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**Staatssekretariat für Wirtschaft SECO**
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**Strukturberichterstattung**
**Nr. 60/5**

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# Impact of agricultural subsidies on farmers' willingness to pay for input goods and services

Schwerpunktthema:
Vor- und nachgelagerte
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# IMPACT OF AGRICULTURAL SUBSIDIES ON FARMERS' WILLINGNESS TO PAY FOR INPUT GOODS AND SERVICES

## JANUARY 2019

**Commissioning body**
Swiss State Secretariat of Economic Affairs (SECO)

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Please quote as: Gentile E., Loi. A., Esposti R. et al. (2019), *Impact of agricultural subsidies on farmers' willingness to pay for input goods and services.* Report mandated by the Swiss State Secretariat of Economic Affairs. Areté srl, Bologna.

# TABLE OF CONTENTS

# EXECUTIVE SUMMARY

Swiss agriculture is still extensively supported through a combination of border protection measures and financial support to farmers (mainly in the form of direct payments) in comparison to other countries[1]. In principle, the additional financial resources granted to Swiss farmers through support measures (and especially direct payments) may induce them to incur higher expenses for inputs and services, that they otherwise could not bear. Such **availability to incur higher expenses** may be defined in terms of "**farmers' willingness to pay for input goods and services"**.

This study aims at answering **two key questions**:

1. Is it possible to demonstrate a **linkage between government support** and **Swiss farmers' willingness to pay for input goods and services**?
2. If such a linkage exists, **how strong is the impact of policy support** in this respect?

To answer these questions, the study focuses on the assessment of the **impact of support from direct payments on Swiss farmers' willingness to pay for variable inputs and services** (farmers' WTP henceforth), in the light of the essential importance of direct payments in providing support to the Swiss agricultural sector.

The study assessed **whether and to what extent the observed effects of increased support from direct payments** emerging from the analysis of empirical data at farm level are **consistent with theoretical expectations**. The empirical analysis made use of statistical methods to assess:

1. **whether support from direct payments** granted to Swiss farmers - technically defined as "treatment" - translates into **"responses" by the farmers** themselves in terms of **purchase of <u>variable</u>[2] inputs and/or services**;
2. in presence of the impact at point 1, **in which direction and to what extent different "intensity of support from direct payments"[3]** translates into **different responses by farmers in terms of expenses for <u>variable</u> inputs and/or services**.

From a purely **theoretical standpoint**, the **expected response to direct payments in terms of variable input use** - and hence of farmers' WTP for these inputs - can take **two opposite directions or forms**.

On the one hand, under the assumption that this response occurs with a given farm technology, product mix and endowment of quasi-fixed inputs (labour, capital, land), an increase in direct payments generates a **financial effect** that, especially under credit constraints, may allow farmers to intensify the use of variable inputs per unit of production or revenue (**intensification response**).

On the other hand, however, direct payments may also induce some adaptation of the farm technology, product mix and quasi-fixed input endowment, that would result in a reduction of variable input use (**extensification response**), if this adaptation results in increased efficiency in the use of inputs.

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[1] OECD (2015). *OECD Review of Agricultural Policies: Switzerland 2015*. OECD Publishing.

[2] The empirical assessment performed for the study does not cover expenses for fixed inputs such as machinery, equipment, farm buildings, etc.

[3] The "intensity of support from direct payments" is a measure of the different levels of support granted to individual farmers which is independent from farm size. The intensity of support is measured through the ratio between direct payments and "agricultural revenues": the latter correspond to the "value of raw output from agricultural production" in Agroscope's *Zentrale Auswertung von Buchhaltungsdaten*, which includes revenues from crop farming and animal farming, and excludes revenues from "para-agricultural activities" (e.g. on-farm sale of processed agricultural products) and – above all – direct payments.

However, farmers' response has to face decreasing marginal productivity of variable inputs[4] in the first case, and increasing adaptation costs in the second case. Therefore, in both cases the theoretical expectation is that of a **less than proportional** (or decelerating) **response by farmers in terms of variable input use**.

The study used **two datasets of farm-level data** from Agroscope's *Zentrale Auswertung von Buchhaltungsdaten* (central evaluation system of farm accountancy data) to perform an **empirical assessment of the actual impact of direct payments on Swiss farmers' expenses for variable inputs**. Due to specific features of the datasets, the assessment was broken down into:

1. An assessment for the period preceding the reform of the Swiss system of direct payments (2010-13), performed under a constant policy regime on a sample of 1,399 farms.
2. An assessment comparing the pre-reform period (2010-13) with the first year of application of the reform (2014), and hence focusing on the transition between two policy regimes, performed on a sample of 1,399 farms.
3. An assessment for the 2015-16 period, once again performed under a constant policy regime on a sample of 1,453 farms.

The above approach offered the possibility to empirically assess whether and to what extent the observed response by farmers remains consistent with the theoretically expected one in three distinct samples and under different policy regimes.

The **assessment for the 2010-13 period** allowed to conclude that - except for farms with lower levels of support from direct payments - **the response to higher direct payments per unit of agricultural revenue is a mild, less than proportional increase in the expenses for variable inputs per unit of agricultural revenue**. This result is consistent with most of the literature and, therefore, theoretical expectations. From a policy perspective, this result suggests that **lowering direct payments induces an extensification in the use of variable inputs** per unit of agricultural revenue. On the contrary, **higher direct payments, in practice, provide the funding for an intensification in variable input use** per unit of agricultural revenue**.** The assessment also found that the response to increased intensity of support from direct payments in terms of expenditure for **insurances**, **fertilisers** and **work by third parties** (and also veterinarian services and drugs, even if the robustness of results is much lower in this case) is **positive and less than proportional**, consistently with the theoretically expected response.

Two separate subsamples - one with farms experiencing a decrease in the intensity of support from direct payments with the transition to the new regime, and one with farms experiencing an increase in this respect - were analysed for the **comparative assessment between the 2010-13 period and 2014**. The much higher number of farms in the first subsample (1,066 vs. 333) and the probably high heterogeneity of the second subsample allowed to obtain robust enough results only for the case of decreased intensity of support from direct payments. The assessment **confirmed that a higher/lower intensity of support from direct payments is associated to an intensification/extensification of variable input use,** albeit with statistically weaker results than in the assessment for the 2010-2013 period.

The results of the **assessment for the 2015-16 period** confirmed - even with some limitations in terms of statistical robustness - that **higher direct payments per unit of revenue induce an intensification in the use of variable inputs**. However, farms which have already a high intensity of support from direct payments do not show any response in terms of neither intensification nor extensification in variable input use.

A comparison between the results of the two assessments under a constant policy regime (2010-2013 period vs. 2015-2016 period) showed that **the results are clearly comparable,** as they **both indicate** - consistently with theoretical expectations - that **a higher intensity of support from direct payments**

[4] Marginal productivity of variable inputs measures the additional quantity of product obtained from an additional unit of variable input.

**induces an intensification in the use of variable inputs**. However, the results for the 2015-2016 period are statistically weaker.

To verify the actual reliability of the results of the empirical assessment, these were also assessed against the existing literature on the topic. Analogous micro-level ex-post assessments can be hardly found in the literature; however, **a comparison with a number of recent studies based on simulation models** - used to anticipate the impact of possible policy reforms - **confirmed the reliability of the obtained results** (even if such a comparison requires extreme caution).

Overall, **the results of the three separate empirical assessments** carried out were found to be **consistent with one another**. It is worth observing that, also considering the methodological challenges of the assessment and some limitations deriving from the available datasets, **such consistency does not represent a trivial outcome**.

The findings of the assessment hence allow to conclude that:

a. A **linkage between government support** and **Swiss farmers' willingness to pay for variable inputs and services does exist**, at least in the case of **one of the most important forms of policy support to the agricultural sector in Switzerland, i.e. direct payments**.
b. The **direction of the effect of support from direct payments** in terms of increased/decreased expenditure for variable inputs **varies according to the intensity of support** and to a number of other factors, but this effect is **mainly positive** (increased intensity of support from direct payments often translates into higher expenses for variable inputs per unit of agricultural revenue) and **always less than proportional.**

# RÉSUMÉ

L'agriculture suisse continue d'être largement subventionnée par le biais d'une combinaison de mesures de protection des frontières et de soutien financier aux agriculteurs (principalement sous la forme de paiements directs), en comparaison avec d'autres pays[5]. En principe, les ressources financières supplémentaires octroyées aux agriculteurs suisses par le biais de mesures de soutien (et en particulier les paiements directs) peuvent les inciter à engager des dépenses plus élevées pour les intrants et les services, qu'ils ne pourraient sinon pas supporter. Cette **capacité à engager des dépenses plus élevées** peut être définie en termes de « **disposition des agriculteurs à payer des intrants et des services »**.

Cette étude vise à répondre à **deux questions clés**:

1. Est-il possible de démontrer un **lien entre les aides gouvernementales** et **la disposition des agriculteurs suisses à payer des intrants et des services**?
2. Si un tel lien existe, **quelle est l'incidence de la politique d'aide** à cet égard?

Pour répondre à ces questions, l'étude se concentre sur l'évaluation de **l'incidence du soutien provenant des paiements directs sur la disposition des agriculteurs suisses à payer des intrants et des services variables**, compte tenu de l'importance essentielle des paiements directs pour soutenir le secteur agricole suisse.

L'étude a évalué **si et dans quelle mesure les effets observés du soutien accru lié aux paiements directs** issus de l'analyse des données empiriques au niveau de la ferme **coïncident avec les attentes théoriques**. L'analyse empirique s'est appuyée sur des méthodes statistiques pour évaluer:

1. **si l'aide provenant des paiements directs** octroyés aux agriculteurs suisses, définis techniquement comme un « traitement », se traduit par des **« réactions » des agriculteurs** eux-mêmes en termes **d'achat d'intrants et/ou de services variables**[6];
2. en présence de l'incidence mentionnée au point 1, **dans quelle direction et dans quelle mesure une « intensité différente de l'aide provenant des paiements directs »**[7] se traduit par des **réactions différentes des agriculteurs en termes de dépenses consacrées aux intrants et/ou services variables**.

D'un **point de vue purement théorique**, la **réaction attendue aux paiements directs en termes d'utilisation des intrants variables**, et donc de la disposition des agriculteurs à acheter ces intrants, peut prendre **deux directions ou formes opposées**.

D'une part, en supposant que cette réaction survient avec une technologie agricole donnée, une combinaison de produits et une dotation en intrants quasi-fixes (main-d'œuvre, capital, terre), une augmentation des paiements directs génère un **effet financier** qui, notamment sous des contraintes de crédit, peut permettre aux agriculteurs d'intensifier l'utilisation d'intrants variables par unité de production ou de revenu (**réaction d'intensification**).

[5] OECD (2015). *Examen OCDE des politiques agricoles: Suisse 2015*. Publication OCDE.

[6] L'évaluation empirique effectuée pour l'étude ne couvre pas les dépenses encourues pour les intrants fixes tels que les machines, les équipements, les bâtiments agricoles etc.

[7] «L'intensité de l'aide provenant des paiements directs» est un outil de mesure des différents niveaux d'aide accordés aux agriculteurs individuels qui ne dépend pas de la taille de la ferme. L'intensité de l'aide se mesure à l'aide du rapport entre les paiements directs et le «revenu agricole»: ce dernier correspond à la «valeur de la production brute issue de la production agricole» dans le système *Zentrale Auswertung von Buchhaltungsdaten* d'Agroscope (Dépouillement Centralisé des Données Comptables), qui inclut les revenus provenant de la culture et de l'élevage animal, et exclut les revenus provenant «d'activités para-agricoles» (par ex. vente à la ferme de produits agricoles transformés), et en premier lieu, les paiements directs.

D'autre part, toutefois, les paiements directs peuvent également entraîner une certaine adaptation de la technologie agricole, de la combinaison de produits et de la dotation en intrants quasi-fixes, qui se traduirait par une réduction de l'utilisation d'intrants variables (**réaction d'extensification**), si cette adaptation aboutit à une efficacité accrue au niveau de l'utilisation des intrants.

Toutefois, la réaction des agriculteurs doit faire face à une productivité marginale décroissante des intrants variables[8] dans le premier cas, et à une augmentation des coûts de modulation dans le second cas. Par conséquent, dans les deux cas, on peut s'attendre en théorie à une **réaction moins que proportionnelle** (voire à un ralentissement) **des agriculteurs en termes d'utilisation des intrants variables**.

L'étude s'est appuyée sur **deux séries de données collectées au niveau de la ferme** provenant du système *Zentrale Auswertung von Buchhaltungsdaten* d'Agroscope (Dépouillement Centralisé des Données Comptables) pour réaliser une **évaluation empirique de l'incidence réelle des paiements directs sur les dépenses des agriculteurs suisses, consacrées aux intrants variables**. En raison de caractéristiques spécifiques des séries de données, l'évaluation a été décomposée en:

1. Une évaluation de la période précédant la réforme du système suisse des paiements directs (2010-2013), effectuée sous le régime d'une politique constante sur un échantillon de 1 399 fermes.
2. Une évaluation reposant sur la comparaison de la période avant-réforme (2010-2013) avec la première année d'application de la réforme (2014), en mettant donc l'accent sur la transition entre deux politiques, effectuée sur un échantillon de 1 399 fermes.
3. Une évaluation de la période 2015-2016, effectuée à nouveau sous le régime d'une politique constante sur un échantillon de 1 453 fermes.

L'approche ci-dessus offrait la possibilité d'évaluer de manière empirique si et dans quelle mesure la réaction des agriculteurs ainsi observée restait cohérente avec celle théoriquement attendue d'un échantillon sur trois et sous des régimes de politiques différentes.

L'**évaluation de la période 2010-2013** a permis de conclure que, à l'exception des fermes présentant un niveau plus bas d'aide provenant des paiements directs, **la réaction à des paiements directs plus élevés par unité de revenu agricole est une légère augmentation, moins que proportionnelle, des dépenses consacrées aux intrants variables par unité de revenu agricole**. Ce résultat est conforme à la plupart de la littérature et donc aux attentes théoriques. Du point de vue de la politique, ce résultat suggère qu'une **diminution des paiements directs entraîne un phénomène d'extensification au niveau de l'utilisation des intrants variables**. Au contraire, **des paiements directs plus élevés, dans la pratique, fournissent le financement nécessaire à une intensification au niveau de l'utilisation des intrants variables.** L'évaluation a également révélé que la réaction à une intensité accrue de l'aide provenant des paiements directs en termes de dépenses consacrées aux **assurances**, **engrais** et **travaux réalisés par des tiers** (ainsi que les services vétérinaires et les médicaments, même si la robustesse des résultats est beaucoup plus faible dans ce cas) est **une réaction positive, et moins que proportionnelle**, conformément à la réaction théorique attendue.

Deux sous-échantillons distincts, l'un avec des fermes connaissant une diminution de l'intensité de l'aide provenant des paiements directs avec la transition vers le nouveau régime, et l'un avec des fermes connaissant une augmentation à cet égard, ont fait l'objet d'analyses en vue de **l'évaluation comparative entre la période 2010-2013 et 2014.** Le nombre beaucoup plus élevé de fermes dans le premier sous-échantillon (1 066 contre 333) et l'hétérogénéité probablement élevée du second sous-échantillon ont permis d'obtenir des résultats suffisamment solides uniquement pour le cas d'une diminution de l'intensité de l'aide provenant des paiements directs. L'évaluation **a confirmé qu'une intensité plus élevée/plus faible**

[8] La productivité marginale des intrants variables mesure la quantité supplémentaire de produit obtenue à partir d'une unité supplémentaire d'intrant variable.

**de l'aide provenant des paiements directs est associée à un phénomène d'intensification/d'extensification de l'utilisation des intrants variables,** malgré des résultats statistiquement plus faibles que dans l'évaluation de la période 2010-2013.

Les résultats de **l'évaluation de la période 2015-2016** ont confirmé, même avec certaines limites en termes de robustesse statistique, que **des paiements directs plus élevés par unité de revenu entraînent une intensification de l'utilisation d'intrants variables**. Toutefois, les fermes qui connaissent déjà une intensité élevée de l'aide provenant des paiements directs ne réagissent pas en termes d'intensification ni d'extensification au niveau de l'utilisation des intrants variables.

Une comparaison entre les résultats des deux évaluations dans le cadre d'un régime de politique constante (période 2010-2013 contre période 2015-2016) a révélé que **les résultats sont clairement comparables,** étant donné **qu'ils démontrent tous les deux**, conformément aux attentes théoriques, qu'**une intensité supérieure de l'aide provenant des paiements directs entraîne une intensification au niveau de l'utilisation des intrants variables**. Toutefois, les résultats pour la période 2015-2016 présentent de plus grandes faiblesses au niveau statistique.

Pour vérifier la fiabilité réelle des résultats de l'évaluation, ceux-ci ont également été évalués par rapport à la littérature existante sur le sujet. On ne trouve guère d'évaluations ex-post similaires au niveau microéconomique dans la littérature; toutefois **une comparaison effectuée avec un certain nombre d'études récentes basées sur des modèles de simulation**, utilisés pour anticiper l'impact d'éventuelles réformes politiques, **a confirmé la fiabilité des résultats obtenus** (même si une telle comparaison nécessite une extrême prudence).

Globalement, **les résultats des trois évaluations empiriques distinctes** effectuées se sont révélés **cohérents les uns avec les autres**. Il convient de noter que, si l'on tient compte également des défis méthodologiques de l'évaluation et de certaines restrictions découlant des séries de données disponibles, **une telle cohérence ne constitue pas un résultat négligeable**.

Les résultats de l'évaluation permettent donc de conclure que:

a. Le **lien entre aide gouvernementale** et **disposition des agriculteurs suisses à payer pour des intrants variables et des services existe effectivement**, du moins pour le cas de **l'une des principales formes de politique d'aide au secteur agricole en Suisse, c'est-à-dire les paiements directs.**
b. La **direction suivie par l'impact de l'aide provenant des paiements directs** en termes d'augmentation/diminution des dépenses consacrées aux intrants variables **varie en fonction de l'intensité de l'aide** et d'un certain nombre d'autres facteurs, mais cet effet est **principalement positif** (l'augmentation de l'intensité de l'aide provenant des paiements directs se traduit souvent par des dépenses plus élevées consacrées aux intrants variables par unité de revenu agricole) et **reste toujours moins que proportionnel.**

# INTRODUCTION

Opening of domestic markets to international trade is a key element in the modern economy and a removal/reduction of trade barriers has positive impacts on competition and efficiency of the internal market. However, sometimes countries face a trade-off between open markets, which are beneficial for the whole economy, and the protection of some domestic sectors through import restrictions due to political reasons.

The role of foreign trade is particularly important in the Swiss economy, mainly because of the small dimension of the country and the consequent limited access to natural resources. This also applies to the Swiss agribusiness system, which relies on imports to meet a significant portion of domestic demand for food products, agricultural products and agricultural production inputs. Border protection on agricultural and food products currently in place in Switzerland results in higher prices with respect to neighbouring countries, with consequent negative effects on consumers and on the efficiency of the domestic economy (reduced competitive pressure from foreign producers often translates into reduced search for efficiency gains and innovation by domestic producers). In this context, an increasing need for easing restrictions to agricultural and food imports emerged from research carried out on the topic on behalf of the Swiss Federal Government in recent years (see for instance Areté, 2016[9]). Such research highlighted that Swiss border protection not only creates rents to the benefit of the agricultural sector, but that the largest part of such rents is actually absorbed by downstream stages of the food supply chain (processing and distribution).

