeneity) of both groups (programme participants and non-participants) that could influence subsequent changes over time.[3] In the present study, we expect that application of the PSM-DID estimator to measurement of the RDP support would improve the estimation results compared to a standard PSM estimator (e.g. for estimation of the ATT) that uses only the post-intervention data.

4.3 Two-stage approach to estimate the deadweight loss

While the PSM-DID method is particularly useful for estimation of the RDP effects at farm level, the applicability of a standard PSM method (based on estimation of a logit function) necessitates an assumption regarding the absence of inter-firm adjustments (or general equilibrium effects) to investment support. In other words, the standard PSM estimates are only valid under an assumption of *no indirect effects* of a given RDP on non-supported farms. The presence of inter-firm adjustments would bias the deadweight effects of the support, as non-beneficiaries (i.e. a control group) might also be affected, thus potentially showing a different performance relative to a situation without the support.

To overcome this problem, we employ a two-stage approach. First, we perform a regional analysis in order to check whether non-beneficiaries are affected by the support by estimating inter-firm effects of the investment support at the level of non-supported farms. As a measure of farm performance we use a set of commonly applied result indicators suggested in EC guidelines (i.e. Gross Value Added, employment, profits, etc.). Second, we analyse and test a potential deadweight loss by comparing the supported and non-supported firms, and by dropping the programme affected non-supported farms from the sample.

We start by estimating inter-firm effects of programme *non-beneficiaries* by applying a standard PSM estimator, and by comparing the performance of *non-supported* farms in 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-supported* farms in other regions characterised by a very low AFP intensity (*P*=0). The first group of farms in high AFP regions represents those "unintentionally exposed" whereas the second group (in other regions) captures non-affected farms. The obtained differences in performance of both groups (non-beneficiaries) are statistically tested. A significant difference in the estimated ATT-DID between both groups of *non-supported* farms would indicate the existence of inter-firm adjustments to investment support.

[3] A similar methodology was used by Ravallion, 2004.

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-supported farms found to be affected by the AFP.

At the second stage, i.e. after dropping all non-beneficiary farms affected by the programme, we analyse potential deadweight loss from the AFP. The deadweight loss is measured by comparing the performance of supported farms vis-à-vis non affected non supported farms. At stage-2 a standard PSM method is applied, whereby a logit function using the same covariates as in Stage 1 is re-estimated based on a new (corrected) number of observations (i.e. after cleaning the database by dropping from the dataset of potential controls those indirectly affected by the AFP). The ATT is estimated before the programme (*t'*) and after the programme (*t*), using farm asset value as relevant result indicator measuring the deadweight effect. It is expected that in the case of zero or small deadweight loss, the result indicator, e.g. asset value of the supported farms would increase much stronger compared to the control groups, [4] i.e. the differences in DID-ATT would be significant. In contrast, the presence of deadweight loss would result in similar differences in DID-ATT between the supported and non-supported farms.

According to our knowledge, in other empirical studies which applied PSM method for estimation of investment support effects (see section 2.2.), the possible general equilibrium effects have not been accounted for. This may have lead to additional bias in empirical results presented so far.

5 RESULTS

5.1 Data

The balanced panel we employ in this study covers 7 years (2001-2007) for the Schleswig-Holstein region in Germany. The choice of the period 2001-2007 was determined by the availability of data and in order to cover the period at the start of the 2000-2006 RDP (i.e. 2001) and one years after (i.e. 2007) the programme.[5] 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 approximately 400 datasets from “Testbetriebe” (part of the FADN data set) are used.

Using information about the general- and measure-specific conditions of programme participation, the potentially eligible farms are identified and selected from the available data set. This group of

[4] In the empirical work it is important to identify control group as similar as possible to supported farms. Yet, some farms (programme non-participants) 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- bookkeeping 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. Subsequently, the value of fixed assets (buildings) per farm (in EUR) was used as an appropriate result indicator of deadweight loss effects.

[5] 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 at country and/or regional level and the actual selection of the submitted projects.

farms is divided into supported farms and non-supported farms. 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, 1333 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 1232 non-supported farms, of which 526 were located in high AFP regions (Nordfriesland (NF) and Schleswig-Flensburg (SF)), and 705 were located in other ("non-affected") regions.[6]

5.2 Inter-firm substitution effects

In order to estimate the inter-firm effects we exploit information of non-beneficiaries. As the intensity of the AFP was the highest in two neighbouring sub-regions of Schleswig-Holstein (i.e. NF and SF), we expect that in these two regions the probability of positive/negative indirect inter-firm impact of the programme on non-beneficiaries was also the highest compared to other sub-regions. The economic performance of non-participants 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 profit per farm, economic corrected profit, milk production, corrected profit per person fully employed (AK), corrected profit per family labour, standard profit per fully employed, and standard profit per family labour.

