An Investigation of Conditional Cash Payments in Agricultural Extension: Evidence from Beef Discussion Groups in Ireland

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Abstract

Financially rewarding farmers is an unconventional approach to agricultural extension. We evaluate an extension program, primarily delivered through farmer discussion groups, which rewarded farmers with conditional payments. Combining a matching model with a difference-in-difference estimator to data from the Irish National Farm Survey, we found that there was no significant impact on farm performance from the extension program over a four year period. The results align with previous research and would suggest that financial incentives in the form of conditional payments are not an ideal strategy for agricultural extension or technology adoption.

Keywords: Conditional cash payments; agricultural extension evaluation; propensity score matching with difference in difference estimator.

1. Introduction

Agricultural extension has evolved over its history, continually adopting new methods of delivery. Providing conditional payments to participants is an unconventional approach to agricultural extension; an approach implemented in Ireland over the last decade. Participants receive a cash payment conditional upon completing a number of specified tasks or activities, thus the payment acts as a price effect on extension participation. While payments for participation in extension have been shown to be effective in increasing participation rates by encouraging a cohort of farmers to participate that would have otherwise eschewed extension (Läpple and Hennessy, 2015b), uncertainty exists if these extension programs are effective on a farm's economic performance. Läpple and Hennessy (2015a) found no significant improvement in farm performance of participants that joined an extension program for dairy farmers after a financial incentive was introduced. The effectiveness of financial incentives in the form of conditional payments has also shown mixed results on performance in the context of educational programs in developed countries (Slavin, 2010, Fryer Jr, 2011). Thus, there is a need for further evaluation of extension programs that use conditional payments as a strategy.

Extension program evaluation has received a substantial amount of attention in the agricultural extension literature. The economic impacts of extension programs have been widely studied, with Birkhaeuser et al. (1991) and Evenson (2001) providing comprehensive reviews of this literature. The problem of causal inference creates difficulties in the evaluation of these extension programs, as the counterfactual evidence is not available on the units treated by a program. Heckman and Vytlacil (2007a, 2007b) outline a range of econometric techniques to overcome the causal inference problem in program evaluation. In the case of a non-randomised program, selection bias occurs (Roy, 1951). Difference between participants and non-participants cannot be solely attributed to the program, as differences between participant and non-participants can exist prior to the programs commencement (Heckman, 1997).

In this paper we use data from the Irish National Farm Survey (NFS) of an agricultural extension program that provided participants with conditional payments to estimate the economic returns to participation. Using a propensity score matching model combined with a difference in difference estimator, we were able to evaluate the economic impacts of the extension program over a four year period.

This paper is arranged into seven sections. In the following section, a review of the relevant literature relating to extension evaluation and conditional cash payments is provided. An outline of the extension program is provided in section 3. The empirical approach is outlined in section 4, followed by a description of the data in section 5. The results will be presented in section 6 and the paper will conclude with a discussion in the final section.

2. Relevant Literature

Extension evaluation is wide ranging area that uses both quantitative and qualitative methods from different fields in the social sciences. This is due to different types of agricultural extension, with extension programs having different aims and objectives. For this review of the literature, we shall focus on empirical studies that use econometrics of program evaluation. Empirical evaluation studies have used several types of econometric modelling techniques to estimate the impact of extension programs. These include, *inter alia*, difference in difference, instrumental variables, propensity score matching and the endogenous switching regression model, with the evaluation method dependent on the design of the extension program and the data available to the researcher. Data quality issues and issues concerning methodology as highlighted by Evenson (2001) and Anderson (2007) have called into question some of the results concerning these extension program evaluations. For example, in a re-evaluation of the economic effects of a 1980's training and visit extension program in Kenya, Gautam and Anderson (1999) found that estimates obtained by Bindlish and Evenson (1997) were significantly overestimated after correcting for data processing errors.

Economic impact studies of agricultural extension programs are overwhelmingly focused on extension programs in economically developing countries, as agricultural extension is an important development tool in these countries. Feder et al. (2004) used difference in difference to estimate the effect on yields for participants of Indonesian farmer field schools and their neighbours that encouraged pesticide use. The result from the study did not provide any evidence of increased yields. A variation of the difference in difference method was also used to estimate the economic returns to the extension services provided by the National Agricultural Advisory Services in Uganda from 2004 to 2007 (Benin et al., 2011). A propensity score was obtained first to match the program participants and nonparticipants for the difference-in-difference method. The analysis showed significant returns from the extension service both from direct and indirect impacts. The impact that agricultural education has on the adoption of technology was estimated using an endogenous switching regression model by Alene and Manyong (2007). It focused on farmers in the northern states of Nigeria and examined how education had an impact on the uptake of growing improved cowpea varieties. It was concluded that education did have a positive impact on technology adoption rates and as a result, productivity of the cowpea farmers.