A series of measures have been taken by the Swiss government in the last years in order to address these issues and to improve the competitiveness and the efficiency of the Swiss agriculture: among them, the progressive dismantling/lowering of tariffs and the increased recourse to direct payments to farmers, aimed at supporting their incomes with reduced distortion to market dynamics, international trade and competition. Swiss agriculture is still extensively supported through a combination of border protection measures and financial support to farmers (mainly in the form of direct payments) in comparison to other countries (OECD, 2015). In principle, the additional financial resources granted to Swiss farmers through support measures may induce them to incur higher expenses for inputs and services, that they otherwise could not bear.

For the purposes of the study, "**farmers' willingness to pay for input goods and services**" is defined as their **availability to incur higher expenses** for them deriving from variations in input quantity and/or price.

A number of studies have been commissioned by the State Secretariat for Economic Affairs (SECO) to analyse specific aspects concerning the agricultural sector and related input goods. This study aims at answering **two key questions**:

1. Is it possible to demonstrate a **linkage between government support** and **Swiss farmers' willingness to pay for input goods and services**?
2. If such a linkage exists, **how strong is the impact of policy support** in this respect?

After a synthetic outline of the study methodology (§ 1), the potentially relevant policy measures are identified and classified according to their direct or indirect influence on the Swiss farmers' willingness to pay for input goods and services, and their importance in the overall framework of policy support to the Swiss agricultural sector is assessed (§ 2). An overview of the potential linkages between policy support and higher WTP by farmers, based on the findings of the reference scientific literature on the topic (§ 3) is followed by a detailed illustration of the results of the empirical assessment of the actual impacts of policy

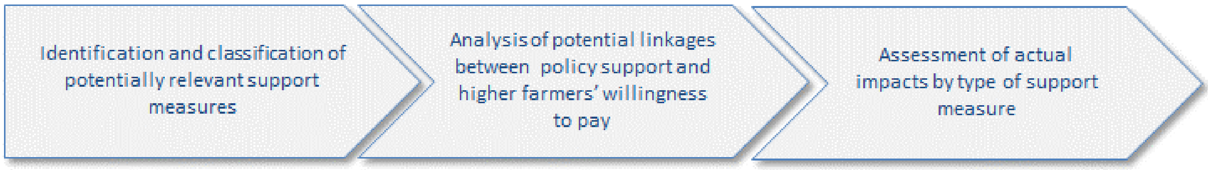
[9] Areté (2016). *Policy Evaluation of Tariff Rate Quotas*. Study carried out for the Federal Office of Agriculture (FOAG).

support on the Swiss farmers' WTP, focusing on the most important typology of support measures, i.e. direct payments (§ 4). Conclusions based on the findings of the assessment are finally provided (§ 5).

# 1 STUDY METHODOLOGY

## 1.1 Overall approach

The overall approach to the study is outlined in the scheme below.




For the purposes of the study, "**farmers' willingness to pay for input goods and services**" (WTP henceforth) is defined as their **availability to incur higher expenses** for them. These higher expenses do not distinguish between price and quantity variations.

As explained in detail at § 3 and § 4, the empirical assessment of WTP is based on cross-sectional[10] samples of farms; this allows to assume prices as constant, and hence to assume that differences/variations in expenses for inputs/services are entirely due to differences/variations in purchased quantities.

The preliminary steps in the assessment of farmers' WTP are the **identification of the potentially relevant support measures** among those targeting the Swiss agricultural sector, and their **classification** in terms of **potential influence on farmers' WTP** (see § 1.2). Already from a theoretical standpoint, support measures have a different potential in this respect, according to:

- their **intervention logic**, which is the set of hypothetical causal relations that describe how a policy measure (intervention) is expected to achieve its objectives;
- their **implementation mechanisms**, such as the conditions to benefit from support, the granting of different levels of support for different geographical areas, typologies of beneficiaries, farming conditions, etc.

A second step in the assessment aims at **analysing the potential linkages** between **policy support** and a **higher farmers' WTP**. Due to the **high importance of direct payments** in the framework of policy support to the Swiss agricultural sector (see § 2), the focus of this theoretical analysis (see § 1.3) will be on this specific typology of support measures.

The final step focuses on the **assessment of actual impacts**, in terms of i) **presence/absence of impacts**, ii) **direction** and iii) **magnitude of the impacts** (see § 1.4). The magnitude of the impacts is assessed in **quantitative terms** (increases in the expenses for inputs/services by Swiss farmers), within the limits allowed by the availability of suitable evidence (and in particular of production and economic data at individual farm level). **Qualitative judgments** on the extent of the impacts are elaborated wherever the available evidence does not allow a quantification of the extent of the impacts.

[10] A cross-sectional sample is made of individuals observed at the same point of time (it can be the same year but also the same period of time if the average or the variation is taken).

## 1.2 Identification and classification of potentially relevant support measures, and assessment of their importance for Swiss agriculture

The identification and classification of the main support measures available in Switzerland which could have an influence on farmers' WTP is based on the **analysis of the legislative texts** and of any **accompanying documentation** (e.g. guidelines for the administration of support measures).

Support measures can be **classified in two main groups** (see § 2):

1. Measures with **direct influence on farmers' WTP**. In principle, these include:
    a. Measures supporting **investments** (fixed inputs: facilities, machinery, equipment).
    b. Measures supporting purchase and use of **specific variable inputs/services**, due to their innovative nature and/or to their contribution to achieving specific objectives (environment conservation, efficient use of natural resources, etc.).
2. Measures with **indirect influence on farmers' WTP**. In principle, these include:
    a. Measures where support is **conditional on the use of inputs/services**, but does not necessarily imply their purchase:
        i. **Direct support to farmers' income**, which is conditional on the carrying out of farming activities. In Switzerland, this is granted mainly in the form of direct payments.
        ii. **Border protection measures**: import tariffs, quantitative limitations to import volumes, etc. These are aimed mainly at supporting domestic producers of the protected products.
        iii. **Measures supporting production and/or marketing** of domestic products, quality products, products with geographical indications (GI), etc.
    b. Measures where support is **not conditional on the use of inputs/services**, and hence does not necessarily imply their purchase:
        i. Measures granting additional **support to farmers which is conditional on subjective and/or objective requirements** (age, gender; geographical location of farms/plots; etc.).

The analysis of the different typologies of support measures is mainly aimed at **identifying the most important ones for the Swiss agricultural sector**, which will be analysed from a theoretical standpoint to identify their potential linkages with farmers' WTP (see § 1.3), and which will be the object of an empirical assessment of their actual impacts on expenses for variable inputs and services by Swiss farmers, according to the methodology outlined at § 1.4. As it will be seen at § 2, **direct payments have critical importance in the overall framework of policy support to the Swiss agricultural sector**.

## 1.3 Analysis of potential linkages between policy support and higher farmers' willingness to pay for input goods and services

The analysis of potential linkages between policy support to the agricultural sector (which is provided through a combination of different support measures) and higher farmers' WTP is based on:

- The specific **intervention logic and implementation mechanisms** of the support measures identified as the most important ones (see § 2), with special attention to the relationship between the conditions to be met by farmers to benefit from the support and the need (or lack thereof) of purchasing inputs/services to meet these conditions.
- The **findings of scientific research** on the topic. These findings are identified through a **review of the available literature**, in order to define a **reference theoretical framework** (see § 3). Both the

consistency of empirical results with such reference framework and any elements which may contribute to explain apparent inconsistencies are considered in the assessment of actual impacts of policy support on the Swiss farmers' WTP (see § 4).

## 1.4 Assessment of actual impacts of policy support on the Swiss farmers' willingness to pay for input goods and services

The assessment of actual impacts of policy support on the Swiss farmers' WTP makes use of **quantitative methods** to assess:

1. **whether support** granted to Swiss farmers - technically defined as **"treatment"** - translates into **"responses" by the farmers** themselves in terms of **purchase of variable[11] inputs and/or services**;
2. in presence of the impact at point 1, **in which direction and to what extent different levels of support** translate into **different responses by farmers in terms of expenses for variable inputs and/or services**.

Whether, how and to what extent policy support affects the farmers' demand for production inputs/services and, therefore, their willingness to pay for them, can be estimated by matching and comparing supported with non-supported farms or, since farms not receiving any policy support are extremely rare in Switzerland, by **comparing the behaviour of farmers receiving different levels of support.**

The assessment methodology relies on the availability of **production and economic data for individual farms**, technically defined as "**farm-level data" (or "micro-data**"). In Switzerland, these data are collected and elaborated by Agroscope (*Zentrale Auswertung von Buchhaltungsdaten*[12]), which collects – among others – farm-level data on expenses for agricultural inputs (both fixed and variable ones), expenses for services, and a wide array of other variables defining farm structure and farm management models. These data are not collected for all farms in the country - the so called "universe" - but for a sample of farms which can be considered as "representative of the universe".

**Two separate sets of farm-level data made available by Agroscope** are used for the assessment. A "merger" between the two datasets proved to be unfeasible, and each dataset presented some specificities which translated into limitations on the use of the foreseen quantitative methodology.

The **Reference Farm Sample (RFS)** (*Stichprobe Referenzbetriebe*) contains farm-level data for the 2003-2014 accounting years. Only the data for the accounting year 2014 concern the agricultural policy framework currently in force (2014-2017), which is the result of a reform of the system of direct payments (*Direktzahlungen*) to Swiss farmers. Only data on the total amount of direct payments granted to each farm in the sample are available in the sub-dataset for the accounting year 2014; no breakdown into individual typologies of direct payments is available. The dataset features a detailed breakdown of expenses for inputs and services and it also allows performing analyses by "branch of activity" at farm-level (crop farming, animal farming, etc.).

The **Income Situation Sample (ISS)** (*Stichprobe Einkommenssituation*) contains farm-level data for the 2015 and 2016 accounting years. These data relate to the agricultural policy framework currently in force (2014-2017). Similarly to the RFS sub-dataset for the accounting year 2014, only data on the total amount of direct payments granted to each farm in the sample are available in the ISS for the accounting years 2015 and

[11] The empirical assessment performed for the study does not cover expenses for fixed inputs such as machinery, equipment, farm buildings, etc.

[12] More information available (in German) at https://www.agroscope.admin.ch/agroscope/en/home/topics/economics-technology/farm-management/za-bh.html

2016; no breakdown into individual typologies of direct payments is available. The ISS contains only broad aggregates for expenses for inputs and services, and lacks the detailed breakdown of the RFS.

The aforementioned specificities translate into **two main limitations to the assessment**:

1. Only an assessment of the **aggregate influence of "direct payments as a whole"** on Swiss farmers' WTP can be made:
    a. with reference to the 2014-2017 programming period;
    b. in comparative terms between the 2010-2013 and 2014-2017 programming periods.
2. An assessment of the influence of "direct payments as a whole" on the expenses for **specific typologies of inputs/services** (e.g. fertilisers, plant protection, insurance, contract machinery work, etc.) can be made for the 2003-2013 period only.

Quantitative analyses are performed by extracting "**balanced panels**" from these datasets . This means that individual farms in the samples are always the same over the entire period considered. The balanced panel extracted from the RFS for the 2010-2014 period includes 1,399 farms; the balanced panel extracted from the ISS for the 2015-2016 period includes 1,531 farms.

**On these panels, three types of variables** are identified for the application of the foreseen methodology:

1. **"Treatment variable"**, aimed at measuring the intensity of policy support to farmers. As explained below, the "**intensity of support**" is a **measure of the different levels of support** granted to individual farmers which is **independent from farm size**.
2. **"Outcome variable"**, aimed at measuring the intensity of farmers' response to policy support in terms of expenses for the purchase of variable inputs and services.
3. **"Confounding variables"** which take into account the possible influence of factors other than policy support (e.g. geography, farm specialisation, farm structure, education or age of farmers, etc.) on both expenses for inputs and services.

**Both treatment and outcome variables are expressed in relative terms** (i.e. as ratios to "agricultural revenues" or other proxies of farm size), to make the **quantification of both treatment and response independent from farm size**. To ensure consistency with the outcome variable (as defined below), "**agricultural revenues**" correspond to the "value of raw output from agricultural production"[13] in the Agroscope datasets; this variable includes revenues from crop farming and animal farming, and excludes revenues from "para-agricultural activities" (e.g. on-farm sale of processed agricultural products) and – above all – **direct payments**.

The **treatment variable** is defined as the ratio between i) the total amount of direct payments granted to the farm and ii) its agricultural revenues (as defined above) or alternative proxies for farm size.

The **outcome variable** is alternatively defined:

1. In **aggregate terms**: sum of (material costs for crop farming) + (material costs for animal farming) + (expenses for insurances, for work by third parties and for machine rental) on agricultural revenues. Material costs for crop farming and animal farming only include variable input costs.
2. In terms of **expenses for specific typologies of inputs or services** on agricultural revenues. The following typologies are considered in the assessment: fertilisers; plant protection; concentrated feed; veterinarian services and drugs; work by third parties and machine rental; insurances.

As within the adopted methodologies the inclusion of categorical variables may be problematic, when possible confounding variables are defined as continuous variables. This implies that some **confounding variables** provided as categorical variables (CAT) in the AGROSCOPE dataset (e.g. region, farm type) are

[13] "Rohleistung aus landwirtschaftlicher Produktion".

expressed through **sets of continuous variables** (CON), which were identified as the best available proxies in the dataset:

1. **Region** (CAT): plains, hills, mountains **=>** considered in terms of **altitude of the farm** (CON).
2. **Farm type** (CAT): arable crops; special crops; dairying; suckling cows; other cattle; horses/sheep/goats; pigs/poultry; combined dairying + arable crops; combined suckling cows + arable crops; combined pigs/poultry + arable crops; combined others **=>** considered in terms of **% share of usable agricultural area under arable crops, permanent crops and permanent pastures/meadows** (CON), also taking into account the presence/absence of animal farming (see point 6).
3. **Education of farmers** (CAT): no vocational training; currently receiving education / training; apprenticeship / vocational training completed; further education; college of applied sciences, higher education.
4. **Age of farmers** (CON).
5. **Usable agricultural area** (CON)
6. **Total size of livestock herd** (CON)**.**

The assessment is performed through methodological approaches belonging to the so-called **Treatment Effects (TE) Econometrics**, whose basic underlying logic consists in evaluating the policy in question as the "response" (of the outcome variable) to a "treatment" and recreating the (statistical) conditions of an experiment even though observational rather than experimental data are used. For this reason, such approaches are sometimes called "quasi-experimental" methods. Different intensity of support at farm level corresponds to different "treatment intensity".

This "quasi-experimental" logic is here adopted to **answer a sequence of two policy questions**:

1. Question 1: what was the impact of the pre-reform policy support system (i.e. the one applying until 2013) on the farmers' input/service purchase behaviour?

2. Question 2: what was the impact on this purchase behaviour of the 2014 reform of the system of direct payments?

Question 2 is answered through the following **sequence of analyses**:

a. Comparing the pre-reform (2010-2013 period) with the post-reform (2014) purchase behaviour.

b. Analysing the purchase behaviour under the post-reform constant policy regime (2015-2016 period).

In order to properly apply the "quasi-experimental" logic to these policy questions, **three balanced panels** are used:

- The 2010-2013 RFS balanced panel (**Panel 1**) for question 1.

- The 2010-2014 RFS balanced panel (**Panel 2**) for the comparative analysis under question 2.a.

- The 2015-2016 ISS balanced panel (**Panel 3)** for the analysis under question 2.b.

These panels allow performing three cross-sectional comparisons[14]. **Panel 1** and **Panel 3** are used to compute farm-level averages of the variables under analysis over four years (2010-2013) and two years (2015-2016), respectively. Comparison is thus performed on these farm-level averages. **Panel 2** is used to compute as treatment and outcome variables the farm-level pre-reform (2010-2013 average) vs. post-

[14] A cross-sectional sample is made of individuals observed at the same point of time (it can be the same year but also the same period of time if the average or the variation is taken). Therefore, a cross-sectional comparison indicates a comparison across individuals of a cross-sectional sample.

reform (2014) variations of the respective indicators. Comparison is thus performed on these farm-level variations. In all these comparisons and when controlling for the confounding variables, the relationship between the outcome and the treatment variables is investigated within a Multivalued Treatment (MT) approach that estimates such relationship as a Dose-Response Function (DRF) whose first-order derivative eventually expresses the Treatment Effect (TE) of interest.

# 2 IDENTIFICATION AND CLASSIFICATION OF POTENTIALLY RELEVANT SUPPORT MEASURES

As underlined at § 1.4, some specificities of the datasets of farm-level microdata available at Agroscope did not allow for a "measure by measure" assessment of the influence of policy support on Swiss farmers' WTP. This notwithstanding, the identification and classification of individual measures which are potentially more relevant in this respect, due to their intervention logic and implementation mechanisms as well as to their relative importance in providing support to the Swiss agricultural sector, is important for the interpretation of the results of the assessment.

The **relative importance of individual measures** can be appreciated from the extent of expenditure by the Swiss Confederation for their funding (see Table 2.1).

The **importance of direct payments** (accounting for nearly 77% of Federal expenditure in 2016) in providing support to the Swiss agricultural sector is clear, and confirms that it is opportune to focus on them in the quantitative assessment (see § 1.4).

By contrast, measures aimed at improvement of production potential and accompanying social measures (4% of Federal expenditure in 2016) and measures supporting production and marketing (less than 12% of Federal expenditure in 2016) have a much lesser importance. Within the latter group of measures, those aimed at supporting dairy farming accounted by themselves for over 8% of Federal expenditure in 2016.

Safe remaining the importance of support from direct payments for Swiss farmers, it should nevertheless be considered that, according to the approach followed by OECD, **market price support still accounted for around 50% of total support to the agricultural sector in Switzerland** over the 2015-2017 period (OECD, 2018).

As for the appraisal of **potential relevance of measures by virtue of their intervention logic and implementation mechanism**, a synthetic overview of the key features[15] is provided for the main support measures with direct (§ 2.1) and indirect (§ 2.2) influence on farmers' WTP, with **special attention to direct payments**.