The estimated results show that profits per farm among programme *non-beneficiaries* located in regions with low AFP intensity increased by EUR +41,371 between 2001 and 2007, whereas in the group of matched farms (non-beneficiaries) in high AFP regions it increased by (EUR +37,824 (Table 1). The estimated substitution effects suggest a slight deterioration in the economic performance of farms, which did not receive programme support (programme non-beneficiaries), 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. Similar negative substitution effects of the AFP affecting non-programme participants located in high AFP regions were found also for corrected profit, milk production, corrected profit per person fully employed (AK), 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 many 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 leasing price for agricultural land remained at the same level in the regions where support from the AFP was very intensive, it dropped by 7.3% in those regions, where the programme was not implemented or the intensity of the AFP implementation was low[7]. Other possible channel, through which the AFP may have affected non-beneficiaries, is crowding out of funding opportunities (e.g. bank loans). First, funds available on the market may relocate from non-beneficiaries to beneficiaries' investments. Second, when the deadweight effect of support is high, the support may stimulate beneficiaries' private spending on off-farm assets (leverage effects), and under certain conditions increase price of those assets for non-beneficiaries. Both effects may reduce non-beneficiaries investment activity (either farm or off-farm), thus leading to a lower performance.

[6] For specification test results see Appendix A1.

[7] Obviously, the AFP lead to an increase of economic capacities of these farms that could later afford to pay a higher rental or sale price for land.

These results provide empirical evidence of inter-firm crowding out effects of investment support. Although, the support may improve performance of beneficiaries, it has a negative impact on non-beneficiaries, implying that the overall effect of the AFP is ambiguous. A second important implication of the results is that the estimation of the deadweight effects could be biased, if we would not control for affected firms in the counterfactual non-beneficiary group.

5.3 Deadweight loss

Results from the previous section suggest considerable inter-firm substitution effects, which would yield biased estimates of deadweight effects using the full sample. In order to eliminate this bias, all programme non-beneficiaries located in regions with high programme intensity, i.e. NF and SF were dropped from further analysis, and the AFP effects were re-estimated. The adjusted panel consists of 244 farms,[8] 83 of which were programme beneficiaries and 161 non-beneficiaries. For comparison purposes, we also include results for the full sample (376 farms). This will allow us to quantify the underestimation because of the deadweight effect, when not controlling for the bias. We estimate the deadweight effect using variable farm assets as, according to the theoretical literature, any change in farm assets should be a result of investment undertaken by farm.

According to the results reported in Table 2, there is a substantial deadweight loss linked to farm assets of the AFP implemented in Schleswig-Holstein.[9] 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-beneficiaries increased by 86% compared with the base year (prior to the programme). At the same time, the value of farm assets in the group of programme beneficiaries increased by 92%, implying that the estimated deadweight effects were as high as 82% (the ratio of 60,552 EUR/73,487 EUR).

When controlling for the inter-firm substitution effect, the deadweight effects increase to 99% (or the ratio of 71,939 EUR/72,329 EUR). In the control group of the matched programme non-beneficiaries, the value of farm assets increased over-proportionally by 71,939 EUR (i.e. by 126.8%), compared to the group of farms supported by the AFP (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, eventually due to favourable economic conditions for dairy farms (i.e. significant increase in milk price). These results also suggest that, if we would not control for the bias, the deadweight loss would be underestimated by around 17 percent.

Theoretical expectations imply that the deadweight loss may occur either in the absence of market imperfections or due to inter-temporal substitution of investments. The presence of high deadweight loss 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

[8] Due to dropping of programme non-participants 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-beneficiary farms were left to re-estimate deadweight loss effects.

[9] For specification test results se Appendix A2.

able to undertake all profitable investment opportunities also without the RDP. They do not significantly increase their investment level, when support becomes available.

Further, given that we cover a 7 year period, farms may have changed the timing of investments within the study period, by taking into consideration the period of programme implementation. To comply with program 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 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 study period, we would need to observe an increase in beneficiaries' investments relative to non-beneficiaries investments over the study period. As reported in Table 2, the assets of non-beneficiaries increase by 126.8% over the period of 2001-2007, whereas for beneficiaries the increase in farm 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.