Studies of farmer discussion groups in Ireland have provided us with findings with regards to extension programs in developed countries. Hennessy and Heanue (2012) found that Irish dairy farmers who were members of a discussion group had adopted new technologies and farm management practices at a higher rate than non-members. Membership of a discussion group was also found to have a positive impact on farm profitability, with farmers in discussion groups having higher gross margins per litre of milk produced and higher gross margins per hectare. As noted by the authors, self selection bias was not fully controlled for in the analysis. Läpple et al. (2013) controlled for self-selection bias when quantifying the economic returns from these farmer discussion groups. An endogenous switching regression model was estimated and found positive economic returns that were statistically significant for discussion group members.

In recent years, research into financial incentives in extension has also been conducted. In analysis of the role of a financial incentive, Läpple and Hennessy (2015b) found that introducing a financial incentive to discussion group participants encouraged some farmers to join a discussion group that otherwise would not. In a companion paper exploring the effect of this incentive's introduction, it was found that farmers who joined a discussion group prior to the financial payment improved their farm's performance in comparison to non-participants (Läpple and Hennessy, 2015a). Comparing those farmers that joined after the introduction of the incentive with non-participants, the estimates showed that there was no impact on the economic performance of the farm. Therefore, the payment for participating was a windfall gain for those farmers and can call into question the effectiveness of using a financial incentive as a means of encouraging extension program participation.

While financial incentives in the form of conditional payments are an unusual feature in agricultural extension and therefore, little evidence exists on their effectiveness; the impact and effectiveness of conditional payments have been comprehensively evaluated in other fields, including conditional cash transfer (CCT) programs in education and health. CCTs are a popular tool in the area of economic development to alleviate poverty and to build social capital. CCT programs have proven to be effective in the developing world; however their effectiveness in developed countries is far less certain (Slavin, 2010). In a comprehensive study of financial incentives used in schools across three cities in the United States, Fryer Jr. (2011) estimated that the impact of the financial incentives was zero in each city. In the developed countries, the financial incentive faces higher opportunity costs (Slavin, 2010).

While the outcomes of CCT programs have been extensively evaluated; attention has also been given to the effect that program design has on participation and outcomes. Using regression discontinuity analysis to an educational CCT program in Cambodia where the transfers varied in magnitude, Filmer and Schady (2011) found that there were sharply diminishing returns to the size of transfer on school attendance. Therefore, the size of the transfer is an important aspect to consider when designing a program with conditional payments. When testing the importance of conditionality using Mexico's PROGRESA program, de Brauw and Hoddinott (2011) showed that the absence of forms used to monitor school attendance reduced the likelihood of children attending school. This result showed the importance of the conditionality requirement in program design.

From our review of the relevant literature, we have outlined some of the issues surrounding extension program evaluation and presented empirical studies that explore the economic impact of farmer discussion groups. The use of financial incentives in extension and in the wider field of conditional cash transfers has also been explored, with research showing that program design is an important feature if a financial incentive is to be effective.

3. Program Description

In 2010 the Irish government launched Food Harvest 2020 (DAFF, 2010), a framework that sets out the government's vision and strategy for the direction of Ireland's agri-foods industry. Targets - to be reached by 2020 – were established for each agri-food sector with the beef sector tasked to increase output value by 20%[1]. This growth target was subsequently revised upwards to 40% (30% in volume, 10% in value) on the advice of the 2020 Beef Activation Group (DAFM, 2011). The poor economic performance of cattle farms was recognised as an obstacle in achieving this target; therefore, government policy has placed a

[1] The baseline was set as the average output between 2007 and 2009

focus on the role of knowledge and technology transfer to help improve the economic performance of cattle farms (DAFM, 2011).

The Beef Technology Adoption Programme (BTAP) was one of the knowledge and technology transfer measures introduced, with the Irish government providing an annual funding of €5million for the extension program. Commencing in 2012 for a three year period, BTAP sought to address the poor technical performance and low levels of innovation on Irish beef farms by focusing on key performance areas of the cattle enterprise. Grassland management, herd health, herd improvement and the greater use of IT were amongst the key performance areas focused on by BTAP.

The extension program was delivered through the use of farmer discussion groups. Effective in promoting the adoption of new technologies (Hennessy and Heanue, 2012), this method of extension delivery has become widely used by the providers of farm advisory services in Ireland. The farmer discussion groups were based locally, with a maximum membership of twenty. Each discussion group had an accredited facilitator who managed the group, along with an elected chairman and secretary. The discussion groups met on a regular basis, with the meetings consisting of an on farm walk, followed by a discussion session.

Participating farmers were required to complete two tasks each year from a suite of ten tasks provided. This provision was included in the program to provide an impetus for the adoption of new technologies and management practices on cattle farms. Along with the tasks provision, the participating farmer had to attend a minimum of six discussion group meetings per year. Conditional on satisfying these requirements, BTAP participants received a payment up to but not exceeding €1,000[2]. This financial incentive was included in the program to encourage a greater number of cattle farmers to join a local beef discussion group.