[15] The description is based on information provided:

- on the website of the Federal Office for Agriculture (FOAG): https://www.blw.admin.ch/blw/de/home/politik.html and https://www.blw.admin.ch/blw/de/home/instrumente.html
- on the *Agrarbericht 2017* online edition: https://www.agrarbericht.ch/de

*Table 2.1 – Expenditure by the Swiss Confederation for agriculture and food policy (1,000 CHF; calendar years)*

| Agrarbericht wording (German version) Ausgabenbereich | *English translation Domain* | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | % of total (2016) |
|---|---|---|---|---|---|---|---|---|
| **A) Aufgabengebiet Landwirtschaft und Ernährung** | **Tasks concerning agriculture & food** | **3 663 016** | **3 711 112** | **3 705 974** | **3 692 510** | **3 667 267** | **3 659 325** | **100,0%** |
| **A.1) Innerhalb Zahlungsrahmen** | **Within the expenditure threshold** | **3 370 376** | **3 441 200** | **3 438 065** | **3 429 696** | **3 385 284** | **3 384 246** | ***92,5%*** |
| A.1.1) Grundlagenverbesserung & Soziale Begleitmassnahmen | Improvement of production potential and accompanying social measures | 134 666 | 191 902 | 189 244 | 184 090 | 159 564 | 148 009 | 4,0% |
| *Strukturverbesserungen* | *Structural upgrading* | *83 000* | *87 000* | *87 808* | *89 157* | *94 659* | *83 808* | *2,3%* |
| *Tierzucht und genetische Ressourcen* | *Crop farming & animal farming* | *37 646* | *37 958* | *37 747* | *36 973* | *37 549* | *38 479* | *1,1%* |
| | *Other disbursements* | *14 021* | *66 944* | *63 689* | *57 960* | *27 356* | *25 722* | *0,7%* |
| A1.2) Produktion und Absatz | Production & marketing | 440 805 | 440 104 | 450 089 | 430 739 | 430 535 | 434 462 | 11,9% |
| *Qualtitäts- und Absatzförderung* | *Promotion of quality products & marketing* | *55 385* | *55 900* | *56 366* | *59 736* | *60 797* | *62 246* | *1,7%* |
| *Milchwirtschaft* | *Dairy economy* | *295 311* | *300 738* | *301 329* | *295 530* | *295 436* | *295 492* | *8,1%* |
| *Viehwirtschaft* | *Animal farming* | *12 423* | *11 490* | *11 846* | *11 876* | *11 967* | *12 166* | *0,3%* |
| *Pflanzenbau* | *Crop farming* | *77 686* | *71 976* | *80 549* | *63 597* | *62 335* | *64 558* | *1,8%* |
| A.1.3) Direktzahlungen | Direct payments | 2 794 905 | 2 809 194 | 2 798 732 | 2 814 866 | 2 795 185 | 2 801 776 | 76,6% |
| *Direktzahlungen Landwirtschaft* | *Direct payments in agriculture* | | | | *2 814 866* | *2 795 185* | *2 801 776* | *76,6%* |
| *Allgemeine Direktzahlungen* | *General direct payments* | *2 181 905* | *2 177 894* | *2 150 471* | | | | |
| *Ökologische Direktzahlungen* | *Environmental direct payments* | *613 000* | *631 300* | *648 261* | | | | |
| **A.2) Ausserhalb Zahlungsrahmen*** | **Beyond the expenditure threshold** | **292 640** | **269 912** | **267 909** | **262 815** | **281 982** | **275 078** | ***7,5%*** |
| **B) Ausgaben ausserhalb der Landwirtschaft**** | **Expenditure outside agriculture** | **146 040** | **145 102** | **145 488** | **146 836** | **150 022** | **147 672** | |

* administration, controls, etc.
** Support to Research & Development, contributions to United Nations Food and Agriculture Organisation (FAO), etc.
Source: adapted from FOAG, *Agrarbericht 2017*.

## 2.1 Measures with direct influence on willingness to pay for input goods and services

As explained at § 1.2, the theoretically relevant measures are those concerning:

1. **Support to investments** (*fixed inputs: facilities, machinery, equipment, etc.*)
2. Support to **purchase and use of specific variable inputs/services,** due to their innovative nature and/or to their contribution to achieving specific objectives (*environment conservation, efficient use of natural resources,* etc.).

The intervention logic of these measures is based on **provision of financial support to reduce disbursements by farmers to purchase fixed or variable inputs**. Reduced disbursements may (or may not) translate into increased farmers' WTP, as an increased amount of farmers' own financial resources becomes available. In any case, provision of financial support is conditional to the purchase of fixed or variable inputs.

In Switzerland, most of support falling under the typologies at points 1 and 2 above comes from **measures aimed at structural upgrading**[16]. Support under these measures is provided to individual farmers in the form of refundable loans at zero interest rate. However, total Federal expenditure for these measures is relatively limited in Switzerland (around 84 million CHF in 2016; see Table 2.1). In addition, Swiss Cantons disbursed around 300 million CHF in **credits for investments** in 2016. Most of these credits concerned the construction of rural buildings (over 262 million CHF for individual projects and over 22 million CHF for collective projects). Also in this case, support to individual farmers is provided in the form of refundable loans at zero interest rate.

Overall, **the importance of measures with direct influence on farmers' WTP is rather limited in Switzerland**. In addition, it should be noted that support to investments in Switzerland is not provided in the form of non-refundable contributions, and this should further limit its potential impact on farmers' WTP. Swiss farmers must refund the financial support granted to them for structural upgrading, even if at favourable conditions (zero interest rate).

## 2.2 Measures with indirect influence on willingness to pay for input goods and services

As explained at § 1.2, the theoretically relevant measures are the following:

1. Measures where support is **conditional to use of inputs/services**, but does not necessarily imply their purchase:
    a. Direct payments conditional to the carrying out of farming activities.
    b. Border protection measures.
    c. Measures supporting production and/or marketing of domestic products, quality products, GI products, etc.
2. Measures where support is **not conditional to use of inputs/services**, and hence does not necessarily imply their purchase:
    a. Measures granting additional support to farmers which is conditional to subjective and/or objective requirements (age, gender; geographical location of farms/plots; etc.)

It is important to underline that the classification of support measures under the above typologies presents some challenges, and may not be clear-cut. For instance, eligibility to support from direct payments or from measures supporting production and marketing, and/or the intensity of such support, can be partially

[16] See: https://www.agrarbericht.ch/de/politik/strukturverbesserungen-und-soziale-begleitmassnahmen/strukturverbesserungen

related to objective requirements (especially geographical location of farms/plots: e.g. higher payments per hectare in certain areas with specific conditions). This implementation solution establishes a link between these typologies of support measures and measures granting additional support to farmers which is conditional to subjective and/or objective requirements.

It is equally important to note that eligibility for support from certain measures (especially those focusing on organic farming, animal welfare, and conservation of the environment, biodiversity, rural landscape and natural resources) may actually imply lower/no use of certain inputs (such as agrochemicals, concentrate feed, etc.), but also higher use of other inputs (such as manual labour or machinery work).

*The **intervention logic** of each relevant typology of support measures, its **linkage with farmers' WTP**, and the most important **forms of practical implementation in Switzerland** are outlined in the following sections.*

**Direct payments** conditional to the carrying out of farming activities basically grant additional resources to farmers: these additional resources may (or may not) be used:

- to purchase additional quantities of inputs/services;
- to purchase inputs/services at higher prices.

In any case, direct payments can indirectly increase farmers' WTP by providing additional financial resources which can be allocated (at least in part) to additional purchase of inputs/services.

Table 2.2 provides a breakdown of Federal disbursements for the different typologies of direct payments since 2014. The slight differences with the aggregate figures in Table 2.1 (e.g. 2.80 billion CHF vs. 2.79 billion CHF for 2016) derive from the consideration of different reference periods (calendar years vs. contribution years)[17].

In 2016, around 1,091 million CHF were granted to Swiss farmers in the form of **direct payments for supply security**[18]. These include the basic payment (75% of total expenditure for this type of direct payments), the payment for challenging production conditions (15% of expenditure; its granting is conditional to objective requirements concerning the farms/plots) and the payment for arable land and permanent crops (10% of expenditure). Always in 2016, substantial Federal expenditure was also allocated to **direct payments for agricultural landscape conservation**[19] (around 507 million CHF) and **direct payments for biodiversity**[20] (around 400 million CHF), whose granting is also conditional to objective requirements. Another important form of direct payments is aimed at supporting production systems (around 458 million CHF of Federal expenditure in 2016). **Direct payments for production systems**[21] include contributions for: welfare of farmed animals (around 270 million CHF of Federal expenditure[22]); fodder-based meat and dairy farming (109 million CHF of Federal expenditure); organic farming (45 million CHF of Federal expenditure); extensive production of cereals, sunflower, rapeseed and protein crops (34 million CHF of Federal expenditure). Other

[17] As explained in the *Agrarbericht 2017* online edition, whereas figures in Table 2.1. are referred to calendar years ("Kalenderjahre"), figures in Table 2.2 are referred to the entire contribution year ("Beitragsjahr"). See https://www.agrarbericht.ch/de/politik/direktzahlungen/finanzielle-mittel-fuer-direktzahlungen

[18] See: https://www.agrarbericht.ch/de/politik/direktzahlungen/versorgungssicherheit?_k=NnO4X99N&1401&_n

[19] These include: the contribution for preservation of open landscapes (28% of total expenditure for this typology of direct payments in 2016); the contribution for summer pastures (25% of total expenditure); the contribution for transfer to alpine pastures (22% of total expenditure); the contribution for the use of steep-sloping agricultural areas (21% of total expenditure); the contribution for the use of extremely steep-sloping agricultural areas (2% of total expenditure); the contribution for steep-sloping vineyards (2% of total expenditure).

See: https://www.agrarbericht.ch/de/politik/direktzahlungen/kulturlandschaft?_k=zJTdhxra&138&_n

[20] See: https://www.agrarbericht.ch/de/politik/direktzahlungen/biodiversitaet?_k=IISp__8G&1407&_n

[21] See: https://www.agrarbericht.ch/de/politik/direktzahlungen/produktionssysteme?_k=ADhzFqg4&1410&_n

[22] Around 189 million CHF for the RAUS-program and around 80 million CHF for the BTS program.

forms of direct payments are targeted at **improving the quality of rural landscape** (142 million CHF of Federal expenditure in 2016) and at **promoting protection and efficient use of natural resources** (37 million CHF of Federal expenditure). Finally, the so called "**transition contributions**" (162 million CHF of Federal expenditure in 2016) are aimed at ensuring a socially sustainable transition towards the reformed system of direct payments in the 2014-2017 programming period[23].

*Table 2.2 - Expenditure by the Swiss Confederation for direct payments (million CHF; contribution years)*

| Agrarbericht wording (German version) | *English translation* | | | | % of total (2016) |
|---|---|---|---|---|---|
| **Ausgabenbereich** | ***Domain*** | **2014** | **2015** | **2016** | |
| Kulturlandschaftsbeiträge | Direct payments for agricultural landscape conservation | 496 | 504 | 507 | 18% |
| Versorgungsicherheitsbeiträge | Direct payments for supply security | 1 096 | 1 094 | 1 091 | 39% |
| Biodiversitätsbeiträge | Direct payments for biodiversity | 364 | 387 | 400 | 14% |
| Landschaftsqualitätsbeitrag | Direct payments for improving the quality of rural landscape | 70 | 125 | 142 | 5% |
| Produktionssystembeiträge | Direct payments for production systems | 439 | 450 | 458 | 16% |
| Ressourceneffizienzbeiträge + Beiträge für Gewässerschutz- und Ressourcenprogramme | Direct payments for promoting protection and efficient use of natural resources | 37 | 43 | 37 | 1% |
| Übergangsbeitrag | Transition contributions | 308 | 178 | 162 | 6% |
| Kürzungen/Vor- und Nachzahlungen usw. | Reductions/advances & additional payments | - 6 | - 2 | - 4 | |
| **Gesamt** | **Total** | **2 804** | **2 779** | **2 792** | **100%** |

Source: adapted from FOAG, *Agrarbericht 2017*.

**Border protection measures** are aimed at ensuring higher selling prices and/or larger marketed volumes for domestic agricultural products, thanks to reduced competitive pressure from imported products. These more favourable market conditions may (or may not) translate into purchase of additional quantities of inputs/services, and/or in their purchase at higher prices. When this happens, border protection measures indirectly increase farmers' WTP; this effect clearly concerns only farmers producing products which benefit (directly or indirectly, as in the case of border protection granted to processed agricultural products) from border protection.

Switzerland applies border protection (mainly in the form of import tariffs and tariff rate quotas) to a wide array of agricultural products and processed food products. As already underlined, border protection still plays an important role in providing support to Swiss farmers (OECD, 2018). However, the influence of this form of support on farmers' WTP cannot be assessed at individual farm level through the approach outlined at § 1.4, as the level of market price support provided through border protection is not differentiated across farms.

[23] Transition contributions ("übergangsbeitrag") should help farmers to adapt to the new conditions; their amount gradually decreases over the years.

See: https://www.blw.admin.ch/blw/de/home/instrumente/direktzahlungen/uebergangsbeitrag.html

**Measures supporting production and/or marketing** of domestic products, quality products, products with geographical indications, etc. may ensure additional revenues, higher selling prices and/or larger marketed volumes for Swiss agricultural products. These additional resources or more favourable market conditions may (or may not) translate into purchase of additional quantities of inputs/services, and/or in their purchase at higher prices by Swiss farmers. When this happens, these measures indirectly increase farmers' WTP; of course this effect is limited to farmers producing directly or indirectly supported products (indirect support is provided through measures supporting processed agricultural products).

Support to production and/or marketing of agricultural and food products in Switzerland is mainly provided in the form of:

- The already mentioned **direct payments for production systems**, which accounted for a Federal expenditure of around 458 million CHF in 2016 (see Table 2.2).
- **Supplement to milk price**, which is granted to Swiss dairy farmers through cheese producers purchasing milk for processing. This measure was funded with a Federal expenditure of over 295 million CHF in 2016 (see Table 2.1).
- **Coupled payments for specific crops** (mainly sugar beet and rapeseed). These accounted for a Federal expenditure of over 64.5 million CHF in 2016 (see Table 2.1).

There is finally the case of **measures granting additional support to farmers which is conditional to subjective and/or objective requirements** (age, gender; geographical location of farms/plots; etc.). Also these measures grant additional resources to farmers, which may (or may not) be used to purchase additional quantities of inputs/services, and/or to purchase inputs/services at higher prices. Also these measures may hence indirectly increase farmers' WTP.

Besides the already highlighted examples of support conditional to objective requirements, the most significant form of support conditional to subjective requirements of beneficiaries in Switzerland is the **initial support to young farmers**, granted in the framework of national rural development policy. Federal expenditure for this type of start-up support amounted to 80 million CHF in 2016[24].

[24] See: https://www.blw.admin.ch/blw/de/home/instrumente/laendliche-entwicklung-und-strukturverbesserungen/investitions--und-betriebshilfen/nichtbauliche-massnahmen.html and https://www.agrarbericht.ch/de/politik/strukturverbesserungen-und-soziale-begleitmassnahmen/strukturverbesserungen for the related funding.

# 3 THE EXPECTED IMPACT OF DIRECT PAYMENTS ON INPUT USE

This chapter provides a **reference theoretical framework for the empirical assessment of the effect of policy support on Swiss farmers' WTP for variable production inputs** (see § 4). Economic theory provides a helpful conceptual background to anticipate and interpret this empirical evidence. The chapter moves from an overview of the key theoretical concepts concerning the farm-level relationship between production levels and input use (§ 3.1) to a theoretical analysis of the effect of direct payments on farm production levels (§ 3.2), and finally establishes a linkage between the reference theoretical framework and the empirical assessment made at § 4, focusing on the **impact of direct payments on input use** (§ 3.3).

In principle, a micro (farm-level) and an aggregate/macro (market or economy-wide) level should be considered in the theoretical analysis of the impact of policy support.

The **farm-level** impact of policy support depends on how farmers decide to use this support, i.e. on their response to it. When policy measures are directly aimed at supporting the purchase of inputs, the link between policy and response is rather straightforward. When the support takes the form of direct payments, as in the case under study here, the direction and magnitude of farmers' response is less obvious. In such case, in fact, the response in terms of input use is an indirect effect of support. Direct payments affect farm income/revenues in the first place: this, in turn, affects farmers' production decisions and, finally, on-farm use of inputs to pursue those production decisions.

The impact of policy support at the **aggregate or macro level** (market or economy-wide) is even less predictable. As clearly shown by the literature on this topic and, in particular, by studies based on large multi-equational market models (Chantreuil et al., 2012; Brady et al., 2017), any response in terms of production and input use produces a feedback on the respective prices. On the output side, production growth generates a negative effect on prices that may downsize, completely offset or even revert the expected impact of support[25]. On the input demand side, a higher use of inputs induces a positive effect on prices that, in turn, reduces the demand response itself[26].

However, the assessment of such aggregate effects on prices is not part of this study. This does not mean that it is assumed here that input prices do not react to the overall level of support. It simply means that the farm-level response is assessed here under the assumption that, within the panel, output and input prices are constant in the cross-sectional dimension and, though they can vary over time, also their dynamics are assumed to be the same across all farms[27]. Given this assumption on input prices, **the impact on input use in terms of quantity corresponds to the impact in terms of expenditure**: within a cross-sectional comparison, if all farms face the same price levels or dynamics, the differences observed among them in terms of expenditure for inputs are only due to differences in the quantities of inputs used. This allows to perform the investigation by looking at the expenditure for inputs rather than at the quantities of

[25] "[…] the additional supply generated by direct payments also lowers output prices, which reduces the profitability of commodity production; thereby partially offsetting the additional revenues from direct payments" (Brady et al., 2017, p. 8).

[26] If seen from the perspective of the agricultural household as a consumption unit and not only as a production unit (the farm), the relationship between input demand response and market price adjustment may be even more complex. In particular, it can be expected that a higher support implies higher income of the agricultural household, and this may decrease the demand elasticity to input prices: if farmers receive higher support, their demand reacts less strongly to price growth than at lower support. This may have relevant implications for the study, because in the presence of trade barriers (including natural trade barriers such as distance), such lower price elasticity is expected to translate into a higher price level of input goods purchased by farmers compared to other countries with lower support. On the relationship among price levels, elasticity of demand and income levels in the standard economic theory, see for instance Frank (2008).

[27] For the same reason, i.e. the focus on micro-level analysis, other possible aggregate impacts of direct payments, which are highly emphasised in the reference literature, are disregarded here. In particular, direct payments may determine medium and long-term structural changes of the agricultural sector, like land abandonment, variation in the average farm size, variation of the off-farm labour, etc.

inputs used. This assumption seems plausible just because the analysis is performed at the micro level, i.e. with farm-level data, and it seems reasonable to assume that farms face the same price levels and dynamics whenever they all behave as price takers on the same markets.

It remains true that, as the response to direct payments measured in this farm-level study does not include the response of prices, the results presented here might overestimate the impact that would be actually observed at the aggregate level.

## 3.1 The farm-level relationship between production levels and input use

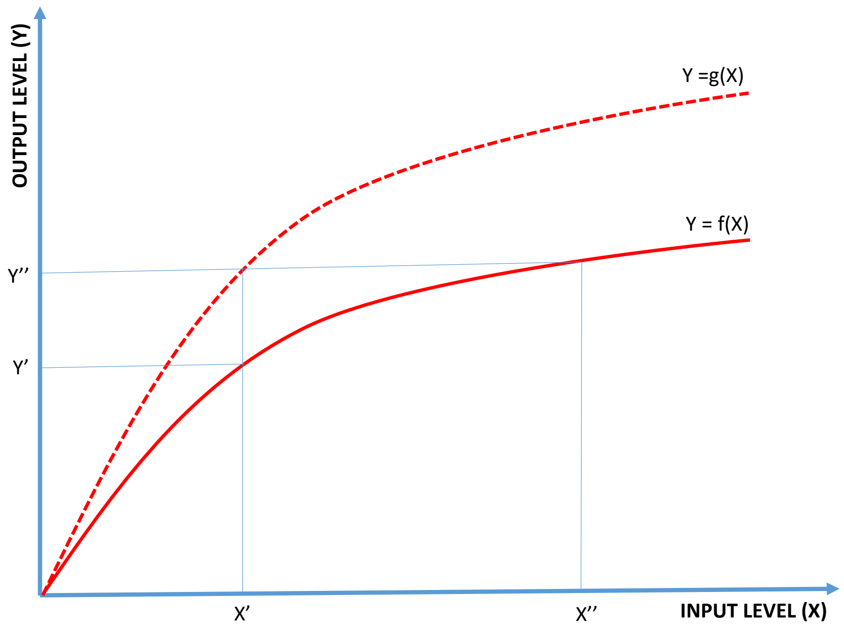
The standard (i.e. the so called "neoclassical") firm/farm equilibrium theory is based on the *production function* Y = *f* (X), where Y stands for production volume and X for the quantity of variable production inputs. This functional relationship expresses the state of the current technology available to the farm and allows to identify its equilibrium under the given market conditions (i.e. input and output prices). This equilibrium is found at that level of input use X - and hence at the consequent output level Y = *f* (X) - that maximizes the farm's profit. For this equilibrium to exist, the assumption of decreasing marginal productivity[28] of all inputs is typically made. Under this assumption, the profit maximising condition is the equalisation of marginal revenue (corresponding to the price of Y) to marginal cost.