5.4 Robustness tests

To check the robustness of the deadweight effects, we estimate the leverage effect. The leverage effect occurs if public funding induces off-farm spending of programme beneficiaries. Overall, the support will 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 deadweight effect. It can be expected that in the case of significant deadweight effects, the leverage effect will be positive and significant.

The leverage effect is identified by comparing the supported and non-supported farms before and after the programme. First, we select individual units j supported by the RDP. Second, we identify a control group matching with j units (identical distribution of covariates) in period t' (i.e. prior to j's access to the programme). 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. We expect that in the case of significant leverage effects the calculated DID-ATT would be positive and significant, indirectly implying the presence of deadweight effects.

The leverage effect can be considered as an indirect consequence of the AFP being diverted from farm investments to off-farm investments. Given the fact that we found a significant deadweight loss, we expect that the AFP would have a substantial impact on private off-farm spending. As above, for comparison purposes we also include results for the full sample and for the subsample, where we control for the bias related to inter-firm effects.

The results reported in Table 3, Table 4 and Table 5 indicate considerable leverage effects.[10] For the full sample, the AFP brought about significant transfers of funds from farms to farm households. On average, additional money transfers from farm to farm households for living expenses increased by EUR +4,653 (12.8%) (Table 3) for beneficiaries, compared to EUR +3,178

[10] For specification test results see Appendix A3.

(9.4%) for non-beneficiaries (Table 4), while additional total money transfers from farms to farm households expanded by EUR +14,550 (19.9%) (Table 5). These results suggest that the propensity to consume among farms that received support from the AFP was much higher compared to non-beneficiaries (i.e. the programme leverage effect was substantial).

As expected, the results, which are based on a reduction of the selection bias (originating from the inter-firm substitution effects), show that the AFP has slightly higher leverage effects compared to former outcomes, in particular for money transfers from farm to farm household for 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 beneficiaries, i.e. participation in the AFP led to: (i) an increase in money transfers from farm to farm household for living expenses compared to similar non-beneficiaries by approximately +4,659 EUR (13.2%) per farm (Table 3); (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 4); and (iii) an increase in the total money transfer from farms to farm households by approximately +22,702 EUR (27.0%) (Table 5). These results indirectly confirm presence of the deadweight loss of the AFP implemented in Schleswig-Holstein. The AFP significantly increases off-farm household spending boosted by resources freed from the substitution of on-farm private investments with the public support.

5.5 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 (participation or non-participation). 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, 2005; Becker and Caliendo, 2007).

In our study the presence 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, 2005). As stated in Becker and Caliendo (2007), 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. Sensitivity analysis is applied using the Mantel and Haenszel (1959) test statistics suggested 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 (FADN data), one of the most important sensitivity tests was to find the minimal/optimal set of conditional variables to be included in the estimations.

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 6). 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.

6 CONCLUSIONS

Investment support to farms is one of the main measures within the Rural Development Programme and an essential component of the productivity enhancing strategy within the Common Agricultural Policy in the EU. As part of the RDP, more than 11 billion Euro (representing 11.5 percent of the total RDP budget) have been spent for supporting farm investment. Form a policy perspective, a key question is the extent to which the public support actually stimulates private investment, and what are the second order induced effects on productivity, employment, environment, etc.

The main objective of the present paper is to estimate the extent to which the RDP investment support has a complementary or a substitutionary effect on farm investments. In order to answer this question, we attempt to quantify the potential deadweight loss 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, attempting to account for the potential impact of the support on non-beneficiaries.

In the empirical analyses we employ the propensity score matching (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 deadweight loss is performed on the basis of the PSM approach in 2-stages by correcting for the inter-firm substitution effect, i.e. by dropping the programme affected non-supported farms from the sample. We base our estimation on a sample of 1333 farms from Schleswig-Holstein region (Germany) for the period 2001-2008.

We find that the deadweight loss of the RDP on farm investment is around 100%, implying that firm investment would have been undertaken also without the support. According to the theoretical hypothesis, these results suggest that farms in Schleswig-Holstein are not credit constrained, and hence do not significantly increase their investment level, when investment support becomes available. These results imply that credit market distortions are not significant. 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 7 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 deadweight loss has not been studied in the context of the RDP in Germany before.

Our results have important policy implications. Identifying the inter-firm adjustments of the RDP investment support is important for at least two reasons: (i) it facilitates assessment of the crowding out effect; and (ii) it allows to correct for the bias related to estimation of deadweight effects arising from application of traditional evaluation techniques.