4. Empirical Methodology

The aim of a program evaluation study is to determine if there is a significant causal effect from treatment, *I*, on a specified outcome, represented as Y^I. In our case, the treatment under consideration is a farmer's participation in the extension program BTAP, and the outcome of interest is the economic performance of the cattle enterprise, which we measure by gross

[2] The yearly payment amount was dependent on the numbers of participants in the program in the year of question.

margin per hectare (GM ha^{-1}) and gross margin per livestock unit (GM lu^{-1}). We represent program participation by letting

$$I_{i,t} = \begin{cases} 0, & if\ non\ participant \\ 1, & if\ a\ participant \end{cases}$$

to indicate if farm *i* is a participant in the extension program in time period *t*. The economic performance of the cattle enterprise in time period *t+k* that received treatment can be denoted as $Y^1_{i,t+k}$, where $k \geq 0$, and $Y^0_{i,t+k}$ denotes the outcome of the cattle enterprise if the farm did not receive treatment. Thus, the causal effect of extension participation on the economic outcome of farm unit *i* in time period *t+k* can be defined as:

$$\Delta_{i,t+k} = Y^1_{i,t+k} - Y^0_{i,t+k}$$

However, the fundamental problem of causal inference is encountered, as it is impossible to observe the same farm unit *i* as being both treated and untreated (Holland, 1986). The counterfactual evidence of what the outcome of a treated unit would be if it were not treated does not exist.

Following Blundell and Costa Dias (2000), we specify the following outcome functions:

$$Y^T = f^T(X) + u^T$$
$$Y^C = f^C(X) + u^C$$

where Y^T and Y^C represent the outcomes of the treatment group (participants) and control group (non-participants), respectively. The outcomes of these two groups are defined to be a function, *f*, of the set observable variables X and unobservable term u^T and u^C. The goal of our evaluation is to estimate the average treatment effect on the treated (ATET), which is defined as:

$$\widehat{ATET} = E(Y^T - Y^C | X, I = 1)$$

The method used for estimating the ATET is dependent on the design of the program, the data available to the researcher and the underlying assumptions of the intended evaluation model. The design of the program determines if data can be classified as experimental or non-experimental. When selection into the program is determined by a randomised selection process, the data from the program can be regarded as experimental and the causal effect can be estimated as the treatment and control groups are statistically identical to the population. When selection is non-random, as is the case in this study with voluntary participation, the data is non-experimental and selection problems are introduced (Blundell and Costa Dias, 2000). Unobservable factors can have an influence on the selection decision, thus introducing endogeneity problems and selection bias. Blundell and Costas Dias (2000) review several program evaluation methods for non-experimental data, which include difference-in-difference and matching. Both these methods have strengths and weaknesses when applied to non-experimental data.

Matching models allow for the conditions of a controlled randomisation to be simulated. The most common matching technique which was proposed by Rosenbaum and Rubin (1983, 1984) is propensity score matching, where units are given a probability (propensity score) of receiving a treatment. Propensity score matching is a popular matching technique as it reduces the dimensionality problems encountered by other matching techniques (Blundell and Costa Dias, 2000). Instead of controlling for a set of variables X, one controls on the propensity score $P(X)$, where

$$P(X_I) = Prob(I_i = 1|X_i)$$

Propensity scores should be bounded between zero and one, to create a common support for marching; therefore, propensity scores are usually estimated using a binary choice model (e.g. logit or probit). The ATET estimator for propensity score matching is defined as:

$$\widehat{ATET}_M = \sum_{i \in T} (Y_i - \sum_{j \in C} W_{ij} Y_j) w_j$$

where W_{ij} represents a weight placed on j when matched with i and w_i is a reweighting factor. Matching can be performed by a number of different matching procedures, which Caliendo and Kopeinig (2008) outline in detail. For the purpose of this study, we use nearest neighbour matching where the ATET estimator can be defined as:

$$\widehat{ATET}_M = \sum_{i \in T} \frac{(Y_i - Y_j)}{N_T}$$

where j denotes the nearest neighbour in the control group to i in the treatment group in terms of estimated propensity score and N_T is the number of treatment units within the common support.

A central assumption of the propensity score-matching model is the conditional independence assumption or unconfoundedness (Caliendo and Kopeinig, 2008) and is represented as:

$$(Y^T, Y^C) \perp I | P(X)$$

Unconfoundedness assumes that treatment is dependent on observable variables only; an assumption that cannot be assumed to be fulfilled when selection was based on voluntary participation. Unobservable factors could have had an influence on the participation decision. This strong conditional independence assumption can be somewhat relaxed by combining matching with a difference in difference estimator.