The main implication of this assumption is that if some production inputs can be considered as fixed in the short term (the so called "quasi-fixed" inputs: typically land, capital and at least part of labour), an increase in output can only be obtained through a more than proportional increase in the use of variable inputs. In practice, for only one output Y and one variable input X, it is assumed that the production function takes the concave shape represented in Figure 3.1. As a further consequence, a larger output level (Y''>Y') implies a higher X/Y (input/output) ratio (X''/Y''>X'/Y'). If we call the X/Y ratio "input intensity", the conclusion is that the assumption of decreasing marginal productivity of X, under a given technology and with a fixed combination of some other inputs, implies ***input intensification*** associated to an output increase.

However, under the assumption that production technology is not fixed and hence that the production function can shift from *f* (X) to *g* (X), and/or under the assumption that all inputs are variable (i.e. that there are no quasi-fixed inputs), an increase in output from Y'' to Y' could be obtained with a less than proportional increase in the use of a given input X, or even with the same initial quantity of input X'. In such case, the output increase is associated to an ***input extensification***, i.e. to a reduction of the X/Y ratio.

[28] This means that the additional production volume obtainable from an additional unit of input gradually decreases to a point where it becomes zero.

*Figure 3.1 – Graphical representation of the production function and of the consequent input-output ratio (X/Y)*




According to the above theoretical framework, **understanding how direct payments affect input use implies two logical steps**: i) how direct payments affect the marginal revenue, thus inducing an increase in output; ii) whether an increase in output implies input intensification or extensification.

## 3.2 How do direct payments affect farm production levels?

The empirical assessment carried out at § 4 deals with the impact on farmers' choices, and in particular on those concerning input use, of direct payments and of possible changes in their amount. Despite the wide empirical literature produced on the effects of direct payments at different aggregation levels (from individual farms to entire countries) and on several aspects (from off-farm labour to land rental prices) (Anton, 2006; OECD, 2011), few studies have actually focused on the direct farm-level assessment of how large the response to the direct payments has been, in particular in terms of increase/decrease in input use.

In fact, the existing literature suggests that the response to direct payments may depend on many different aspects and, therefore, its empirical assessment incurs a set of complex theoretical and methodological issues. More importantly, this complexity implies that the response significantly differs across farms due to their heterogeneity, as expressed by the set of structural features eventually affecting their response. Providing empirical evidence on the issue requires farm-level approaches admitting heterogeneity of the determinants of this response. These determinants are many and complex (see Figure 3.2), can be found both inside (internal environment) and outside (external environment) the farm, and include – among others – the farm-level production technology and its rigidity (due to quasi-fixed inputs), the functioning of the (local) input and output markets (which determines input and output prices), credit constraints, the agricultural households' objectives, risk attitude and expectations.

Nonetheless, on the basis of the simple theoretical framework outlined above, some conclusions can be drawn on the expected farm-level impact of direct payments on production volume and on the associated variable input use. In fact, the existing literature does not agree on the eventual aggregate impact of direct payments on agricultural production levels. Such disagreement, however, only depends on the magnitude of the market price feedback mentioned above. If this feedback is large, it may eventually offset the direct payments impact on production possibly observed at constant prices. However, as discussed, the empirical assessment at § 4 is performed at the farm level through cross-sectional comparisons, and this implies that the assumption of constant prices can be reasonably maintained. In this respect, **there is a substantial agreement in the existing literature that the farm-level response to direct payments at constant prices is positive for both production levels and input use**. When coupled to a specific production activity, direct payments evidently increase the farm marginal revenue thus moving the profit maximisation equilibrium to a higher production level. However, this positive effect on production induced by the direct payments holds even for (totally or partially) decoupled payments. In practice, **it is generally accepted that a decoupled payment at least partially behaves as a subsidisation of agricultural production**, even though the magnitude of this *subsidisation effect* actually remains controversial[29].

The main argument for this subsidisation effect is that an increase of direct payments, even when these are decoupled from production, increases the financial assets of the farm (*financial effect*) or, in other words, makes the farm/household richer (*wealth effect*). The consequence of this effect on production choices is that, under credit constraints and risk aversion, **the higher endowment of financial resources deriving from direct payments allows the farm to buy more inputs and hence push production levels forward** (Hennessy, 1998).

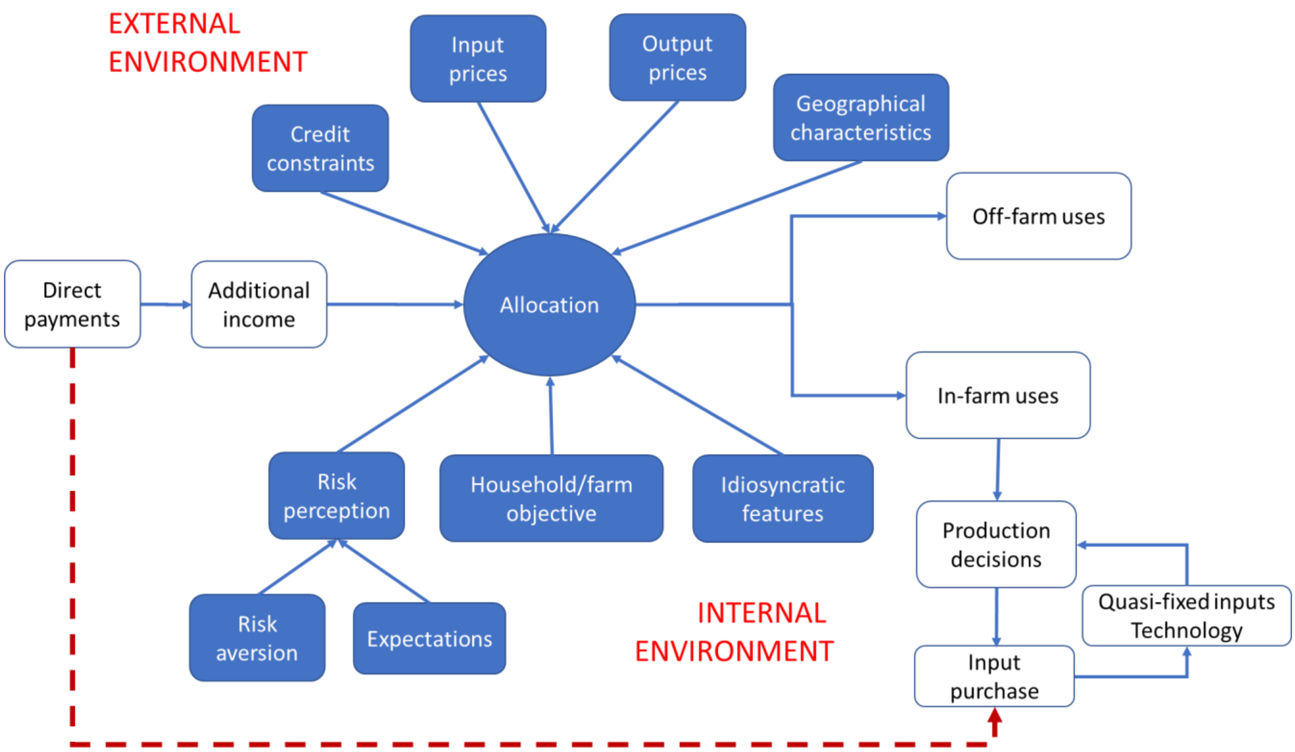
A comprehensive analysis of all possible explanations of the subsidisation effect of decoupled direct payments goes beyond the scope of the present study[30]. These explanations may also include sociological and ethical aspects and, above all, may apply differently across heterogeneous farms. Indeed, the inclusion of the so called "confounding variables" in the assessment methodology (e.g. farm typologies, farmers' age and education, etc.: see § 1.4) is aimed at addressing, at least in part, the possible influence of such factors on each farm's response to direct payments.

The complexity of the whole set of aspects discussed in the existing literature which should - in principle at least - be considered in the analysis of the impact of direct payments on farm production decisions is outlined in Figure 3.2. However, **leaving aside all the theoretical complexity, the empirical investigation carried out for the study focuses on the most straightforward linkage between direct payments and input use** (represented by the red dashed line in Figure 3.2), which is discussed at § 3.3.

[29] "Changes in decoupled payment values lead to responses by farmers that are analogous to, but smaller than, farmers' responses to changes in agricultural output prices" (Esposti et al., 2012, p. 42).

[30] For an extensive discussion on the point, see Goodwin and Mishra, 2005, OECD, 2006, Serra et al., 2006, Bečvářová, 2007, Rude, 2008, and Moro and Sckokai, 2011.

*Figure 3.2 - Effect of direct payments on farmers' production choices: overall conceptual framework*




## 3.3 From the theory to the empirics: the impact of direct payments on input use

Regardless the possible underlying motivations, the theoretical framework outlined at § 3.1 and 3.2 clearly indicates that **the linkage between direct payments and input use is not necessarily unidirectional**, that is, it does not imply a univocal response in terms of input-output ratio (X/Y). As shown in Figure 3.1 at § 3.1, a farm-level increase in production - which can be induced by direct payments, as explained at § 3.2 - may be associated to either intensification or extensification in input use. If technology and some inputs are assumed as fixed, the variable input-output ratio (X/Y) is expected to increase, and intensification in input use is hence expected. On the contrary, one of the financial effect of direct payments - as explained at § 3.2 - could be to allow the farmers to improve the endowment in quasi-fixed inputs (land, capital, some forms of labour) and to adopt new (and better) technologies, thus achieving a reduction of the variable input-output ratio, i.e. an efficiency gain for variable input use. However, **the impact of direct payments on quasi-fixed inputs endowment and use can be more complex**. For instance, another consequence of the "wealth effect" of direct payments discussed at § 3.2 is that it makes the family labour (typically considered as a quasi-fixed input) implicitly more expensive, due to the higher value of leisure time. This may induce farmers to partially substitute their own / their family's labour with other variable inputs, and in particular with work by third parties and rented machinery work (which are considered in the empirical assessment at § 4). This reduction of the farmers' effort may also take the form of lower efficiency in variable input use (the farm falls below the production function frontier depicted in Figure 3.1 at § 3.1), and hence of a higher variable input-output (X/Y) ratio (intensification of input use) (Ferjani, 2008). As a consequence of this combination of effects, while extensification in input use as a response to direct payments cannot be excluded in principle, it is unlikely to be observed at farm level.

Figure 3.3 outlines the two possible theoretical responses to an increase in direct payments. In order to be consistent with the empirical application presented at § 4, and following the assumption of constant prices (see the introduction to this chapter), the X/Y ratio in Figure 3.3 is expressed by aggregate values, i.e. as the ratio between "expenses for variable inputs"[31] and "agricultural revenues"[32]. The direct payments are also expressed as ratio on "agricultural revenues" ("intensity of support"[33]), in order to make this indicator independent from farm size. As explained at § 1.4, the response to direct payments by farmers in terms of expenses for variable inputs takes the form of a "**Dose-Response Function**" (DRF) to a variation in the intensity of support from direct payments ("**treatment intensity**").

In both cases represented in Figure 3.3, the theoretical expectation is that of a *monotone concave* (or non-convex) *response*[34] to direct payments, i.e. of a *decreasing marginal response to a marginal increase of the intensity of support from direct payments*. There are two main arguments supporting this concavity hypothesis. In the first place, the measure of the response to direct payments (expressed as "expenses for variable inputs/agricultural revenues" ratio in Figure 3.3) may encounter upper and lower bounds, so once it approaches the maximum/minimum, a further increase in the treatment intensity (expressed as "direct payments/agricultural revenues" ratio in Figure 3.3) cannot induce a further response[35]. Therefore, it can be argued that the closer the response to these bounds, the lower the marginal response. In the second place, the production response encounters some rigidity (production technology; endowment of quasi-fixed inputs) taking the form of high adjustment costs in practice. Farms start adjusting without incurring particular adjustment costs; then, further adjustments induced by higher treatment intensity encounter increasing difficulties (costs), and this will then be reflected in a decreasing response to a marginal increase of the treatment intensity.

The response to direct payments displayed in Figure 3.3 can be more intuitively expressed in terms of the **Treatment Effect** (TE), i.e. the marginal response of the farm to a unit increase in the intensity of support from direct payments it receives. This is simply the first order derivative of the response function, thus its slope. As is evident in Figure 3.3, in both cases, the monotone concave response implies a monotone TE which is positive but declining to 0 in the case of intensification, while it is negative but growing to 0 in the case of extensification.

[31] As explained at § 1.4, "expenses for variable inputs" cumulate the expenses for variable inputs for crop farming and animal farming and the expenses for work by third parties and machine rental.

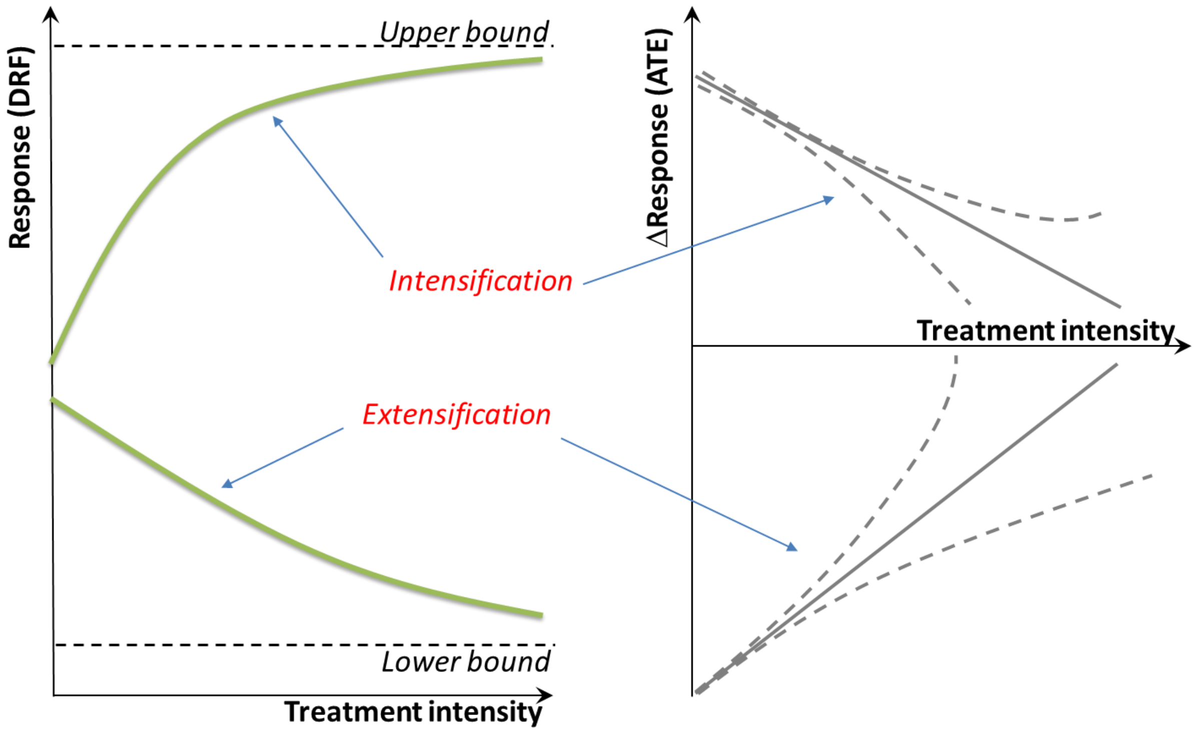
[32] As explained at § 1.4, "agricultural revenues" cumulate revenues from crop farming and animal farming, and exclude revenues from "para-agricultural activities" (e.g. on-farm sale of processed agricultural products) and direct payments.

[33] As explained at § 1.4, the "intensity of support" is a measure of the different levels of support granted to individual farmers which is independent from farm size.

[34] Monotone concave response indicates a response that always moves in the same direction (always increasing or always decreasing) but whose movement always decelerates. From a mathematical point of view it is a function that shows either a positive first order derivative and a negative second order derivative, or a negative first order derivative and a positive second order derivative.

[35] Evidently, expenses for variable inputs cannot be negative and the ratio "expenses for variable inputs/agricultural revenues" cannot go below 0. At the same time, this ratio can approach 1, and occasionally also exceeds 1, but still 1 represents a sort of "upper bound" for this indicator.

*Figure 3.3 - Input use (expenses for variable inputs/agricultural revenues) response to direct payments under increasing treatment intensity (direct payments/agricultural revenues)*




In the end, **the present study aims to empirically assess which kind of farm response** in Figure 3.3 **can be eventually detected on the basis of real-world data**. Two aspects are worth noticing to define the proper empirical approach in this respect. First of all, in order to provide robust evidence on this response function, no complex parametric specifications of the underlying neoclassical technology are needed[36]. As discussed above, theory is needed to provide a consistent interpretation of the empirical results, but it is not needed to generate them. Secondly, as heterogeneity across farms may clearly imply heterogeneous responses by farmers, an empirical approach admitting this heterogeneity should be evidently preferred. Looking for a response like that expressed in Figure 3.3 within a real-world farm sample, a mixed shape can emerge (for instance, a U or an inverted-U shape) simply because the sample combines farms with a different intensity of support from direct payments, and also responding in different (if not opposite) ways to this support. However, widely adopted complex parametric specifications inevitably impose arbitrary restrictions on the underlying farm/household heterogeneity (Serra et al., 2005). In fact, the main advantage in using farm-level data consists in the possibility of taking farms' heterogeneity, and the consequent heterogeneous response to direct payments, fully into account.

For these main reasons, the empirical assessment of the response shape in Figure 3.3. is here performed with an **original empirical strategy that does not need any parametric representation of the underlying production technology**. These research questions are here answered within a **farm-level data-driven approach** where the **direct payments received by a farm are considered as a multivalued *Treatment*** and,

[36] A neoclassical production technology can be specified either with a profit function or with a dual function (cost or profit function). In order to be a good approximation of the real unknown technology (or, in more technical terms, in order to be *flexible*) such specifications must show definite mathematic properties and contain a large number of parameters to be estimated.

consequently, the **response of the farm as a *Multivalued Treatment Effect (MTE)***. The related assessment methodology is explained in detail in the annex (§ 7.1).

# 4 THE ACTUAL IMPACT OF DIRECT PAYMENTS ON SWISS FARMERS' EXPENSES FOR VARIABLE INPUTS

A general explanation of the methodological approach used for the present empirical assessment is provided at § 1.4. Further technical details can be found in the Annex (§7.1).