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Table 1: Inter-firm substitution of the AFP on farm profits

	No. of observations	Profit per farm (EUR)		DID (2007-2001)	
		2001	2007	EUR	%
Unmatched P=1	526	46,349	84,703	38,354	83
Unmatched P=0	705	40,531	83,034	42,503	105
Matched M =1	517	45,933	83,757	37,824	82
Matched M= 0	677	48,559	89,930	41,371	85
ATT		-2,626	-6,172	-3,546	-3

Table 2: Deadweight loss of the AFP on farm assets

	Full sample				Sub-sample with excluded programme affected beneficiaries			
	No. of observations	2001	2007	DID (2001-2007)	No. of observations	2001	2007	DID (2001-2007)
		EUR (%)				EUR (%)		
Participants (P=1)	83	80,058	153,545	73,487	83	80,058	153,545	73,487
Non-participants (P=0)	293	57,379	108,539	51,160	161	51,607	107,265	55,658
Matched participants (M=1)	83	80,058	153,545	73,487 (+92%)	78	77,609	149,938	72,329 (+93.2%)
Matched non-participants (M=0)	263	70,181	130,733	60,552 (+86%)	155	56,704	128,643	71,939 (+126.8%)
Deadweight loss				93%				100%

Table 3: Leverage effects of the AFP to farm household living expenses

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

Table 4: Leverage effects of the AFP to building of private non-farm assets

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

Table 5: Leverage effects of the AFP to farm household

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

Table 6: Rosenbaum bounds for milk production (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 programme beneficiaries and 706 programme non-beneficiaries. The list of variables (38) that determine both programme participation and outcomes and were included as relevant covariates is provided in Table A1-1. Among variables used to match programme beneficiaries with programme non-beneficiaries an important one was the former level of support obtained from RDP previously implemented in Schleswig-Holstein (vsupp). Inclusion of this variable allowed to overcome a problem mentioned in many evaluation studies concerning the non-existence of non-supported farms (by the current and previous RDP) in a specific programme area.

Table A1-1: List of variables selected as covariates to estimation of logit function

List of variables	
v1025i2	Value of fixed assets – buildings
v1030i2	Operating facilities (value)
v1031i2	Machinery (value)
v1091i2	Cattle (value)
v1110i2	Inventory stock
v1449i2	Capital stock (value)
v2129i5	Revenues beef/cattle/milk sales
v2705i5	Purchased concentrated feed for cattle
v2799i5	Labour costs (total)
v4116i2	Milk yield (per cow)
v5111i2	Fem. Calves > 0.5 year
v5112i2	Fem. Calves > 0.5 and < 1 year
v5113i2	Fem. Cattle > 1 and < 2 years
v5114i2	Breeding Heifer
v5115i2	Heifer
v5116i2	Milk cows
v5117i2	Suckler cows
v5118i2	Slaughter cows
v5120i2	Male calves > 0.5
v5121i2	Male cattle > 0.5 and < 1 year
v5122i2	Male cattle > 1 and < 1.5 years
v5123i2	Male cattle > 1.5 and < 2 years
v5124i2	Male cattle > 2 years
v5125i2	Breeding bulls
v6104i7	Pasture area
v6119i7	Agricultural area (total)
v7098i3	Non-family labour
v7099i3	Labour total
vmilkprod	Milk production
v8026i2	Excess milk quota
v9001	Equity capital formation
v9003	v9003
v9005	Labour productivity (cattle/beef/milk per total labour)
v9006	Labour productivity (milk per total labour)
profit01	profit01
v9004	Adjusted equity capital formation
profit_co~01	Profit per farm (adjusted)
v8213i2	Earnings from non-self-employment
v2381i5	Interest subsidy to investment
vsupp	Obtained level of support from previous programmes

Table A1-2: Results of a logit function estimation

Logistic regression			
	Number of obs	=	807
	LR chi2(40)	=	121.30
	Prob > chi2	=	0.0000
Log likelihood = -243.64496	Pseudo R2	=	0.1993