Through the introduction of a combined matching model with a difference-in-difference estimator, time invariant unobservable factors can be controlled for. Due to the availability of longitudinal data, we are able to apply this model. This combination of a matching model with a difference in difference estimator is outlined in Blundell and Costas Dias (2000). We redefine the outcome functions to include this difference in difference estimator

$$Y_{it}^T = f_t^T(X) + \delta_i + \varphi_t^T + \nu_{it}^T$$
$$Y_{it}^C = f_t^C(X) + \delta_i + \varphi_t^C + \nu_{it}^C$$

where δ_i is a time invariant individual unobservable term, φ_t^T and φ_t^C are time dependent unobservable terms and ν_{it}^T and ν_{it}^C are individual time dependent unobservable terms. Now the conditional independence assumption can be replaced by

$$(Y_{t_1}^T - Y_{t_0}^T, Y_{t_1}^C - Y_{t_0}^C) \perp I | P(X)$$

where t_0 and t_1 represent the pre- and post-program time periods. The ATET can now be obtained from a propensity score matching with difference in difference estimator defined as:

$$\widehat{ATET}_{M-DID} = \sum_{i \in T} \frac{(Y_{it_1} - Y_{it_0}) - (Y_{jt_1} - Y_{jt_0})}{N_T}$$

In the agricultural economics literature, matching models combined with difference in difference have been applied in a number of areas, including to analyse structural change in Austrian agriculture (Kirchweger and Kantelhardt, 2015) and to estimate the economic returns to the extension services in Uganda (Benin, et al., 2011).

5. Description of the Data

We use data from the annual Irish National Farm Survey (NFS), which is collected by Teagasc[3] to comply with the legal requirements of the EU's Farm Accountancy Data Network (FADN) set out under the Council Regulation (EC) No 1217/2009. The dataset consists of individual farm households, with the data consisting of farm business and physical indicators. Household data are additionally included in the survey, making the NFS a rich resource for both economic and social research.

The data used in this study covers the period 2011 to 2015[4], which includes the BTAP period 2012 to 2014. During the period of study, between 890-1100 farm households are selected for the survey each year. These farms are selected based on a random stratified sample which is nationally representative of approximately 85000-110000 farms[5] and there is a sample turnover of less than 10%. The low level of sample turnover allows for a longitudinal (panel data) analysis to be performed (Bradley and Hill, 2015).

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[3] Ireland's Agricultural and Food Development Authority

[4] Hennessy et al., (2012), Hennessy et al., (2013), Hanrahan et al., (2014), Hennessy and Moran (2015) and Hennessy and Moran (2016)

[5] The population of farms that reaches the NFS threshold changes each year, therefore the NFS makes adjustments to account for this population change. The 2011 NFS represented 105,535 farms, while 84,259 farms were represented in the 2015 NFS.

The variables used in this study are presented in Table 1, together with a definition of each variable. There are three dependent variables in the models, a treatment variable which is participation in BTAP and two economic outcome variables of interest: gross margin per hectare (€ ha^{-1}) and gross margin per livestock unit (€ lu^{-1}). Gross margin is defined as the gross output of the farm's cattle enterprise minus direct costs associated with this enterprise. Due to the mixed enterprise nature of Irish farming, net margin of the cattle enterprise is not always available due to fixed costs being spread across various enterprises. As gross margin is a monetary value, the CSO agricultural output price index for cattle was used as a deflator, with 2010 set as the base year.

The explanatory variables are used in the logit model to estimate the propensity score and consist of farmer attributes, farm structure and region. All the explanatory variables are from 2011, as we want to calculate the propensity score prior to the commencement of BTAP. Farmer attributes consist of age, marital status, agricultural education attainment and use of farm advisory services. Age has been shown to decrease the probability of participation in extension, while formal agricultural education and used of farm advisory services indicate a farmer's willingness to obtain skills and information, thus increasing the likelihood of a farmer to participate in the extension process.

Farm specific characteristics included in the model are farm size (defined as utilisable agricultural area), stocking density and type of cattle system. Four dummy variables, calf to weaning/store, weaning/store to finish, calf to finish and cattle other account for the type of system present in the cattle enterprise. The type of cattle system is based on which life stage the animal enters and exits the cattle enterprise, with 70% being set as the threshold for entry and exit. The calf to weaning/store farms are predominantly based on suckler herds, while weaning/store to finish systems is focused on fattening of cattle for meat processing. The calf to finish system is an integrated system, where the progeny of the herd are brought through to slaughter. Cattle other farms are classed as those that do not fit into any of these three types of cattle system. Included in this cattle other system classification are barley beef and veal farms and mixed system cattle enterprises.

Three regional dummy variables are included in the model to control for regional characteristics. The distribution of farming types in Ireland has a regional aspect, with the proportion of cattle farms differing across regions. The BMW (Border, Midlands and West) region has a high concentration of cattle farms, while the south-west region is dominated by dairy farming and the east region contains most of Ireland's tillage farms. This regionalised distribution of beef farms could have led to a pre-determined provision of local discussion groups by BTAP administrators. In addition, these three regions have differing pedological and meteorological features. Consequently, these different features can be a factor on the overall productivity and profitability of a beef farm by influencing the viable stocking rate and grassland management decisions. The eastern and south-western regions are characterised with better quality soil types and less than average precipitation. In comparison, the BMW region is predominated by low permeability gley soils and higher than average rainfall.