*The technicalities of the assessment method are rather complex for readers lacking specific knowledge of the methods used. The necessary technicalities are reported for sake of transparency; however, the sections of the following paragraphs focusing on the relevant elements for replying to the study questions are highlighted by a grey background, to improve readability for non-specialist readers.*

Results are provided in a sequence of three different applications in order to assess the robustness of the empirical evidence across different samples of Swiss farms from Agroscope's *Zentrale Auswertung von Buchhaltungsdaten* and across different policy regimes. The sequence is consistent with the chronological order of the available information but also with the respective statistical robustness (the 2010-2014 sample provides a richer and more robust information compared to the 2015-2016 sample). First, the analysis on the 2010-2014 farm sample focuses on the 2010-2013 period, i.e. on the constant policy regime preceding the reform of the system of direct payments. Then, the application is performed in terms of comparison between the pre- and post-reform policy regimes, still using the 2010-2014 sample. The final application concerns the post-reform constant policy regime, and is performed on the 2015-2016 sample. All applications use the time dimension of the panels to either compute farm averages over time (the 2010-2013 and 2015-2016 cases) or time variations (the pre- vs post-reform application). Consequently, all the analyses performed for the study are cross-sectional ones.

## 4.1 Impacts of the pre-reform policy regime (2010-2013)

### *4.1.1 Descriptive evidence*

Table 4.1 reports some descriptive statistics for all variables (treatment variable, outcome variable, confounding variables; see § 1.4 for more details on their definition) for the farms in the 2010-2013 panel. These statistics are provided as averages over the 2010-2013 period in order to appreciate the heterogeneity within the sample (as expressed by standard deviations) in terms of treatment variable, outcome variable and confounding variables. It is worth noticing that such heterogeneity in treatment and outcome variables cannot be the consequence of differences in farm size, since in the present analysis these variables are expressed as ratios in order to be size-independent. Nonetheless, it may still be true that "size matters" due to the different behaviour of farms of different size and, for this reason, some of the adopted confounding variables are expected to control for the role of size in this respect.

Statistics in Table 4.1 suggest that the ratio between direct payments and agricultural revenues[37] (treatment variable) amounts, on average, to 62%, with a significant variability (standard deviation of 57%) as also suggested by the wide range of variation (from a minimum of 2.5% to a maximum of 629.9%). Such variability is also evident when direct payments per hectare of Utilised Agricultural Area (UAA henceforth)

[37] As explained at § 1.4, "agricultural revenues" correspond to the "value of raw output from agricultural production" in the Agroscope datasets; this variable includes revenues from crop farming and animal farming, and excludes revenues from "para-agricultural activities" (e.g. on-farm sale of processed agricultural products) and – of course – direct payments. The above definition of "agricultural revenues" applies to the entire § 4.

are considered. It is therefore essential to control for the confounding variables that can be the source of such heterogeneity.

The ratio between agricultural costs[38] and agricultural revenues (outcome variable) amounts on average to 52%, still with a wide range of variation (from 9% to 492%). Among the different cost components considered for an in-depth assessment (see § 4.1.4), expenses for concentrated feed are those with the highest ratios against agricultural revenues (14% on average), followed by work by third parties (8%) and insurances (7%).

*Table 4.1 - Descriptive statistics of the treatment, outcome and confounding variables (for any farm, the 2010-2013 averages are considered).*

| Variable | UoM* | Obs* | Mean | Std. Dev.* | Min | Max |
|---|---|---|---|---|---|---|
| Dir.Payments/Agr.Revenues | % | 1399 | 62.00 | 57.22 | 2.51 | 629.91 |
| Dir.Payments/UAA | CHF/Ha | 1398 | 2983.42 | 686.89 | 812.42 | 5956.23 |
| Agr.Costs/Agr.Revenues | % | 1399 | 52.16 | 23.37 | 9.24 | 492.37 |
| Agr.Costs/UAA | CHF/Ha | 1398 | 4241.35 | 4222.64 | 392.73 | 43427.15 |
| PlantProtection/Agr.Revenues | % | 1399 | 1.46 | 2.76 | 0 | 59.60 |
| ConcentratedFeed/Agr.Revenues | % | 1399 | 14.23 | 10.46 | 0 | 87.62 |
| VeterinarianDrugs/Agr.Revenues | % | 1399 | 3.45 | 2.58 | 0 | 26.29 |
| WorkThirdParties/Agr.Revenues | % | 1399 | 7.93 | 10.71 | 0 | 251.69 |
| Insurance/Agr.Revenues | % | 1399 | 7.29 | 6.96 | .72 | 126.79 |
| Fertilisers/Agr.Revenues | % | 1399 | 2.12 | 2.73 | 0 | 36.21 |
| Usable Agr. Area (UAA) | Ha | 1399 | 23.07 | 11.05 | 4.15 | 97.89 |
| Altitude | MASL* | 1399 | 695.63 | 241.81 | 300 | 1740 |
| Livestock | N. | 1399 | 30.02 | 21.43 | 0 | 157.07 |
| Farmer Age | Years | 1399 | 47.75 | 8.19 | 24.5 | 69.5 |
| Farmer Education | Levels* | 1399 | 3.30 | .78 | 1 | 5 |
| ArableLand/UAA | % | 1399 | 21.91 | 26.23 | 0 | 97.45 |
| PermanentPastures/UAA | % | 1399 | 61.18 | 34.82 | 0 | 100 |
| PermanentCrops/UAA | % | 1399 | 1.90 | 9.52 | 0 | 99.19 |

* UoM = unit of measurement; Obs = number of observations; Std. Dev. = Standard Deviation; MASL= Meters Above the Sea Level; Levels: 1 = no vocational training; 2 = currently receiving education / training; 3 = apprenticeship / vocational training completed; 4 = further education; 5 = college of applied sciences, higher education.

Figure 4.1 displays the distribution (expressed by the Kernel density) of the treatment variable not only indicating that this distribution is obviously truncated at 0, but also showing a long right-hand tail due the presence of observations with very high ratios. Beyond possible data collection errors, the presence of these extremely high values in both treatment and outcome variables depends on those very few farms that experienced a remarkable decrease of agricultural revenues during the period due to partial, temporary or permanent deactivation or restructuring. These unusual low values of the denominator cause very high values of the respective ratios.

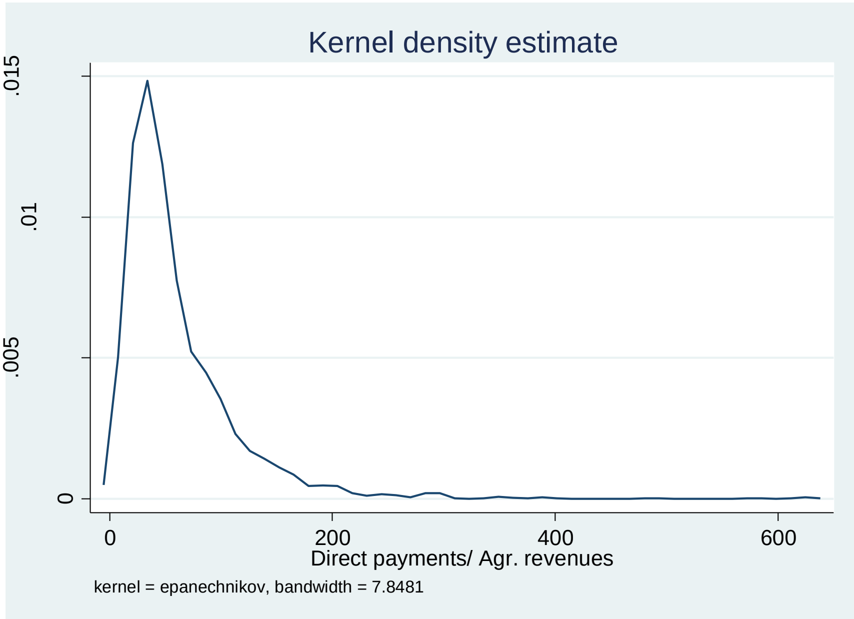
To some extent the shape of the statistical distribution of this sample is typical in any methodology analysing treatments, as they usually cannot be negative by definition. Therefore, the methodology itself

[38] For sake of conciseness, the term "agricultural costs" is used throughout § 4. This term refers to the definition of outcome variable provided at § 1.4, i.e. to the sum of (material costs for crop farming) + (material costs for animal farming) + (expenses for work by third parties and machine rental), where material costs only include expenses for <u>variable</u> inputs.

takes care of the issues raised by this "natural" non-normality of the data by applying proper transformations (e.g. the Box-Cox or the logarithmic transformations) that restore the normality distribution required by these statistical methods. In the present case, these extremely high values might prevent from restoring normality even after such data transformations. Whenever this occurs, these observations are considered as outliers and eliminated from the sample until normality is satisfied.

As Table 4.1 shows, not only the distribution of the treatment variable is truncated at 0 by definition, but its minimum value in the considered sample is 2.51%, indicating the lack of "non-treated" units (i.e. farms which did not benefit from direct payments in the 2010-2013 period) in the sample. This clearly points out that any evaluation relying on a counterfactual framework based on a binary definition of treatment (i.e. "treated" vs. "non-treated" units) cannot be applied in this situation: all farms in the panel benefitted from direct payments in the 2010-2013 period.

*Figure 4.1 - Distribution of the continuous treatment variable: direct payments on farm's agricultural revenues (in %; 2010-2013 averages): Kernel density.*




### 4.1.2 GPS estimation

Following the Hirano and Imbens (2004) approach, the Generalized Propensity Score (GPS) function is here specified as a linear flexible function. The functional form actually estimated is the best fitting specification selected according to the Akaike Information Criterion (AIC) starting from a fully interacted second-order polynomial (quadratic specification). Table 4.2 reports the Maximum Likelihood (ML) estimate of this GPS function[39]. Most estimated parameters are significantly different from 0, the only exceptions being those concerning the farmer age and the share of permanent pastures on the UAA.

The interpretation of these estimates is that, *ceteris paribus*, a greater generalised propensity (that is, a higher probability to achieve a higher direct payments/agricultural revenues ratio) is associated with a

[39] Unlike the DRF estimation (see § 4.1.3), the GPS function is not estimated via the Ordinary Least Squares (OLS) estimation method but via the Maximum Likelihood (ML) estimation method. Therefore, it is not possible to compute indicators like the conventional $R^2$ as a measure-of-fitness quality.

larger farm size (in physical terms) and with farms located in the mountainous areas; roughly speaking, these cases can be designated as "extensive farms". On the contrary, a lower propensity (that is, a higher probability to achieve a lower direct payments/agricultural revenues ratio) is associated with farms evidently showing some kind of intensive specialisation, like the larger presence of livestock and the higher share of arable crops and permanent crops on total UAA. Also farmer education is apparently associated to lower propensity score (higher probability to achieve a lower direct payments/agricultural revenues ratio). As no linkage is observed with the farmer age, the role of education is here not referable to the prevalent correspondence of young farmers to highly educated farmers but, more likely, to the fact that the farmers with higher education tend to orient their activities towards highly specialised intensive farming.

The above results show that treatment assignment to farmers (i.e. the allocation of direct payments to them) is not random, but depends on their specific features (this is consistent with the design of the Swiss policies supporting the agricultural sector). More importantly for the purpose of the present analysis, the above results confirm that **disregarding these confounding variables in estimating the impact of direct payments on input purchase - and hence on agricultural costs - could bring about a significant bias**, since at least part of the effect would be attributed to the treatment (direct payments) while, in fact, it depends on the confounding variables themselves (farm size, specialisation, farmers' education, etc.). This issue is discussed further at §4.1.3.

*Table 4.2 - Hirano-Imbens (2004) ML estimation of the linear GPS function (standard errors in parenthesis)[a]*

| | Coefficient | (std. err.) |
|---|---|---|
| Agricultural Area | 0.0151818 | (0.001) * |
| Livestock | -0.0131685 | (0.000) * |
| Farmer Age | -0.000212 | (0.001) |
| Farmer Education | -0.0504254 | (0.010) * |
| Altitude | 0.000362 | (0.000) * |
| ArableLand/UAA | -0.0050328 | (0.001) * |
| PermanentPastures/UAA | 0.0006739 | (0.000) |
| PermanentCrops/UAA | -0.0157575 | (0.001) * |
| Constant | 3.045125 | (0.080) * |

[a] The Box-Cox transformation of the treatment variable is used
*Statistically significant at 0.05 level

### 4.1.3 Dose-Response Function (DRF) and Treatment Effect (TE) estimation

Table 4.3 reports the results of the second estimation step in the Hirano-Imbens approach. It is the estimation of the individual Dose-Response Function (DRF), that is, a function of the respective observed treatment levels and of the Generalized Propensity Score (GPS) estimated in the previous stage (see § 4.1.2). The empirical parametric specification of the function to estimate is a fully-interacted quadratic (therefore, non-linear) form in both arguments, as it emerges as the best fitting specification according to the AIC. As evident in Table 4.3, this adopted specification includes both the quadratic terms and the interaction term of the two arguments[40]. The estimation is performed through the Ordinary Least Squares (OLS) method.

As emphasised in the empirical literature (Hirano and Imbens, 2004; Bia and Mattei, 2008; Esposti, 2017a), **these estimates cannot be given any direct economic interpretation**, except that testing whether all

[40] The interaction term is aimed at capturing the effect of higher direct payments depending on the level of the estimated GPS. It is also worth noticing that all individual DRF specifications include a constant term to take into account that a >0 expenditure for variable inputs is observed independently from the intensity of support from direct payments.

coefficients involving the GPS are equal to zero can be interpreted as a test of whether the covariates introduce any selection bias. Hence, the **estimation of the individual DRF still reveals the statistical quality and reliability of the investigation**. In particular, the results presented below suggest that the response is significantly affected by both the treatment level and the estimated GPS. This further suggests that, in this case, a significant selection bias would occur in estimating the treatment effect if the confounding variables and their influence on treatment assignment, now captured by the estimated GPS, were not properly considered.

*Table 4.3 - Hirano-Imbens (2004) OLS estimation of the individual DRF[a]*

| Outcome: Agr.Costs/Agr.Revenues | Coefficient | (std. err.) |
|---|---|---|
| Dir.Payments/Agr.Revenues | 0.2438944 | (0.036) * |
| Dir.Payments/Agr.Revenues$^2$ | -0.0000376 | (0.000) |
| Gpscore | -24.52155 | (6.719) * |
| Gpscore$^2$ | 16.89673 | (3.651) * |
| Dir.Payments/Agr.Revenues*Gpscore | -0.1846671 | (0.027) * |
| Constant | 52.8767 | (3.143) * |
| $R^2$ | 0.2189 | |

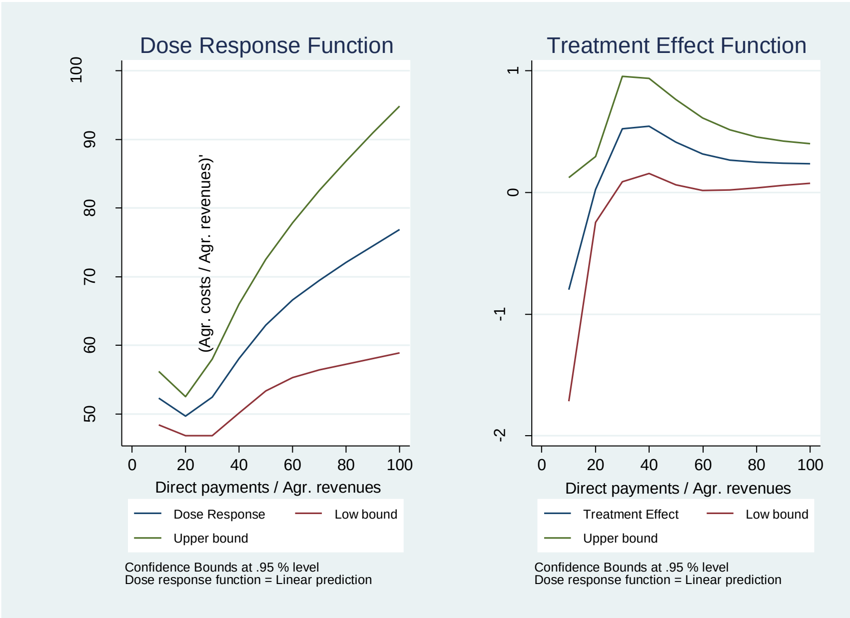
[a] The BoxCox transformation of the treatment variable is used
*Statistically significant at 0.05 level

The estimation of the individual DRF leads to the **final estimation step** consisting in the **estimation of the average DRF** and, consequently, of its first order derivative, i.e. the **average treatment effect (TE)** of main interest. **The sign, the magnitude and the shape of these two functions are the key results of the present analysis** as they represent the **answer to the policy question under investigation: the impact of direct payments on expenses for variable inputs by Swiss farmers**.

**Figure 4.2 displays the estimated average DRF and TE** (point estimates and confidence intervals) over the observed continuous domain of the treatment variable. DRF and TE estimates appear to be of good statistical quality as standard errors are small and, consequently, the confidence intervals relatively thin[41]. Compared to expectations (see Figure 3.3 at § 3.3), the DRF is monotone, increasing but only weakly concave. In fact, the DRF initially declines with the increase of the treatment up to the 20% level. Then, it starts increasing for the higher treatment levels. However, as evident in Figure 4.1 and Table 4.4., only few farms show a lower than 20% treatment intensity, while most of the sample concentrates in the monotone increasing part of the DRF. For this reason, this is the shape of the DRF that will be considered relevant and commented here.

[41] In general terms, as the sample tends to be more numerous around the treatment level sample average (see also Figure 4.1 and Table 4.4), the confidence intervals are thinner when approaching the mean values, while they clearly widen at the lower levels.

*Figure 4.2 - Hirano-Imbens (2004) DRF and ATE estimation*[a,b]




[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (*variable*)' indicates the first derivative of *variable*

The implication of this DRF shape is the consequent behaviour of the average TE function. Its shape is a sort of increasing linear function starting from negative values below 20% for the TE (which characterise 11.5% of the farms in the sample) then moving to a positive territory when the DRF inverts its pattern. Also statistical significance is achieved only when the treatment level exceeds about 30%. It must also be noticed that the magnitude of the TE itself is consistent with theoretical expectations (see § 3.3). Whether negative or positive, the effect is always lower than one. Therefore the variation of the outcome variable after a variation of the treatment variable is always less than proportional: as both variables are expressed in percentage terms, a 1% increase of the treatment variable induces a variation of the outcome variable which ranges, in absolute terms, between 0 and 0.5% and tends to stabilize around 0.25%. In any case, except for the lower treatment levels, these results indicate that **the response to direct payments is a mild, less than proportional intensification of the variable input use** which is itself consistent with most of the literature and, therefore, theoretical expectations (see § 3.3).

This empirical evidence deserves a deeper discussion. It can be concluded that **farmers' production choices, and their consequent input use, tend to be quite conservative with respect to changes in the intensity of policy support**. Nonetheless, the shape of the estimated DRF and TE functions suggests a main policy implication, that is, **lowering direct payments induces an extensification in the use of variable inputs**. On the contrary, **higher direct payments, in practice, provide the funding for an intensification in variable inputs use.**

However, this conclusion is here derived from a cross-sectional comparison, and it is not obvious whether what emerges from comparing different farms may also hold true for any individual farm after a change in its own support level. Two main arguments would suggest caution in this respect. The first argument is that **farms are heterogeneous and the response itself can be heterogeneous** (Esposti, 2017b). As discussed at § 3, **different and even opposite responses are admitted by the theory**. What is observed, therefore, is the final combination of these different responses that, however, cannot be applied mechanically to any individual farm. The second argument has more to do with the **possible limitations of the methodology adopted**. As anticipated at § 1.4, the TE econometrics tools applied aim to eliminate the selection bias inherent in any treatment within observational (i.e. non-experimental) data. Controlling for confounding variables is needed to eliminate such bias. In practice, the estimated DRF and TE could be attributed to some unobserved feature that characterises the less supported farms compared to the more supported ones. **Production specialisation** might be a serious candidate to being this **not-fully-observed feature in the present analysis**. However, as it is shown below, the **confounding variables included in the model are suitable for controlling for farm specialisation**.