particip	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
v1025i2_01	2.02e-06	2.35e-06	0.86	0.390	-2.59e-06	6.63e-06
v1030i2_01	-4.51e-06	7.51e-06	-0.60	0.548	-.0000192	.0000102
v1031i2_01	-.0000268	7.17e-06	-3.74	0.000	-.0000408	-.0000127
v1091i2_01	1.97e-06	.0000146	0.13	0.893	-.0000267	.0000306
v1110i2_01	.0000383	.0000487	0.79	0.432	-.0000572	.0001338
v1449i2_01	-2.54e-07	3.65e-07	-0.69	0.488	-9.70e-07	4.63e-07
v2129i5_01	6.66e-06	9.42e-06	0.71	0.480	-.0000118	.0000251
v2705i5_01	.0000454	.0000106	4.28	0.000	.0000246	.0000662
v2799i5_01	.0001077	.0004719	0.23	0.819	-.0008171	.0010326
v4116i2_01	-.0000613	.0002764	-0.22	0.825	-.000603	.0004805
v5111i2_01	.0186913	.0178942	1.04	0.296	-.0163807	.0537632
v5112i2_01	.0118835	.0167657	0.71	0.478	-.0209766	.0447436
v5113i2_01	-.0121226	.0153492	-0.79	0.430	-.0422064	.0179613
v5114i2_01	-.0060769	.0137317	-0.44	0.658	-.0329905	.0208366
v5115i2_01	-.0134439	.0618279	-0.22	0.828	-.1346243	.1077365
v5116i2_01	-.0613138	.0338315	-1.81	0.070	-.1276224	.0049947
v5117i2_01	-.016113	.0720671	-0.22	0.823	-.1573618	.1251358
v5118i2_01	-.0048062	.0287148	-0.17	0.867	-.0610862	.0514739
v5120i2_01	.0121035	.0156262	0.77	0.439	-.0185234	.0427303
v5121i2_01	.0165394	.0131412	1.26	0.208	-.0092169	.0422956
v5122i2_01	.014429	.013428	1.07	0.283	-.0118895	.0407475
v5123i2_01	.0051632	.0197474	0.26	0.794	-.0335411	.0438675
v5124i2_01	-.285279	.3196748	-0.89	0.372	-.9118302	.3412722
v5125i2_01	.1216614	.1539543	0.79	0.429	-.1800836	.4234063
v6104i7_01	.0072186	.0068231	1.06	0.290	-.0061544	.0205916
v6119i7_01	.0050058	.0079983	0.63	0.531	-.0106706	.0206822
v7098i3_01	-.581429	.4297761	-1.35	0.176	-1.423775	.2609166
v7099i3_01	.3884432	.3904466	0.99	0.320	-.376818	1.153704
vmilkprod_01	7.79e-06	5.58e-06	1.40	0.163	-3.15e-06	.0000187
v8026i2_01	1.93e-06	3.32e-06	0.58	0.562	-4.59e-06	8.44e-06
v9001_01	8.19e-07	1.47e-06	0.56	0.577	-2.06e-06	3.70e-06
v9003_01	-.0001288	.0004732	-0.27	0.786	-.0010563	.0007987
v9005_01	-3.84e-06	.0000143	-0.27	0.787	-.0000318	.0000241
v9006_01	.0005672	.0006534	0.87	0.385	-.0007134	.0018478
profit01	-4.90e-06	8.59e-06	-0.57	0.568	-.0000217	.0000119
v9004_01	2.55e-07	2.98e-06	0.09	0.932	-5.58e-06	6.09e-06
profit_co~01	1.37e-06	5.39e-06	0.25	0.800	-9.20e-06	.0000119
v8212i2_01	-.0005951	.0013484	-0.44	0.659	-.0032378	.0020476
v8213i2_01	.0000249	.000037	0.67	0.500	-.0000476	.0000975
vsupp_01	-1.32e-06	.0000126	-0.10	0.917	-.0000261	.0000234
_cons	-3.443257	2.004407	-1.72	0.086	-7.371823	.4853098

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 R^2 (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 bias[11] (after matching) and applying min{min} as the main selection criterion. In all considered cases (various matching algorithms)[12] 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 A1-3.

Table A1-3: 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

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 programme beneficiaries[13].

The application of the above procedure and common support restrictions resulted in dropping 46 farms (2 programme supported and 44 non-programme supported) from further analysis, thus selecting *comparable* 761 farms of which: 99 were programme participants and 662 were programme non-participants (Table A1-4).

[11] 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).

[12] This does not apply to local linear weighting function matching which first smoothes 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, 2007).

[13] The caliper matching algorithm (0.07) was also found to perform satisfactory concerning other important Selection criteria, i.e. balancing property and pseudo R^2 tests.

Table A1-4: Overview of the matched sample

Treatment	Common support		Total
	Off support	On support	
Untreated	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 (programme beneficiaries vs controls) 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 supported and non-supported groups of 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 A1-5. 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. beneficiaries 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 R^2 decreased as expected, i.e. dropped from 0.201 to 0.119 respectively, i.e. by 41%.