6. Results

Prior to examining the results of our model for the ATET of the difference in difference estimators, it is necessary to examine that the conditions that allow for propensity score matching are satisfied. Upon estimating propensity scores using a logit model, the assumption of common support has to be verified. The assumption of common support requires that there is an overlap in the propensity scores of participants and non-participants. This is graphically illustrated in Figure 1 for each of the four time periods in question, with the assumption of common support being satisfied for each time period.

The results of the logit models used to estimate the propensity scores are presented in Table 3. The models indicate that the farmer attributes of age, marital status and use of farm advisory services all had a significant impact on participation in the program. Age decreased the probability of participation, while being married and an advisory service client both increased the probability of BTAP participation. Farms that were classified as having a cattle other system, had a decreased likelihood of participation in comparison to the base cattle system of calf to weaning/store. Farmers in the south-west region had a decreased probability of participating in BTAP when compared against the base region of the BMW.

Table 4 reports the ATET for the difference in difference estimator for the years 2012 to 2015. The outcome variables of gross margin per hectare and gross margin per livestock unit are presented, with their standard errors and p-value. By using the `teffect psmatch` command in Stata[6] , standard errors as outlined by Abadie and Imbens (2011) were obtained. These Abadie-Imbems standard errors are able to take into account that the propensity scores are estimated, unlike the standard errors produced using the user written `psmatch2` command.

The results indicate that there was no significant effect on farm performance for the period of the study in the two economic outcome indicators. This insignificant impact can be clearly visualised using Figure 2, which plots the difference in difference estimators with the error bars representing the 95% confidence intervals. Our findings are in line with the previous research by Läpple and Hennessy (2015a) and add further weight to the questions surrounding the effectiveness of a financially incentivised extension program.

As with many program evaluation models, the potential problems of externalities and attrition cannot be accounted for in this study. Externalities can occur if non participants are somehow affected by the extension program or by equilibrium effects, thus affecting the ATET estimators. Attrition might bias the results, if attrition is non-random. Data from BTAP has shown there to be attrition in the program during its three-year period; however, it is impossible to determine if this attrition was random or non-random.

7. Conclusions

In this paper, a propensity score matching model combined with a difference in difference estimator was used to estimate the private economic returns to participants of an extension program for Irish cattle farmers. The extension program focused on encouraging technology adoption through a farmer discussion group format. Unusually for agricultural extension, the participating farmers received a payment for participation which was conditional upon satisfying the provisions set out by the program. Overall, our findings indicate that there was no significant economic impact from the extension program over a four year period. The results are consistent with previous research that assessed the impact of a financial incentive in participatory extension (Läpple and Hennessy, 2015a), thus giving further doubt to the efficacy of paying farmers to participate in extension.

[6] Available in versions Stata 13 and Stata 14.

However, this study examines the impacts of the extension program over a short time period of four years; therefore, the results of this study are somewhat limited by this time frame. As Evenson (2001) notes, the economic impacts of technology adoption are not instantaneous but accrue over a period of time. Program effects in other fields of economics such as job training programs have shown time lags (Heckman and Smith, 1999, Bergemann et al., 2009).

While participatory extension has previously shown to improve the rates of technology adoption (Hennessy and Heanue, 2012), economic performance (Läpple et al., 2013) and even social relations (Bogue, 2014), questions still surround the reasoning for financially rewarding farmers to participate in extension. Farmers that economically benefited from this extension have been voluntary participants and thus, have motivations that differ from those farmers that join due to the economic incentive. The Irish cattle sector can be characterised by low levels of profitability and having significant reliance on subsidies. Therefore, the financial incentive in the case of BTAP was not an insignificant sum of money when compared to the average family farm income of cattle farms in this period[7]. It must be asked, did cattle farmers participate in BTAP as a means of improving their farm performance or was the financial incentive used as a source of secure income.

[7] Average family farm income for cattle farms in this period ranged from €10,000 to €20,000 in the period of BTAP

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Table 1: List of variables and definitions

Variable	Description
BTAP	=1 if a member of BTAP; = 0 otherwise
GM ha^{-1}	Cattle enterprise gross margin per hectare (€ ha^{-1})
GM lu^{-1}	Cattle enterprise gross margin per cattle livestock unit (€ lu^{-1})
Explanatory variables	
Age	Age of the farmer in 2011
Married	Marital status of the farmer: = 1 if married; = 0 otherwise
Agricultural Education	= 1 if farmer has received a formal agricultural education; = 0 otherwise
Advisory Service Client	= 1 if farmer is an agricultural advisory service client; = 0 otherwise
Size	Size of farm measured in utilisable agricultural area (ha)
Stocking Density	Stocking density of the cattle enterprise measured in livestock units per hectare (lu/ha)
Calf to weaning/stores	= 1 if the cattle enterprise predominantly calf to weaning/store system; = 0 otherwise
Calf to finish	= 1 if the cattle enterprise predominantly calf to weaning/store system; = 0 otherwise
Weaning/store to finish	= 1 if the cattle enterprise predominantly weaning/store to finish system; = 0 otherwise
Other	= 1 if the cattle enterprise is none of the above systems; = 0 otherwise
BMW	= 1 if farm is in the Border, Midlands and West region; = 0 otherwise
South-west	= 1 if farm is in the South-west region; = 0 otherwise
East	= 1 if farm is in the East region; = 0 otherwise