Looking at the different average treatment levels received by farms according to their production specialisation (expressed in terms of "direct payments/agricultural revenues" % ratios in Table 4.4), it appears that the confounding role of specialisation might be large. Average treatment levels range between a minimum of about 18% (for pig/poultry farms) to about 150% for suckling cows farms. Since the applied methodology does not allow for the inclusion of dummy variables as confounding variables, the continuous variables "Arable Land/UAA", "Permanent Pastures/UAA" and "Permanent Crops/UAA" where included as a proxy for farm specialisation. Table 4.5 shows the average values of these variables for each typology of farm specialisation. It appears that the **confounding variables included in the model are suitable for controlling for farm specialisation**, since the three categories with the highest average treatment levels highlighted in Table 4.4 – i.e. suckling cows, other cattle and horse/sheep/goats – are also those with the highest share of permanent pastures and the lowest incidence of arable land (Table 4.5). By contrast, the same correspondence is weaker when moving to the categories with the lowest treatment levels: only for special crops farms it is possible to identify a correspondence with the share of arable land (and permanent crops) on the total UAA.

Additional analyses are helpful to define the average composition of direct payments (i.e. their breakdown into individual components) across different farm specialisations over the 2010-2013 period. Table 4.6 reports the average % composition of total direct payments for different farm typologies. It emerges that for the three farm types where the average treatment levels are higher (suckling cows, other cattle, horses/sheep/goats: see Table 4.4), the share of "general area contribution" is relatively low in comparison with the other categories. On the contrary, for the same farms, the relative incidence of "roughage feeders contribution", "supports to livestock farming in difficult production conditions" and "contributes for use of steep-sloping agricultural areas" are well above the average. For the farm types where the average treatment levels are lower (especially pigs/poultry and combined pigs/poultry: see Table 4.4), the relative importance of direct payments for "animal friendly livestock housing systems" and for "regular outdoor animal farming" is higher. Even though it can be argued that at higher altitudes farms tend to apply relatively less intensive production techniques due to the difficult conditions and, therefore, they receive more compensating payments, it remains difficult to establish any general, evidence-based linkages between eligibility for the different types of direct payments, on the one hand, and more or less input-intensive production techniques, on the other hand.

Table 4.7 measures the average level of the same individual components of direct payments against the average agricultural revenues, always according to the different farm types. It can be noticed that support from "roughage feeders contribution", "supports to livestock farming in difficult production conditions" and "contributes for use of steep-sloping agricultural areas" is relevant also if measured against agricultural revenues in the three farm types where the average treatment levels are higher (suckling cows, other cattle and horses/sheep/goats: see Table 4.4). This implies that these specific components of support from direct payments have higher importance for the economic viability of these farm typologies (compared to revenues from crop farming and animal farming), and suggests considerations on a hypothetical linkage with less intensive production techniques which are analogous to the ones mentioned above. Also in this case, however, it remains difficult to establish any general, evidence-based linkages between the importance of certain forms of direct payments for the economic viability of certain farm types, on one hand, and the application of more or less input-intensive production techniques, on the other hand.

*Table 4.4 - Average treatment levels (Direct Payments/Agricultural Revenues in % ratio) within the sample across production specialisations (2010-2013 period). Green background: higher levels. Red background: lower levels.*

| **Farm types** | | Arable crops | Special crops | Dairying | Suckling cows | Other cattle | Horses/sheep/goats | Pigs/poultry | Combined dairying/ arable crops | Combined suckling cows | Combined pigs/poultry | Combined others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Years** | 2010 | 57 | 29 | 66 | 147 | 112 | 141 | 16 | 38 | 71 | 24 | 55 |
| | 2011 | 50 | 29 | 65 | 132 | 118 | 137 | 17 | 36 | 66 | 24 | 53 |
| | 2012 | 57 | 30 | 67 | 146 | 114 | 137 | 17 | 38 | 74 | 24 | 58 |
| | 2013 | 61 | 29 | 65 | 158 | 115 | 143 | 15 | 38 | 74 | 23 | 58 |
| | **Avg. 2010/13** | **56** | **29** | **66** | **146** | **115** | **139** | **16** | **38** | **71** | **24** | **56** |

*Table 4.5 - Average land use (% of total UAA) within the sample across production specializations (2010-2013 period). Green background: larger shares. Red background: lower shares.*

| **Farm types** | | Arable crops | Special crops | Dairying | Suckling cows | Other cattle | Horses/sheep/goats | Pigs/poultry | Combined dairying/ arable crops | Combined suckling cows | Combined pigs/poultry | Combined others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arable land/UAA | 2010 | 82.5 | 49.6 | 4.8 | 3.5 | 1.1 | 2.0 | 8.3 | 53.1 | 45.5 | 29.3 | 32.1 |
| | 2011 | 82.3 | 47.1 | 4.9 | 3.9 | 1.5 | 1.0 | 7.8 | 53.0 | 45.6 | 30.0 | 32.7 |
| | 2012 | 82.2 | 46.6 | 4.9 | 4.4 | 1.6 | 1.6 | 6.7 | 52.0 | 43.4 | 29.9 | 33.1 |
| | 2013 | 81.6 | 45.7 | 4.5 | 4.3 | 2.2 | 1.9 | 6.4 | 53.0 | 45.8 | 30.5 | 32.2 |
| | **Avg. 10/13** | **82.1** | **47.2** | **4.8** | **4.0** | **1.6** | **1.6** | **7.3** | **52.7** | **45.1** | **30.0** | **32.5** |
| Permanent pastures/UAA | 2010 | 12.1 | 16.2 | 83.6 | 86.5 | 94.8 | 91.1 | 73.9 | 21.3 | 28.6 | 48.1 | 40.8 |
| | 2011 | 12.6 | 18.1 | 83.3 | 84.7 | 93.1 | 93.1 | 74.3 | 21.2 | 29.7 | 47.7 | 40.7 |
| | 2012 | 12.6 | 18.1 | 83.2 | 84.6 | 92.5 | 93.8 | 77.9 | 22.5 | 30.5 | 47.8 | 40.2 |
| | 2013 | 12.3 | 19.9 | 83.7 | 85.6 | 89.8 | 93.2 | 78.2 | 22.3 | 30.4 | 48.6 | 40.8 |
| | **Avg. 10/13** | **12.4** | **18.1** | **83.5** | **85.3** | **92.5** | **92.8** | **76.1** | **21.8** | **29.8** | **48.0** | **40.6** |
| Permanent crops/UAA | 2010 | 1.1 | 29.1 | 0.2 | 0.5 | 0.7 | 0.8 | 0.2 | 0.5 | 1.5 | 0.7 | 1.5 |
| | 2011 | 1.1 | 30.6 | 0.2 | 0.4 | 0.6 | 0.8 | 0.0 | 0.5 | 1.8 | 0.8 | 1.4 |
| | 2012 | 1.2 | 29.9 | 0.2 | 0.4 | 0.6 | 0.7 | 0.0 | 0.4 | 1.7 | 0.8 | 1.3 |
| | 2013 | 1.2 | 29.7 | 0.2 | 0.5 | 0.6 | 0.6 | 0.5 | 0.4 | 1.4 | 0.7 | 1.3 |
| | **Avg. 10/13** | **1.2** | **29.8** | **0.2** | **0.4** | **0.6** | **0.7** | **0.2** | **0.4** | **1.6** | **0.7** | **1.4** |

*Table 4.6 - Average composition (%) of total direct payments by farm typology (average values over the 2010-2013 period)*

| Individual components of direct payments / Farm types | General area contrib. | Roughage feeders contrib. | TEP - Support to livestock farming in difficult production conditions | Contrib. for use of steep-sloping agricultural areas | Payments for cultivation of specific crops | Contrib. for summer pastures | Contrib. for ecological balance | Direct payments for extensive production of cereals and rapeseed | Direct payments for organic farming | Contrib. for animal friendly livestock housing systems | Contrib. for regular outdoor animal farming | Other direct payments | Total direct payments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arable crops | 64% | 4% | 0% | 0% | 14% | 0% | 7% | 4% | 0% | 1% | 1% | 4% | **100%** |
| Special crops | 67% | 4% | 0% | 3% | 7% | 0% | 7% | 3% | 2% | 0% | 1% | 5% | **100%** |
| Dairying | 36% | 20% | 17% | 5% | 0% | 2% | 4% | 0% | 1% | 2% | 7% | 6% | **100%** |
| Suckling cows | 31% | 23% | 16% | 5% | 0% | 1% | 4% | 0% | 2% | 3% | 6% | 8% | **100%** |
| Other cattle | 31% | 20% | 22% | 9% | 0% | 2% | 3% | 0% | 1% | 1% | 4% | 8% | **100%** |
| Horses/ sheep/goats | 30% | 20% | 18% | 8% | 0% | 2% | 6% | 0% | 1% | 0% | 6% | 10% | **100%** |
| Pigs/poultry | 32% | 18% | 9% | 3% | 0% | 1% | 4% | 0% | 1% | 12% | 14% | 7% | **100%** |
| Combined dairying/ arable crops | 56% | 18% | 1% | 0% | 5% | 1% | 5% | 2% | 0% | 2% | 6% | 4% | **100%** |
| Combined suckling cows | 46% | 22% | 1% | 1% | 4% | 0% | 6% | 3% | 3% | 3% | 6% | 5% | **100%** |
| Combined pigs/poultry | 42% | 17% | 7% | 2% | 2% | 0% | 4% | 1% | 0% | 7% | 10% | 6% | **100%** |
| Combined others | 47% | 19% | 6% | 2% | 2% | 1% | 6% | 2% | 1% | 2% | 6% | 6% | **100%** |

*Table 4.7 - Average ratios (%) "individual components of direct payments/agricultural revenues", by farm typology (2010-2013 period)*

| **Individual components of direct payments**<br>**Farm types** | **General area contrib.** | **Roughage feeders contrib.** | **TEP - Support to livestock farming in difficult production conditions** | **Contrib. for use of steep-sloping agricultural areas** | **Payments for cultivation of specific crops** | **Contrib. for summer pastures** | **Contrib. for ecological balance** | **Direct payments for extensive production of cereals and rapeseed** | **Direct payments for organic farming** | **Contrib. for animal friendly livestock housing systems** | **Contrib. for regular outdoor animal farming** | **Other direct payments** | **All direct payments*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arable crops | 36% | 2% | 0% | 0% | 8% | 0% | 4% | 2% | 0% | 0% | 1% | 2% | **56%** |
| Special crops | 19% | 1% | 0% | 1% | 3% | 0% | 2% | 1% | 0% | 0% | 0% | 2% | **29%** |
| Dairying | 22% | 12% | 13% | 4% | 0% | 2% | 2% | 0% | 1% | 1% | 4% | 4% | **66%** |
| Suckling cows | 44% | 29% | 27% | 9% | 0% | 3% | 5% | 0% | 4% | 3% | 8% | 12% | **146%** |
| Other cattle | 34% | 21% | 26% | 11% | 0% | 3% | 4% | 0% | 1% | 1% | 4% | 10% | **115%** |
| Horses/sheep/ goats | 39% | 22% | 30% | 13% | 0% | 3% | 7% | 0% | 1% | 0% | 7% | 17% | **139%** |
| Pigs/poultry | 5% | 3% | 2% | 0% | 0% | 0% | 1% | 0% | 0% | 2% | 2% | 1% | **16%** |
| Combined dairying/ arable crops | 21% | 6% | 1% | 0% | 2% | 0% | 2% | 1% | 0% | 1% | 2% | 1% | **38%** |
| Combined suckling cows | 33% | 15% | 1% | 1% | 3% | 0% | 5% | 2% | 2% | 2% | 4% | 4% | **71%** |
| Combined pigs/poultry | 10% | 4% | 2% | 1% | 0% | 0% | 1% | 0% | 0% | 1% | 2% | 2% | **24%** |
| Combined others | 25% | 10% | 4% | 2% | 1% | 1% | 4% | 1% | 0% | 1% | 3% | 4% | **56%** |

* average ratios for "all direct payments" correspond to the "average treatment levels" (Direct Payments/Agricultural Revenues in % ratio) at Table 4.4

### *4.1.4 Alternative definitions of the outcome and treatment variables*

As anticipated, the use of relative measures (i.e. ratios) instead of absolute values for both the treatment and the outcome variable is aimed at minimising the implications of different farm size in the analysis. In this respect, two alternative ratios are considered: the ratio on agricultural revenues (assumed as proxy of the farm's economic size) and ratio on UAA (assumed as proxy of the farm's physical size). However, the ratios based on the UAA turn out to generate results of poorer statistical quality: the in-depth analysis illustrated in the previous paragraphs was exclusively based on the ratios on agricultural revenues.

For sake of completeness, the results obtained by repeating the analysis in terms of ratios on UAA are reported in Tables 4.8 and 4.9 and in Figure 4.3. Table 4.10 and Figure 4.4 report the results for a mixed definition of the variables, with the outcome variable expressed as a ratio on UAA (Table 4.10) while the treatment variable remains expressed as ratio on agricultural revenues.

*Table 4.8 - Hirano-Imbens (2004) ML estimation of the linear GPS function (standard errors in parenthesis) - treatment variable: direct payments/UAA in CHF/ha[a]*

| | Coefficient | (std. err.) |
|---|---|---|
| Agricultural Area | -0. 001308 | (0.000) * |
| Livestock | 0.0004694 | (0.000) * |
| Farmer Age | -0.0003345 | (0.000) * |
| Farmer Education | -0.0001102 | (0.001) |
| Altitude | 0. 0000536 | (0.000) * |
| ArableLand/UAA | -0.0000945 | (0.000) |
| PermanentPastures/UAA | 0.0002049 | (0.000) * |
| PermanentCrops/UAA | -0.0007354 | (0.000) * |
| Constant | 3.857227 | (0.009) * |

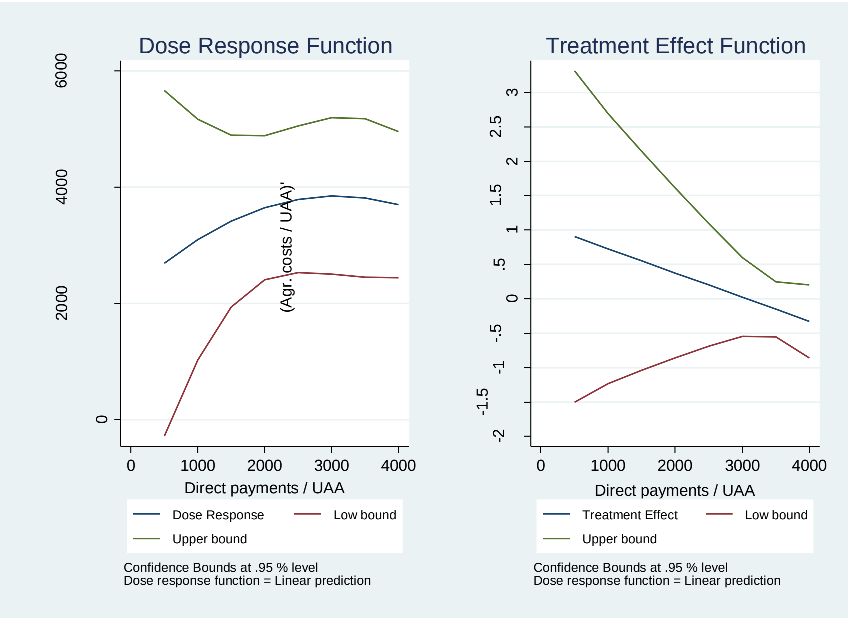
[a] The Box-Cox transformation of the treatment variable is used
*Statistically significant at 0.05 level

*Table 4.9 - Hirano-Imbens (2004) OLS estimation of the individual DRF - treatment variable: direct payments/UAA in CHF/ha[a]*

| Outcome: Agr.Costs/UAA | Coefficient | (std. err.) |
|---|---|---|
| Dir.Payments/UAA | 1.078442 | (1.476) |
| Dir.Payments/UAA$^2$ | -0.0001757 | (0.000) |
| Gpscore | -214.0685 | (209.1) |
| Gpscore$^2$ | 0.3128501 | (10.45) |
| Dir.Payments/UAA*Gpscore | 0.0895124 | (0.045) * |
| Constant | 2193.943 | (2346.9) |
| $R^2$ | 0.0140 | |

[a] The BoxCox transformation of the treatment variable is used
*Statistically significant at 0.05 level

*Figure 4.3 - Hirano-Imbens (2004) DRF and ATE estimation (outcome variable: agricultural costs/UAA in CHF/ha; treatment variable: direct payments/UAA in CHF/ha)[a,b]*



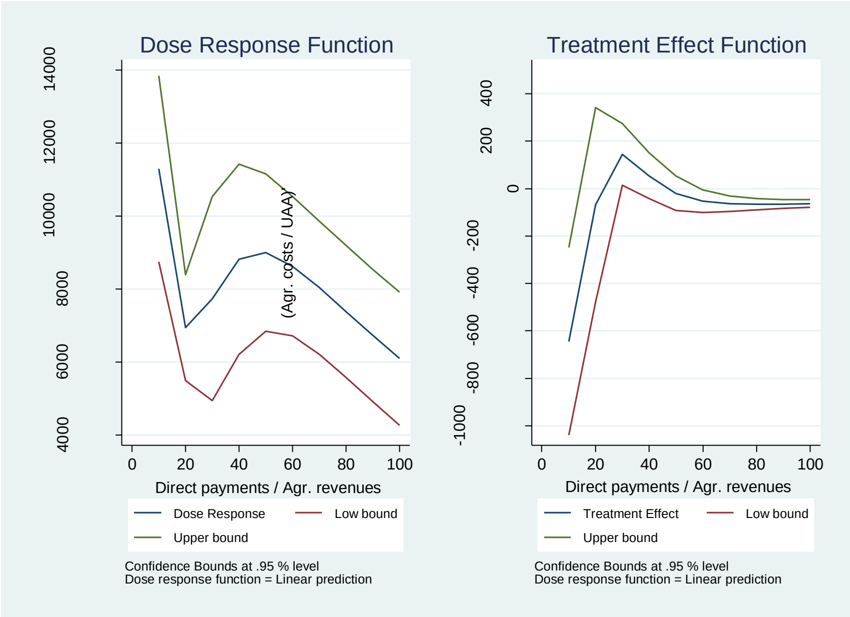

[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (*variable*)' indicates the first derivative of *variable*

*Table 4.10 - Hirano-Imbens (2004) OLS estimation of the individual DRF (outcome variable: agricultural costs/UAA in CHF/ha; treatment variable: direct payments/agricultural revenues in %[a)]*

| Outcome: Agr.Costs/UAA | Coefficient | (std. err.) |
|---|---|---|
| Dir.Payments/Agr.Revenues | -89.5276 | (5.742) * |
| Dir.Payments/Agr.Revenues$^2$ | 0.1333381 | (0.011) * |
| Gpscore | -9727.758 | (1088) * |
| Gpscore$^2$ | -9727.758 | (589.7) * |
| Dir.Payments/Agr.Revenues*Gpscore | 15.58576 | (4.300) * |
| Constant | 13720.08 | (510.8) * |
| $R^2$ | 0.3817 | |

[a] The BoxCox transformation of the treatment variable is used
*Statistically significant at 0.05 level

*Figure 4.4 - Hirano-Imbens (2004) DRF and ATE estimation (outcome variable: agricultural costs/UAA in CHF/ha; treatment variable: direct payments/agricultural revenues in %)*[a,b]

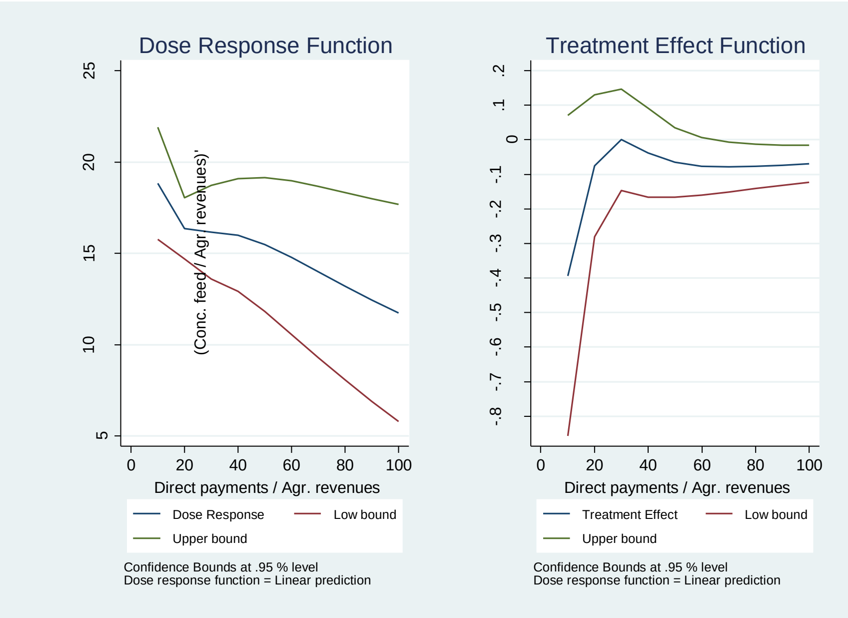



[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (*variable*)' indicates the first derivative of *variable*

A second order of variation of the indicators entering the analysis concerns the definition of the outcome variable. While total "agricultural costs" (i.e. total farm expenses for variable agricultural inputs) were considered in the first step of the analysis, in a second step the estimation can be alternatively focused on specific cost components, i.e. on expenses for concentrate feed, insurances, work by third parties, plant protection products and veterinarian services and drugs. When different and more specific cost components - measured against agricultural revenues as % ratios - are considered as the outcome variable, some differences can be highlighted.