Table A1-5: Balancing property tests

Variable-Name	variable	Sample	Treated	Control	%bias	|bias|
Long-term assets – buildings	v1025i2_01	Unmatched	78645	64423	26.4	
		Matched	77665	77949	-0.5	98
Operating facilities (value)	v1030i2_01	Unmatched	17355	16524	4.4	
		Matched	17400	17474	-0.4	91.1
Machinery (value)	v1031i2_01	Unmatched	28285	32066	-16.3	
		Matched	28410	28297	0.5	97
Cattle (value)	v1091i2_01	Unmatched	1.10E+05	93309	43.7	
		Matched	1.10E+05	1.10E+05	4.8	89
Inventory stock	v1110i2_01	Unmatched	174.12	93.661	4.3	
		Matched	177.64	115.81	3.3	23.2
Capital stock (value)	v1449i2_01	Unmatched	6.80E+05	6.60E+05	5.9	
		Matched	6.80E+05	6.70E+05	2.8	52.3
Revenues beef/cattle/milk sales	v2129i5_01	Unmatched	2.30E+05	1.70E+05	63.7	
		Matched	2.20E+05	2.20E+05	6.3	90.1
Purchased concentrated feed for	v2705i5_01	Unmatched	-29362	-26278	-16	
cattle		Matched	-29955	-30484	2.7	82.9
Labour costs (total)	v2799i5_01	Unmatched	-6808.1	-5562.6	-14.9	
		Matched	-6815.2	-6229.6	-7	53
Milk yield (per cow)	v4116i2_01	Unmatched	7351.9	6572	64	
		Matched	7340.2	7283.7	4.6	92.8
Fem. Calves > 0.5 year	v5111i2_01	Unmatched	17.089	13.544	35.7	
		Matched	16.929	16.114	8.2	77
Fem. Calves > 0.5 and < 1 year	v5112i2_01	Unmatched	21.911	19.007	25.4	
		Matched	21.788	21.116	5.9	76.9
Fem. Cattle > 1 and < 2 years	v5113i2_01	Unmatched	35.119	30.305	32.9	
		Matched	35.03	33.67	9.3	71.7
Breeding Heifer	v5114i2_01	Unmatched	19.218	19.221	0	
		Matched	19.222	19.545	-2.6	-10189.4
Heifer	v5115i2_01	Unmatched	0.18812	0.30028	-6.4	
		Matched	0.19192	0.15312	2.2	65.4
Milk cows	v5116i2_01	Unmatched	71.861	61.584	38.6	
		Matched	71.404	70.437	3.6	90.6
Suckler cows	v5117i2_01	Unmatched	0.13861	0.25212	-6.8	
		Matched	0.14141	0.12746	0.8	87.7
Slaughter cows	v5118i2 _01	Unmatched	2.4158	1.5312	20.9	
		Matched	2.4646	2.2616	4.8	77
Male calves > 0.5	v5120i2 _01	Unmatched	14.762	10.374	41.7	
		Matched	14.525	14.631	-1	97.6
Male cattle > 0.5 and < 1 year	v5121i2 _01	Unmatched	19.465	13.006	44.7	
		Matched	19.364	20.036	-4.7	89.6
Male cattle > 1 and < 1.5 years	v5122i2_01	Unmatched	16.04	9.7578	43.3	
		Matched	15.818	15.918	-0.7	98.4
Male cattle > 1.5 and < 2 years	v5123i2_01	Unmatched	4.6337	2.6785	26.3	
		Matched	4.5556	4.4296	1.7	93.6
Male cattle > 2 years	v5124i2 _01	Unmatched	0.05941	0.2762	-15.4	
		Matched	0.0404	0.04363	-0.2	98.5
Breeding bulls	v5125i2 _01	Unmatched	0.63366	0.61331	2.4	
		Matched	0.60606	0.60544	0.1	96.9
Pasture area (ha)	v6104i7 _01	Unmatched	48.231	39.04	36.1	
		Matched	47.908	45.685	8.7	75.8
Agricultural area (total) (ha)	v6119i7 _01	Unmatched	94.335	83.954	26.9	
		Matched	93.834	92.596	3.2	88.1
Non-family labour (AK)	v7098i3_01	Unmatched	0.17337	0.18493	-2.5	
		Matched	0.17586	0.14761	6.2	-144.3
Labour total (AK)	v7099i3_01	Unmatched	1.7463	1.7426	0.5	
		Matched	1.7523	1.7325	2.7	-429.2
Milk production	vmilkprod_01	Unmatched	5.30E+05	4.10E+05	59	
		Matched	5.30E+05	5.10E+05	5.9	90.1
Excess milk quota	v8026i2_01	Unmatched	22801	15735	20.8	
		Matched	23064	20533	7.4	64.2
Equity capital formation	v9001 _01	Unmatched	1.60E+05	1.30E+05	23.5	
		Matched	1.60E+05	1.50E+05	5.4	77.1
v9003	v9003_01	Unmatched	-5374.4	-4303	-13.2	
		Matched	-5387.1	-4827.3	-6.9	47.8
Labour productivity (cattle/beef /	v9005_01	Unmatched	1.40E+05	1.10E+05	69.6	