Table 2: Descriptive statistics

	2012 Treatment	2012 Potential Controls	2012 Total	2013 Treatment	2013 Potential Controls	2013 Total	2014 Treatment	2014 Potential Controls	2014 Total	2015 Treatment	2015 Potential Controls	2015 Total
Number of Farms	69	454	523	68	415	483	66	382	448	63	367	430
Age	49.188	55.256	54.455	49.132	55.2	54.346	49.394	55.173	54.321	49.333	55.052	54.214
	(12.338)	(11.21)	(11.537)	(12.42)	(11.086)	(11.466)	(12.479)	(11.027)	(11.423)	(12.536)	(10.896)	(11.318)
Married	0.812	0.696	0.711	0.809	0.692	0.708	0.803	0.681	0.699	0.794	0.681	0.698
	(0.394)	(0.460)	(0.454)	(0.396)	(0.462)	(0.455)	(0.401)	(0.467)	(0.459)	(0.408)	(0.467)	(0.460)
Agricultural Education	0.623	0.436	0.461	0.618	0.441	0.466	0.606	0.448	0.471	0.587	0.452	0.472
	(0.488)	(0.496)	(0.499)	(0.49)	(0.497)	(0.499)	(0.492)	(0.498)	(0.5)	(0.496)	(0.498)	(0.5)
Advisory Service Client	0.797	0.586	0.614	0.794	0.595	0.623	0.788	0.589	0.618	0.794	0.586	0.616
	(0.405)	(0.493)	(0.487)	(0.407)	(0.491)	(0.485)	(0.412)	(0.493)	(0.486)	(0.408)	(0.493)	(0.487)
Size	66.415	54.524	56.093	65.831	54.948	56.48	63.182	56.179	57.21	63.76	56.117	57.236
	(35.885)	(38.067)	(37.967)	(35.82)	(37.412)	(37.349)	(29.945)	(38.294)	(37.236)	(29.593)	(38.403)	(37.311)
Stocking Density	1.437	1.33	1.344	1.44	1.35	1.363	1.443	1.356	1.369	1.437	1.362	1.373
	(0.406)	(0.561)	(0.544)	(0.408)	(0.562)	(0.543)	(0.414)	(0.542)	(0.526)	(0.415)	(0.539)	(0.523)
Calf to weaning/stores	0.435	0.421	0.423	0.426	0.424	0.424	0.439	0.421	0.424	0.444	0.417	0.421
	(0.499)	(0.494)	(0.494)	(0.498)	(0.495)	(0.495)	(0.5)	(0.494)	(0.495)	(0.501)	(0.494)	(0.494)
Calf to finish	0.275	0.233	0.239	0.279	0.236	0.242	0.258	0.233	0.237	0.27	0.243	0.247
	(0.450)	(0.424)	(0.427)	(0.452)	(0.425)	(0.429)	(0.441)	(0.423)	(0.425)	(0.447)	(0.429)	(0.431)
Weaning/store to finish	0.203	0.192	0.193	0.206	0.181	0.184	0.212	0.181	0.185	0.206	0.174	0.179
	(0.405)	(0.394)	(0.395)	(0.407)	(0.385)	(0.388)	(0.412)	(0.385)	(0.389)	(0.408)	(0.380)	(0.384)
Other	0.087	0.154	0.145	0.088	0.159	0.149	0.091	0.165	0.154	0.079	0.166	0.153
	(0.284)	(0.362)	(0.353)	(0.286)	(0.366)	(0.357)	(0.290)	(0.372)	(0.361)	(0.272)	(0.373)	(0.361)
BMW	0.551	0.498	0.505	0.559	0.508	0.516	0.576	0.526	0.533	0.587	0.534	0.542
	(0.501)	(0.501)	(0.500)	(0.500)	(0.501)	(0.500)	(0.498)	(0.500)	(0.499)	(0.496)	(0.500)	(0.499)
South West	0.043	0.24	0.214	0.044	0.219	0.195	0.379	0.272	0.288	0.365	0.275	0.288
	(0.205)	(0.428)	(0.411)	(0.207)	(0.414)	(0.396)	(0.489)	(0.446)	(0.453)	(0.485)	(0.447)	(0.454)
East	0.406	0.262	0.281	0.397	0.272	0.29	0.045	0.202	0.179	0.048	0.191	0.17
	(0.495)	(0.44)	(0.45)	(0.493)	(0.446)	(0.454)	(0.21)	(0.402)	(0.383)	(0.215)	(0.393)	(0.376)