A **negative treatment effect** is obtained only to expenditure for **concentrated feed** on agricultural revenues, and it becomes significantly different from zero when treatment levels (direct payments on agricultural revenues) reach 60% (Figure 4.5). Therefore, this is the only cost item for which a significant extensification effect is observed. However, as within the present sample the comparison between different treatment levels is between different units and not within the same units over time, an alternative possible interpretation of this result is that specialisation is not fully taken into account by the adopted control variables. The more intensively supported animal farms may tend to specialise in animal husbandry involving less input-intensive techniques, and hence a lower use of concentrated feed. Therefore, the increase in the level of relative support simply implies less intensive use of concentrated feed due to farm specialisation. The linkage with the higher importance of support from roughage feeders contribution, as well as support to livestock farming in difficult production conditions, animal friendly livestock housing systems and regular outdoor animal farming for farm types focusing on animal farming in the panel (see § 4.1.3, Tables 4.6 and 4.7) may contribute to explain this observed extensification effect, as eligibility for support from these types of direct payments can be linked to animal husbandry techniques implying less intensive use of concentrated feed.

*Figure 4.5 - Hirano-Imbens (2004) DRF and ATE estimation (outcome variable: expenditure for concentrated feed/agricultural revenues in %)*[a,b]

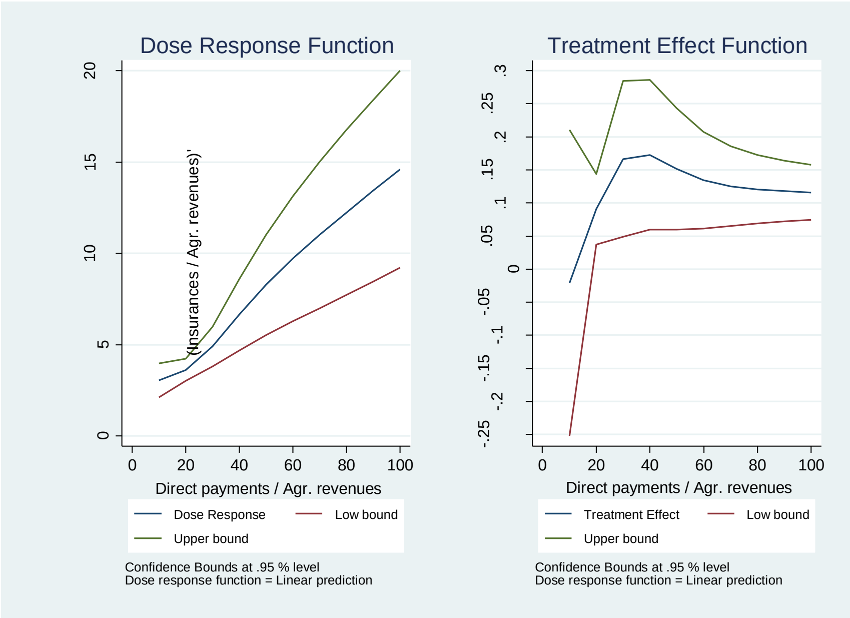



[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (*variable*)' indicates the first derivative of *variable*

All the other cost items confirm what is obtained for the total variable costs. A **positive albeit always less than proportional treatment effect** is obtained with respect to expenditure for **insurances**, **fertilisers** and **work by third parties** when the treatment level exceeds about 30% (Figures 4.6, 4.7 and 4.8, respectively). It is worth noting that these results are also **consistent with the theoretical expectations** (see § 3) **in terms of intensification** (higher expenses for fertilisers) and **"wealth effects"** (farmers become more risk averse => higher expenses for insurances; farmers tend to value more their leisure time => higher expenses to substitute family labour with work by third parties).

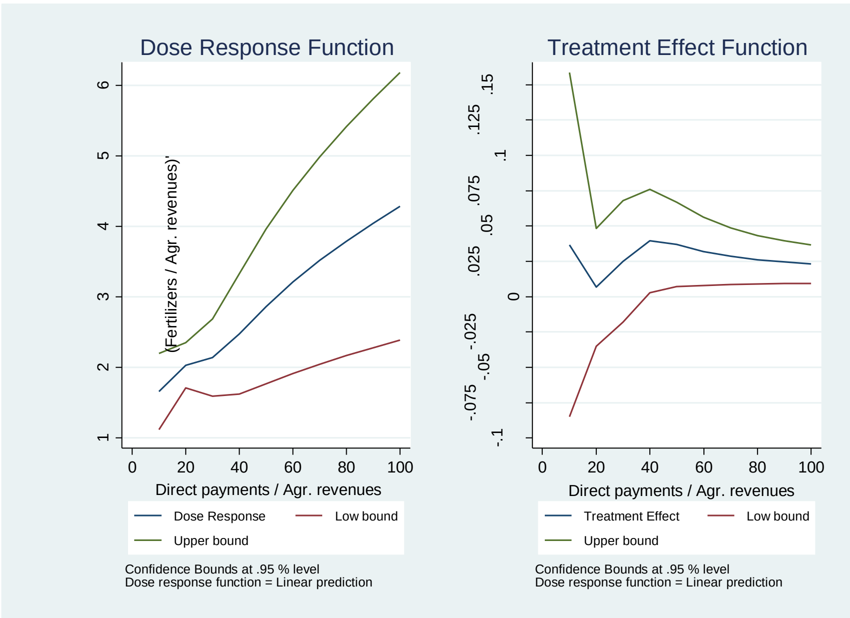
On the opposite, no statistically significant treatment effect was found with respect to expenses for plant protection (Figure 4.9). When finally considering expenses for veterinarian services and drugs, the treatment effect is found to be positive and statistically significant only when the treatment level reaches 70% (Figure 4.10).

*Figure 4.6 - Hirano-Imbens (2004) DRF and ATE estimation (outcome variable: expenditure for insurances/agricultural revenues in %)[a,b]*



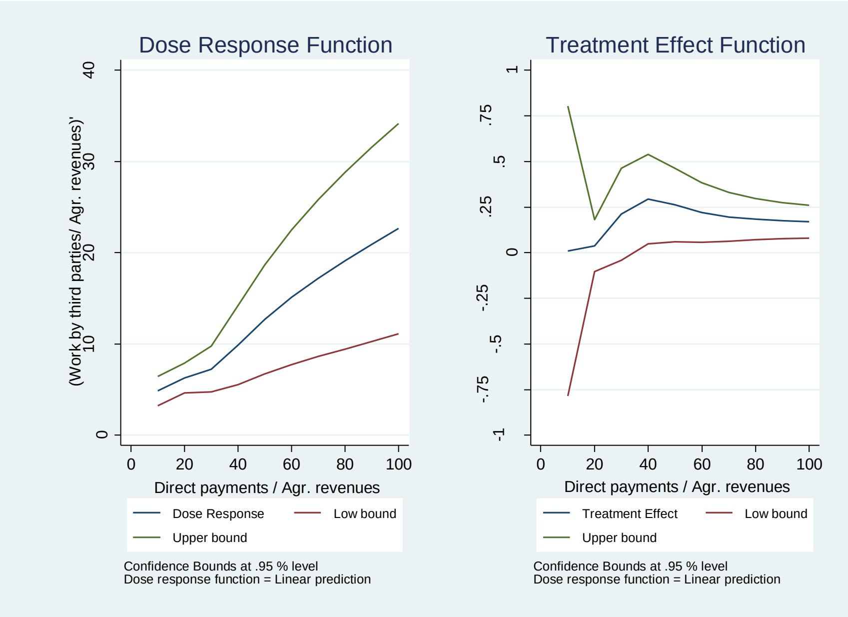

[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (*variable*)' indicates the first derivative of *variable*

*Figure 4.7 - Hirano-Imbens (2004) DRF and ATE estimation (outcome variable: expenditure for fertilisers/agricultural revenues in %)[a,b]*



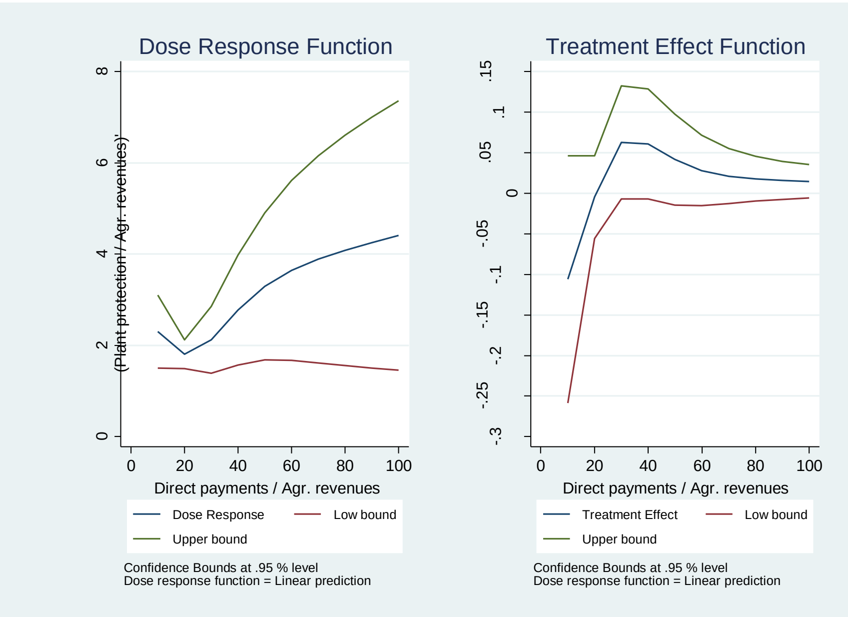

[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (*variable*)' indicates the first derivative of *variable*

*Figure 4.8 - Hirano-Imbens (2004) DRF and ATE estimation (outcome variable: expenditure for work by third parties/agricultural revenues in %)*[a,b]



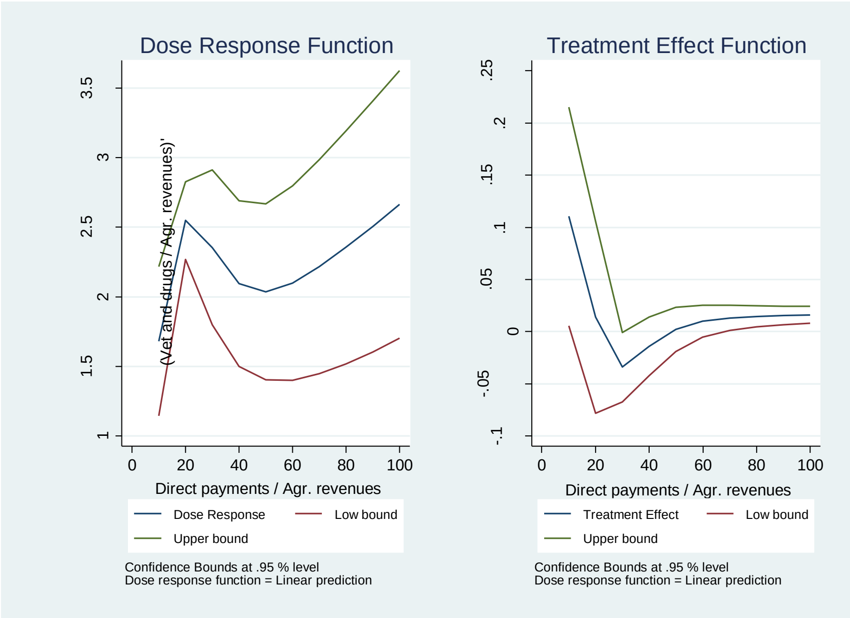

[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (*variable*)' indicates the first derivative of *variable*

*Figure 4.9 - Hirano-Imbens (2004) DRF and ATE estimation (outcome variable: expenditure for plant protection/agricultural revenues in %)*[a,b]




[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (*variable*)' indicates the first derivative of *variable*

*Figure 4.10 - Hirano-Imbens (2004) DRF and ATE estimation (outcome variable: expenditure for veterinarian services and drugs/agricultural revenues in %)[a,b]*




[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (*variable*)' indicates the first derivative of *variable*

## 4.2 Impacts of the 2014 reform (2010-2013 vs 2014)

The same methodological approach used for the 2010-2013 period is also used for the assessment of the farms' behavioural change after the 2014 reform. In this case, **both the treatment and the outcome variable are computed as differences between the pre-reform and the post-reform period**. The pre-reform period is expressed as a four-year (2010-2013) average, while for the post-reform period only one year is available (2014), as the 2015-2016 panel cannot be merged with the panel for the previous period.

### *4.2.1 Descriptive evidence*

Tables 4.11 and 4.12 show the differences in treatment intensity (expressed as % ratio between direct payments and agricultural revenues) between 2014 and the four-year average for the 2010-2013 period. The majority of the considered farms (1066, i.e. 76%) faced a decrease in the ratio between direct payments and agricultural revenues. Only 24% of farms (333) saw an increase in treatment intensity. A comparison between the two subsamples (farms with a negative variation in the intensity of support from direct payments vs. farms with a positive variation in such intensity) makes it clear that the difference in the sign of the variation of the treatment intensity cannot be due to a different dynamics of the denominator (agricultural revenues) between the two periods, since the same difference between the two subsamples is obtained also when treatment intensity is computed as a ratio between direct payments and usable agricultural area (UAA).
Table 4.11 suggests that the average reduction of treatment intensity for the subsample of farms with a negative variation is rather limited, i.e. -9%, but the range of variation is wide, from a minimum of -0.01%

to a maximum of -150.77%[42]. For these farms, the average reduction of the outcome variable (agricultural costs/agricultural revenues) is -3.58%[43]. For what concerns individual cost items, the most important reductions are registered, on average, for the "concentrated feed/agricultural revenues" (-0.86%) and "insurances/agricultural revenues" (-0.77%) ratios.

The 333 farms (see Table 4.12) with a positive variation of the direct payments/agricultural revenues ratio record an average variation of +20.41%, also in this case with a very wide range of variation (from zero to +938%). The average increase in the agricultural costs/agricultural revenues ratio amounted to +1.57%, with negative variations recorded in the concentrated feed/agricultural revenues ratio and positive variations in the works by third parties/agricultural revenues ratio (+2.67%) and insurance costs/agricultural revenues ratio (+1.67%).

Some significant differences between the two subsamples can be found also in terms of confounding variables. Firms with a positive variation are characterised, on average, by: smaller presence of livestock (25 vs. 33 adult bovine equivalents); higher altitude (770 m vs. 672 m); higher share of permanent pastures on UAA (66% vs. 59%). These differences suggest a higher concentration of farms located in mountainous areas in the subsample with a positive variation of treatment intensity between the 2010-2013 period and 2014. However, the unavailability of data on the breakdown of total support into individual types of measures in 2014 prevents from referring the above empirical evidence to the reform of the system of direct payments.

The same Treatment Effect (TE) methodology previously applied to the 2010-2013 period (see § 4.1) is here applied also to the 2010-2013 vs. 2014 variation. Because the treatment variable cannot be negative, the two subsamples (negative and positive variations) are analysed and presented separately.

*Table 4.11 - Descriptive statistics of the treatment, outcome and confounding variables for the subsample of farms with a negative variation of direct payments/agricultural revenues between 2014 and the 2010-13 average (for the confounding variables the farm-level 2010-2014 averages are considered).*

| Variable | UoM* | Obs* | Mean | Std. Dev.* | Min | Max |
|---|---|---|---|---|---|---|
| ΔDir.Payments/Agr.Revenues | % | 1066 | -9.062 | 125.65 | -0.010 | -150.775 |
| ΔDir.Payments/UAA | CHF/Ha | 1066 | -128.65 | 282.02 | -1874.11 | 1894.77 |
| ΔAgr.Costs/Agr.Revenues | % | 1066 | -3.578 | 128.18 | -324.719 | 28.467 |
| ΔAgr.Costs/UAA | CHF/Ha | 1066 | 298 | 1050.92 | -7671.62 | 9594.59 |
| ΔPlantProtection/Agr.Revenues | % | 1066 | -0.134 | 14.39 | -41.119 | 5.850 |
| ΔConcentratedFeed/Agr.Revenues | % | 1066 | -0.856 | 34.13 | -31.724 | 26.779 |
| ΔVeterinarianDrugs/Agr.Revenues | % | 1066 | -0.446 | 13.07 | -11.294 | 6.450 |
| ΔWorkThirdParties/Agr.Revenues | % | 1066 | -0.535 | 67.92 | -194.659 | 31.121 |
| ΔInsurance/Agr.Revenues | % | 1066 | -0.774 | 27.68 | -73.264 | 11.088 |
| ΔFertilisers/Agr.Revenues | % | 1066 | -0.209 | 13.24 | -26.441 | 5.977 |
| Usable Agr. Area (UAA) | Ha | 1066 | 23.47 | 11 | 4.87 | 99.14 |
| Altitude | MASL* | 1066 | 672.43 | 220.66 | 300 | 1730 |
| Livestock | N. | 1066 | 32.58 | 22.872 | 0 | 149.91 |
| Farmer Age | Years | 1066 | 50.48 | 7.99 | 27 | 72 |
| Farmer Education | Levels* | 1066 | 3.45 | 0.76 | 1 | 5 |

[42] The same considerations made in § 4.1 about possible outliers apply also in the present case.