milk per total labour)		Matched	1.40E+05	1.40E+05	0.5	99.2
Labour productivity (milk per total labour)	v9006 _01	Unmatched	3303	2487.6	64.8	
		Matched	3266.7	3255.9	0.9	98.7
profit01	profit01	Unmatched	54629	40518	48.8	
		Matched	54634	52293	8.1	83.4
Adjusted equity capital formation	v9004 _01	Unmatched	4818	2168.3	5.6	
		Matched	4847.6	6284	-3	45.8
Profit per farm (adjusted)	profit_co~01	Unmatched	35728	23889	35.3	
		Matched	35855	34159	5.1	85.7
Earnings from self-employment	v8212i2	Unmatched	9.8107	93.767	-10.2	
		Matched	10.009	11.991	-0.2	97.6
Earnings from non-self-employment	v8213i2	Unmatched	466.01	534.24	-2.3	
		Matched	475	389.37	2.9	-25.5
vsupp_01	vsupp	Unmatched	9340	8685.3	5.8	
		Matched	9206.3	8954.3	2.2	61.5

Appendix A2: Specification test results of the deadweight loss

Given the previously calculated individual propensity scores for programme beneficiaries and non-beneficiaries, 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 programme beneficiaries and 161 on programme beneficiaries), 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 R^2 (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 deadweight loss 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. beneficiaries vs. controls thus making both groups of farms much more comparable.

Table A2-1: Balancing property tests (deadweight loss effect)