Table 3: Results of the logit model to estimate the propensity scores

VARIABLES	2012	2013	2014	2015
Age	-0.0386***	-0.0405***	-0.0409***	-0.0422***
	(0.0130)	(0.0131)	(0.0132)	(0.0135)
Married	0.627*	0.656*	0.676*	0.634*
	(0.343)	(0.345)	(0.348)	(0.349)
Agricultural Education	0.342	0.308	0.262	0.179
	(0.310)	(0.312)	(0.316)	(0.321)
Farm Size	0.00400	0.00442	0.00283	0.00313
	(0.00313)	(0.00330)	(0.00356)	(0.00357)
Stocking Density	0.147	0.0751	0.0880	0.0799
	(0.279)	(0.286)	(0.290)	(0.298)
Calf to Finish	-0.200	-0.195	-0.181	-0.155
	(0.363)	(0.372)	(0.379)	(0.380)
Weaning/store to Finish	-0.170	-0.0603	-0.0305	0.0117
	(0.382)	(0.390)	(0.392)	(0.401)
Cattle Other	-0.758	-0.766	-0.756	-0.897*
	(0.494)	(0.499)	(0.497)	(0.533)
East	0.254	0.250	0.228	0.159
	(0.300)	(0.304)	(0.311)	(0.319)
South-west	-1.725***	-1.598**	-1.468**	-1.366**
	(0.618)	(0.622)	(0.624)	(0.627)
Constant	-0.678	-0.476	-0.326	-0.189
	(0.824)	(0.830)	(0.838)	(0.852)
Observations	523	483	448	430

Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4: Estimation of the ATET

ATET	2012	2013	2014	2015
GM ha^{-1}	-25.162	-14.995	61.034	19.013
(Std. Err)	42.159	54.138	65.376	45.282
p-value	0.551	0.782	0.351	0.675
GM lu^{-1}	-23.510	-46.321	28.618	12.284
(Std. Err)	27.422	51.496	38.252	33.902
p-value	0.391	0.368	0.454	0.717

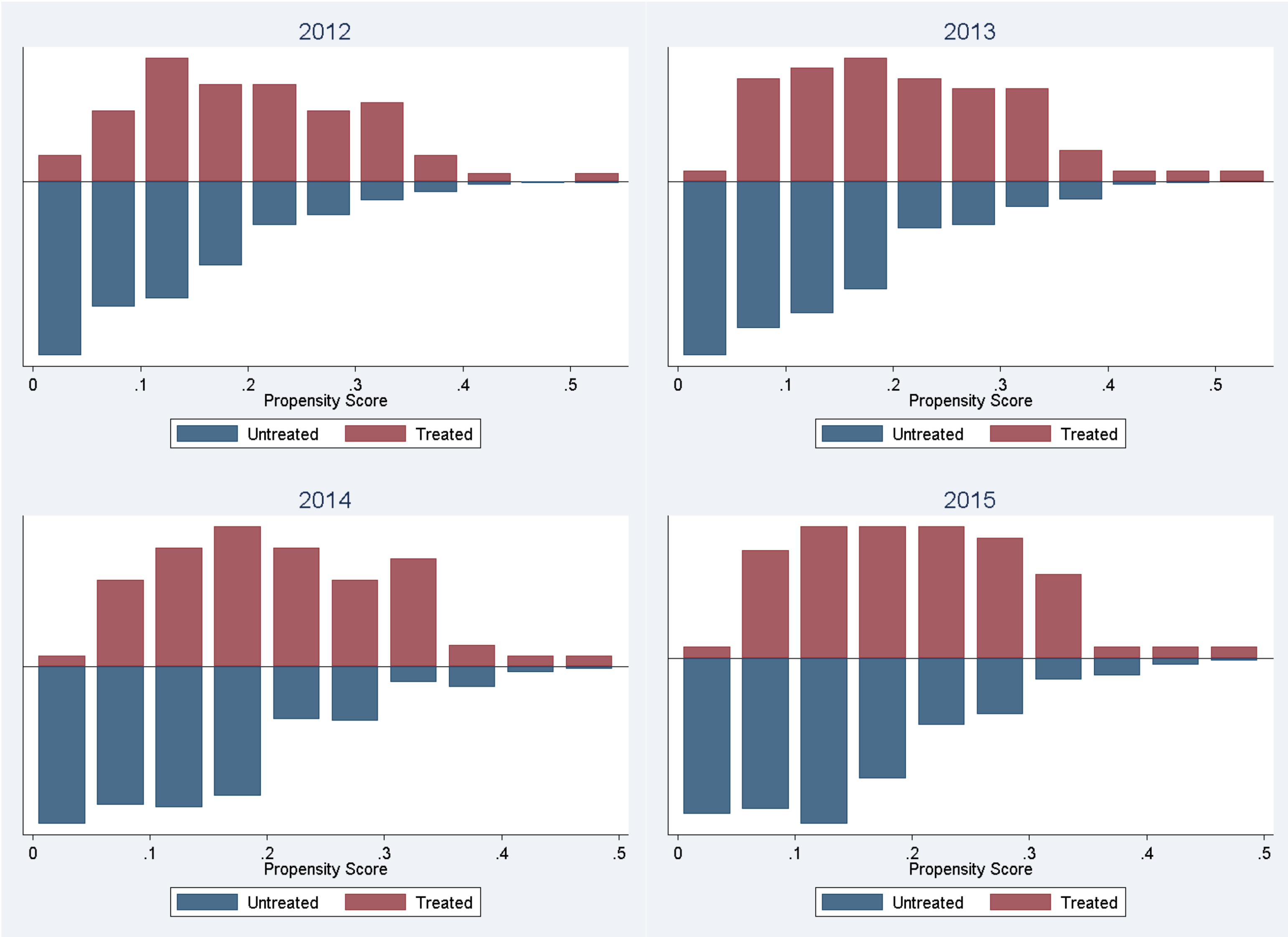

Figure 1: Common support pre-matching

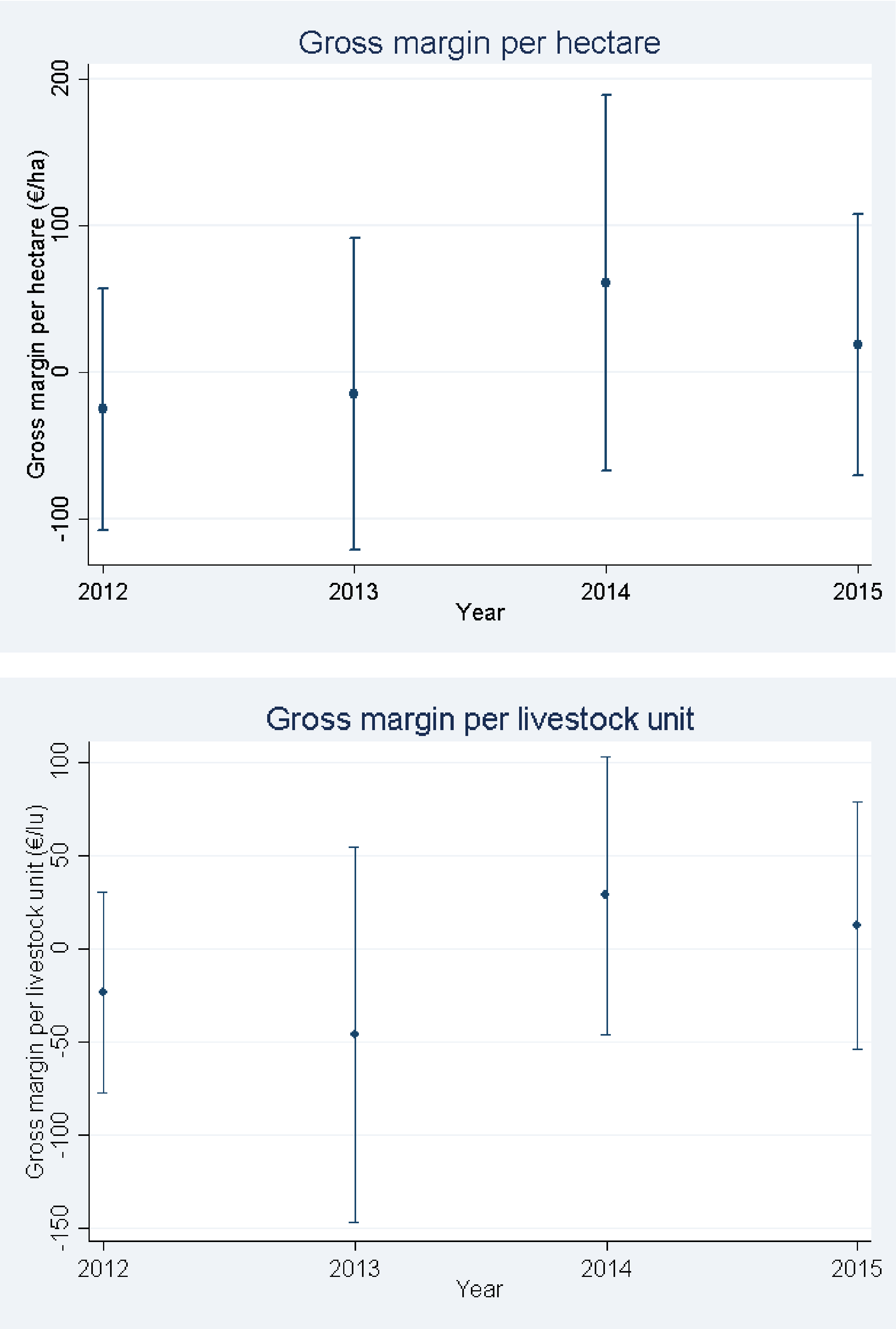

Figure 2: The estimated ATET for gross margin per hectare and gross margin per livestock unit for 2012 to 2015. The error bars represent the 95% confidence interval.