Variable-Name	variable	Sample	Treated	Control	%bias	|bias|
Long-term assets – buildings		Unmatched	80059	51608	57.2	
	v1025i2_01	Matched	77609	56705	42	26.5
		Unmatched	16750	17352	-3.5	
Operating facilities (value)	v1030i2_01	Matched	16952	17281	-1.9	45.3
		Unmatched	27561	35370	-36.9	
Machinery (value)	v1031i2_01	Matched	27622	32227	-21.8	41
		Unmatched	1.10E+05	1.00E+05	23.1	
Cattle (value)	v1091i2_01	Matched	1.10E+05	1.10E+05	-7.8	66.1
		Unmatched	211.8	0	15.5	
Inventory stock	v1110i2_01	Matched	225.4	0	16.5	-6.4
		Unmatched	6.70E+05	6.20E+05	14	
Capital stock (value)	v1449i2_01	Matched	6.60E+05	6.40E+05	4.4	68.6
Revenues beef/cattle/milk sales		Unmatched	2.20E+05	1.90E+05	37	
	v2129i5_01	Matched	2.20E+05	2.20E+05	-6.3	83
Purchased concentrated feed for cattle		Unmatched	-29142	-28927	-1.1	
	v2705i5_01	Matched	-30490	-31376	4.6	-313.5
		Unmatched	-6428.1	-5904.8	-6	
Labour costs (total)	v2799i5_01	Matched	-6232.8	-6232.2	0	99.9
		Unmatched	7330.4	6846.9	38.4	
Milk yield (per cow)	v4116i2_01	Matched	7244.4	7231.2	1.1	97.3
		Unmatched	17.181	14.012	31.2	
Fem. Calves > 0.5 year	v5111i2_01	Matched	16.59	17.002	-4.1	87
Fem. Calves > 0.5 and < 1 year		Unmatched	21.855	20.205	14.1	
	v5112i2_01	Matched	21.372	21.056	2.7	80.9
Fem. Cattle > 1 and < 2 years		Unmatched	35.096	32.168	19.5	
	v5113i2_01	Matched	34.385	33.672	4.7	75.7
		Unmatched	19.06	20.919	-14.2	
Breeding Heifer	v5114i2_01	Matched	19.205	21.536	-17.9	-25.4
		Unmatched	0.22892	0.13043	12.1	
Heifer	v5115i2_01	Matched	0.24359	0.07922	20.2	-66.9
		Unmatched	71.096	64.745	23.6	
Milk cows	v5116i2_01	Matched	69.859	70.878	-3.8	84
		Unmatched	0.16867	0.39752	-9.5	
Suckler cows	v5117i2_01	Matched	0.17949	0.2351	-2.3	75.7
		Unmatched	2.3253	1.4472	21.4	
Slaughter cows	v5118i2 _01	Matched	2.2179	2.2264	-0.2	99
		Unmatched	14.735	11.708	26.8	
Male calves > 0.5	v5120i2 _01	Matched	14.218	15.16	-8.3	68.9
Male cattle > 0.5 and < 1 year		Unmatched	19.542	13.969	38.1	
	v5121i2 _01	Matched	19.359	18.654	4.8	87.3
Male cattle > 1 and < 1.5 years		Unmatched	16.06	11.143	30.4	
	v5122i2_01	Matched	15.821	16.31	-3	90
Male cattle > 1.5 and < 2 years		Unmatched	4.506	3.1615	18.3	
	v5123i2_01	Matched	4.3974	4.686	-3.9	78.5
Male cattle > 2 years	v5124i2 _01	Unmatched	0.06024	0.34161	-14.1	
Male cattle > 2 years	v5124i2 _01	Matched	0.03846	0.04948	-0.6	96.1
Breeding bulls	v5125i2 _01	Unmatched	0.61446	0.58385	3.7	
Breeding bulls	v5125i2 _01	Matched	0.58974	0.57852	1.3	63.3
Pasture area (ha)	v6104i7 _01	Unmatched	49.093	40.81	29.9	
Pasture area (ha)	v6104i7 _01	Matched	48.201	44.891	11.9	60
Agricultural area (total) (ha)	v6119i7 _01	Unmatched	93.311	89.865	9.2	
Agricultural area (total) (ha)	v6119i7 _01	Matched	91.975	94.859	-7.7	16.3
Non-family labour (AK)	v7098i3_01	Unmatched	0.15614	0.20634	-11.2	
Non-family labour (AK)	v7098i3_01	Matched	0.13923	0.18349	-9.9	11.8
Labour total (AK)	v7099i3_01	Unmatched	1.6827	1.7401	-8.3	
Labour total (AK)	v7099i3_01	Matched	1.6683	1.785	-16.9	-103.1
Milk production	vmilkprod_01	Unmatched	5.20E+05	4.50E+05	36.4	
Milk production	vmilkprod_01	Matched	5.10E+05	5.10E+05	-2.5	93.3
Excess milk quota	v8026i2_01	Unmatched	23110	18986	10.7	
Excess milk quota	v8026i2_01	Matched	21233	21270	-0.1	99.1
Equity capital formation	v9001 _01	Unmatched	1.60E+05	1.50E+05	7	
Equity capital formation	v9001 _01	Matched	1.50E+05	1.40E+05	8.3	-18.3
v9003	v9003_01	Unmatched	-5010.7	-4587.9	-5	
v9003	v9003_01	Matched	-4834.9	-4826.6	-0.1	98
Labour productivity (cattle/beef / milk per total labour)	v9005_01	Unmatched	1.40E+05	1.20E+05	49	
Labour productivity	v9005_01	Matched	1.40E+05	1.30E+05	11.8	76.4

(cattle/beef / milk per total labour)						
Labour productivity (milk per total labour)	v9006 _01	Unmatched	3339.9	2746.1	47.6	
Labour productivity (milk per total labour)	v9006 _01	Matched	3269.4	3113.7	12.5	73.8
profit01	profit01	Unmatched	53271	44302	28.9	
profit01	profit01	Matched	50921	51098	-0.6	98
Adjusted equity capital formation	v9004 _01	Unmatched	5701.7	11245	-7.3	
Adjusted equity capital formation	v9004 _01	Matched	6079.4	5885	0.3	96.5
Profit per farm (adjusted)	profit_co~01	Unmatched	34517	25450	28.9	
Profit per farm (adjusted)	profit_co~01	Matched	32722	32037	2.2	92.4
Earnings from self-employment	v8212i2	Unmatched	11.938	14.915	-3.1	
Earnings from self-employment	v8212i2	Matched	12.704	11.316	1.5	53.4
Earnings from non-self-employment	v8213i2	Unmatched	540.52	758.7	-5.9	
Earnings from non-self-employment	v8213i2	Matched	574.63	535.55	1.1	82.1
vsupp_01	vsupp	Unmatched	9207.8	8598	5.4	
		Matched	9007.9	8587.9	3.7	31.1
vsupp_01	vsupp					