[43] With respect to the agricultural costs/UAA ratio, an average positive variation is observed (+298 CHF/Ha) which cannot be reconciled with the aforementioned average reduction of the agricultural costs/agricultural revenues ratio. The variable expressed as a ratio on UAA is hence not considered further in the analysis.

| Variable | UoM* | Obs* | Mean | Std. Dev.* | Min | Max |
|---|---|---|---|---|---|---|
| ArableLand/UAA | % | 1066 | 22.07 | 25.44 | 0 | 94.28 |
| PermanentPastures/UAA | % | 1066 | 59.52 | 34.26 | 0 | 100 |
| PermanentCrops/UAA | % | 1066 | 1.67 | 8.29 | 0 | 99.31 |

* UoM = unit of measurement; Obs = number of observations; Std. Dev. = Standard Deviation; MASL= Meters Above the Sea Level; Levels: 1 = no vocational training; 2 = currently receiving education / training; 3 = apprenticeship / vocational training completed; 4 = further education; 5 = college of applied sciences, higher education.

*Table 4.12 - Descriptive statistics of the treatment, outcome and confounding variables for the subsample of farms with a positive variation of direct payments / agricultural revenues between 2014 and the 2010-13 average (for the confounding variables the farm-level 2010-2014 averages are considered).*

| Variable | UoM* | Obs* | Mean | Std. Dev.* | Min | Max |
|---|---|---|---|---|---|---|
| ΔDir.Payments/Agr.Revenues | % | 333 | 20.411 | 666.88 | 0.001 | 938.263 |
| ΔDir.Payments/UAA | CHF/Ha | 332 | 167.86 | 438.29 | -1432.52 | 2719.34 |
| ΔAgr.Costs/Agr.Revenues | % | 333 | 1.566 | 223.72 | -60.427 | 186.148 |
| ΔAgr.Costs/UAA | CHF/Ha | 332 | -561.98 | 1463.42 | -12633.92 | 6518.62 |
| ΔPlantProtection/Agr.Revenues | % | 333 | 0.507 | 29.01 | -3.175 | 34.682 |
| ΔConcentratedFeed/Agr.Revenues | % | 333 | -1.054 | 47.44 | -25.385 | 27.763 |
| ΔVeterinarianDrugs/Agr.Revenues | % | 333 | 0.054 | 21.64 | -5.489 | 17.343 |
| ΔWorkThirdParties/Agr.Revenues | % | 333 | 2.666 | 139.98 | -58.460 | 127.061 |
| ΔInsurance/Agr.Revenues | % | 333 | 1.668 | 53.01 | -7.691 | 53.651 |
| ΔFertilisers/Agr.Revenues | % | 333 | 0.230 | 17.23 | -13.305 | 9.160 |
| Usable Agr. Area (UAA) | Ha | 333 | 24.33 | 12.63 | 5.18 | 78.8 |
| Altitude | MASL* | 333 | 769.77 | 288.16 | 320 | 1740 |
| Livestock | N. | 333 | 24.67 | 23.58 | 0 | 167.55 |
| Farmer Age | Yrs. | 333 | 49.44 | 8.72 | 23 | 68 |
| Farmer Education | Levels* | 333 | 3.14 | .82 | 1 | 5 |
| ArableLand/UAA | % | 333 | 21.22 | 30.13 | 0 | 98.60 |
| PermanentPastures/UAA | % | 333 | 66.48 | 36.37 | 0 | 100 |
| PermanentCrops/UAA | % | 333 | 2.91 | 13.26 | 0 | 97.18 |

* UoM = unit of measurement; Obs = number of observations; Std. Dev. = Standard Deviation; MASL= Meters Above the Sea Level; Levels: 1 = no vocational training; 2 = currently receiving education / training; 3 = apprenticeship / vocational training completed; 4 = further education; 5 = college of applied sciences, higher education.

### 4.2.2 Results for the subsample with a negative variation in support intensity

Table 4.13 reports the ML estimate of the GPS function for the subsample of firms with a negative variation in support (i.e. treatment) intensity. Parameters that turn out to be not statistically different from 0 are those concerning the farmer age, altitude and the share of permanent pastures on the UAA. It is worth noticing that, as discussed at § 1.4, here the treatment intensity expresses the magnitude of support reduction (in terms of direct payments/agricultural revenues ratio). A greater generalised propensity is associated with a larger farm size, whereas a lower propensity is associated with a higher presence of livestock, a higher farmer education and higher share of arable land or permanent crops on UAA.

The lack of statistical significance of altitude can have two complementary explanations. On the one hand, farms located in mountainous areas also show other typical characteristics like, for instance, a higher presence of permanent pastures. At least for these farms, therefore, this information may be redundant and the effect of altitude is not statistically significant just because its effect is already captured by the other variable(s). In the present case, however, the presence of permanent pastures is itself not statistically significant. The second and more suitable explanation is that there is no large enough variability of altitude among the farms of this subsample to identify an effect of this variable on the treatment assignment. Evidently, farms that actually express a higher variability of altitude tend to be concentrated in the "positive" subsample (see § 4.2.1) where it is confirmed that altitude positively and significantly affects the treatment assignment (i.e. the intensity of support from direct payments; see § 4.2.3).

The results of the second estimation step (estimation of the individual DRF; Table 4.14) do not have the same statistical robustness as the 2010-2013 results, since the response appears to be only significantly affected by the square of the treatment variable and by the interaction of the treatment variable with the GPS. Figure 4.11 displays the estimated average DRF and TE. The wide confidence intervals are the consequence of the lower statistical quality of the results. Nevertheless, it is worth noticing that the average DRF is in negative territory for any treatment level and has a declining shape. Given that the treatment variable here expresses the negative variation of support intensity (i.e., higher values correspond to a larger reduction of direct payments per unit of agricultural revenues), the shape of the estimated average DRF implies that variable input costs on agricultural revenues decrease. The TE function consequently is in negative territory with >-1 values, thus implying a less than proportional treatment effect, but it shows statistical significance only for the range of variation of the treatment intensity falling between 60‰ and 90‰[44]. The same type of results is obtained for all the specific cost items considered (the related empirical evidence is available in Annex 7.2).

Considering the different definition of the treatment variable, these results seem consistent with what obtained for the 2010-2013 period under a constant policy regime. In practice, they represent the same response under two different perspectives. In the 2010-2013 sample, the response is assessed by comparing farms receiving different support. Here, the response is assessed by looking at the behavioural change of farms depending on how much the direct payments they receive actually declined. Nonetheless, a similar response should be expected in both cases. **In the present case it is confirmed that a higher/lower support intensity is associated to an intensification/extensification of variable input use, tough this evidence is also statistically weaker**[45].

[44] Variations of treatment intensity are expressed as ‰ data in order to improve the quality of the estimation.

[45] The only difference is that while in the 2010-2013 period this effect stabilizes at about 0.25, here it is apparently increasing though, in fact, it is always statistically moving around a value of 0.2-0.4.

*Table 4.13 - Hirano-Imbens (2004) ML estimation of the linear GPS function (standard errors in parenthesis)[a]*

| | Coefficient | (std. err.) |
|---|---|---|
| Agricultural Area | 0.0285719 | (0.007) * |
| Livestock | -0.0330503 | (0.003) * |
| Farmer Age | -0.006247 | (0.008) |
| Farmer Education | -0.2738027 | (0.084) * |
| Altitude | 0.0003306 | (0.000) |
| ArableLand/UAA | -0.0153535 | (0.005) * |
| PermanentPastures/UAA | 0.0013518 | (0.003) |
| PermanentCrops/UAA | -0.0218182 | (0.008) * |
| Constant | 7.738727 | (0.667) * |

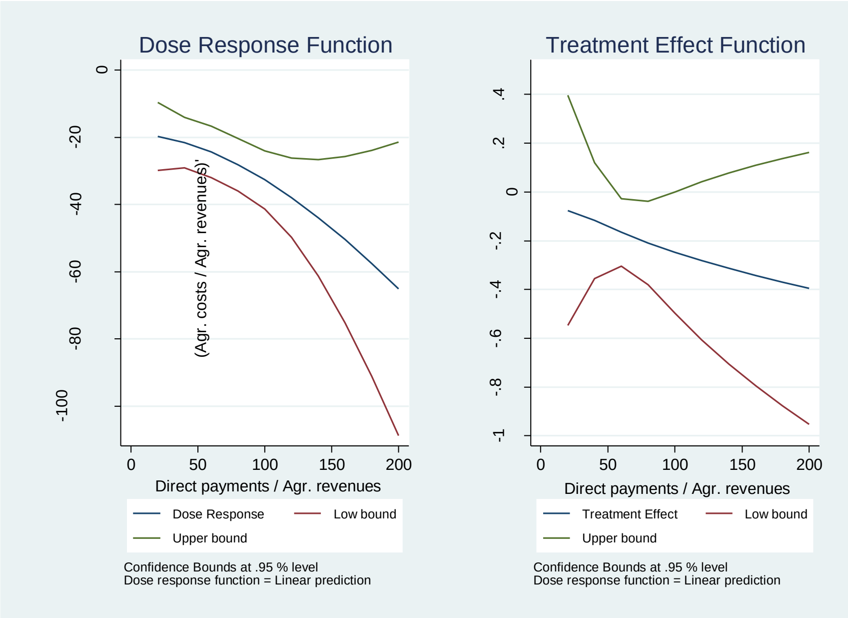
[a] The Box-Cox transformation of the treatment variable is used
*Statistically significant at 0.05 level

*Table 4.14 - Hirano-Imbens (2004) OLS estimation of the individual DRF[a]*

| Outcome: ΔAgr.Costs/Agr.Revenues | Coefficient | (std. err.) |
|---|---|---|
| ΔDir.Payments/Agr.Revenues | 0.1352713 | (0.098) |
| ΔDir.Payments/Agr.Revenues$^2$ | -0.0005891 | (0.000) * |
| Gpscore | -86.92353 | (307.1) |
| Gpscore$^2$ | 528.4627 | (1190.6) |
| ΔDir.Payments/Agr.Revenues*Gpscore | -1.504064 | (0.836) * |
| Constant | -17.52685 | (18.40) |
| $R^2$ | 0.2569 | |

[a] The BoxCox transformation of the treatment variable is used
*Statistically significant at 0.10 level

*Figure 4.11 - Hirano-Imbens (2004) DRF and ATE estimation (outcome and treatment variables in ‰*)[a,b]*




* ‰ data are used in order to improve the quality of the estimation

[a] Bootstrap confidence bounds (1000 replications)

[b] The notation (*variable*)' indicates the first derivative of *variable*

### 4.2.3 Results for the subsample with a positive variation in support intensity

The analysis applied to the second subsample of farms (those recording a positive variation of the direct payments/agricultural revenues ratio) produces inconclusive results. In the estimation of the GPS (Table 4.15) few confounding variables, and no variables expressing specialisation in terms of share of UAA, significantly influence the propensity score. The parameters estimated in the second step of the estimation procedure (Table 4.16) apparently show better statistical quality compared to the other subsample. Nonetheless, the estimated average DRF and the TE show wide confidence intervals (Figure 4.12). The DRF is also in negative territory but never significantly different from 0. The TE is itself quite small (ranging between -0.15 and 0.15) and never significantly different from 0.

As in this case the treatment variable expresses the increase of support from direct payments per unit of agricultural revenues, such results would indicate a response towards extensification, albeit quite small in magnitude. In practice, this group of farms seems to simply maintain the same ratio between agricultural costs (i.e. expenses for variable inputs) and agricultural revenues regardless the intensity of support from direct payments, because the impact of such support on the production levels is very limited - arguably due to environmental or other limitations - and consequently there is also no response in terms of variable input use.

More importantly, however, **these results are statistically very weak and do not justify a deeper economic interpretation**. This weakness can be partially attributed to the low number of farms in this subsample, and to its likely high heterogeneity.

*Table 4.15 - Hirano-Imbens (2004) ML estimation of the linear GPS function (standard errors in parenthesis)[a]*

| | Coefficient | (std. err.) |
|---|---|---|
| Agricultural Area | 0.0165379 | (0.010) * |
| Livestock | -0.0328819 | (0.005) * |
| Farmer Age | -0.0088615 | (0.012) |
| Farmer Education | -0.2936372 | (0.140) * |
| Altitude | 0.0018325 | (0.000) * |
| ArableLand/UAA | -0.0048143 | (0.009) |
| PermanentPastures/UAA | 0.0015476 | (0.008) |
| PermanentCrops/UAA | -0.0172537 | (0.011) |
| Constant | 5.093815 | (1.191) * |

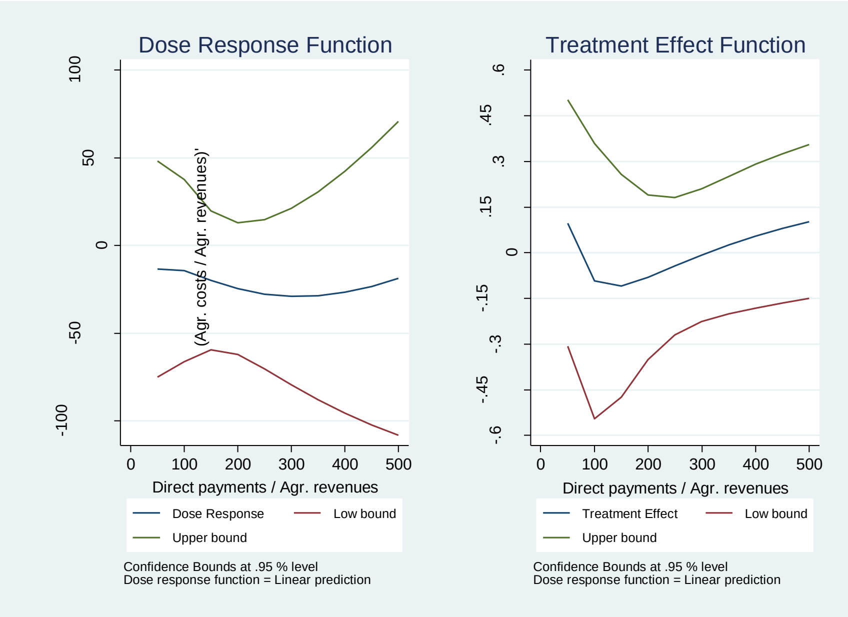
[a] The Box-Cox transformation of the treatment variable is used
*Statistically significant at 0.10 level

*Table 4.16 - Hirano-Imbens (2004) OLS estimation of the individual DRF[a]*

| Outcome: ΔAgr.Costs/Agr.Revenues | Coefficient | (std. err.) |
|---|---|---|
| ΔDir.Payments/Agr.Revenues | 0.4803022 | (0.043) * |
| $\Delta$Dir.Payments/Agr.Revenues$^2$ | -0.0000338 | (0.000) * |
| Gpscore | -1375.007 | (743.5) * |
| Gpscore$^2$ | 6001.146 | (2885.4)* |
| ΔDir.Payments/Agr.Revenues*Gpscore | -3.24109 | (0.552) * |
| Constant | 42.61889 | (43.44) |
| $R^2$ | 0.5576 | |

[a] The BoxCox transformation of the treatment variable is used
*Statistically significant at 0.10 level

*Figure 4.12 - Hirano-Imbens (2004) DRF and ATE estimation (outcome and treatment variables in ‰*)[a,b]*




* ‰ data are used in order to improve the quality of the estimation

[a] Bootstrap confidence bounds (1000 replications)

[b] The notation (*variable*)' indicates the first derivative of *variable*

## 4.3 Impacts of the post-reform policy regime (2015-2016 panel)

A final assessment of the robustness of the results presented in this chapter can be obtained by applying the same methodological approach used for the 2010-2013 panel (see § 4.1) to another balanced panel of farms under a constant post-reform policy regime. This is performed by repeating the analysis on the 2015-2016 cross-sectional comparison. Even though this panel is extracted from a different dataset (see § 1.4) and not all the variables can be properly observed, the policy reform introduced in 2014 is not expected to have introduced a significant change in the farms' response to direct payments in terms of variable input use. As a consequence, at least qualitatively analogous empirical evidence is expected.

### *4.3.1 Descriptive evidence*

According to the descriptive statistics reported in Table 4.17 and the Kernel density displayed in Figure 4.13(a), also in the 2015-2016 sample the treatment variable shows a long right-hand tail, with very few farms showing extremely high values. As already noted (see § 4.1.1), beyond possible data collection errors these values could be attributed to farms experiencing a remarkable (temporary or permanent) decrease of agricultural revenues. Unlike the 2010-2013 sample, however, these farms are considered here as unsuitable observations or, from a statistical point of view, as "outliers", since a normal distribution could not be restored in the estimation stage even after the variables' transformation. Therefore, this right-hand tail is shortened by dropping all farms with a value of the treatment variable (direct payments/agricultural revenues) higher than 200% ("truncated 2015-2016 panel"). The sample size decreases from 1,531 to 1,453 farms, with the distribution of the outcome variable assuming a more appropriate shape (Figure 4.13(b)). Table 4.18 reports the descriptive statistics for this "truncated panel".

It is also important to notice that some of the confounding variables - *farmer's age* and *education*, *altitude* - included in the previous analyses for the 2010-2013 period (see § 4.1) and for the 2010-2013 vs. 2014 comparative analysis (see § 4.2) are not available in the 2015-2016 dataset (see § 1.4). Nonetheless, some aspects about these variables are still worth reminding. *Farmer's age* is the only variable that was never found to have a significant impact on GPS in the previous analyses. *Altitude* can find a proxy in the variable *permanent pastures/UAA*. Only one of these two variables, in fact, is statistically significant in the analyses performed on the 2010-13 panel and on the first subsample considered for the 2010-2013 vs. 2014 comparative analysis (i.e. the subsample containing farms with a negative variation in treatment intensity after the reform). On the contrary, *farmer's education* was found to be significant in all previous analyses.

As a consequence of the prevailing reduction in the intensity of support from direct payments implied by the 2014 reform, the average direct payments/agricultural revenues ratio is lower in the 2015-16 sample than in the pre-reform period (51% in 2015-2016 vs. 62% in 2010-2013), whereas the outcome variable (agricultural costs/agricultural revenues) is found to be higher on average (58% vs. 52%), but with greater variability (standard deviation is 49% in the 2015-2016 sample and 23% in the 2010-2013 sample).

*Table 4.17 - Descriptive statistics of the treatment, outcome and confounding variables for the whole 2015-16 panel*

| Variable | UoM* | Obs* | Mean | Std. Dev.* | Min | Max |
|---|---|---|---|---|---|---|
| Dir.Payments/Agr.Revenues | % | 1531 | 66.90 | 97.22 | 0 | 1662.30 |
| Agr.Costs/Agr.Revenues | % | 1531 | 61.62 | 60.71 | 0 | 993.93 |
| Usable Agr. Area (UAA) | Ha | 1531 | 25.92 | 16.27 | 0 | 194.66 |
| Livestock | N. | 1531 | 36.79 | 31.16 | 0 | 399.38 |
| ArableLand/UAA | % | 1524 | 24.10 | 27.69 | 0 | 98.69 |
| PermanentPasture/UAA | % | 1524 | 69.78 | 30.57 | 0 | 100 |
| PermanentCrops/UAA | % | 1524 | 4.44 | 16.92 | 0 | 100 |

* UoM = unit of measurement; Obs = number of observations; Std. Dev. = Standard Deviation

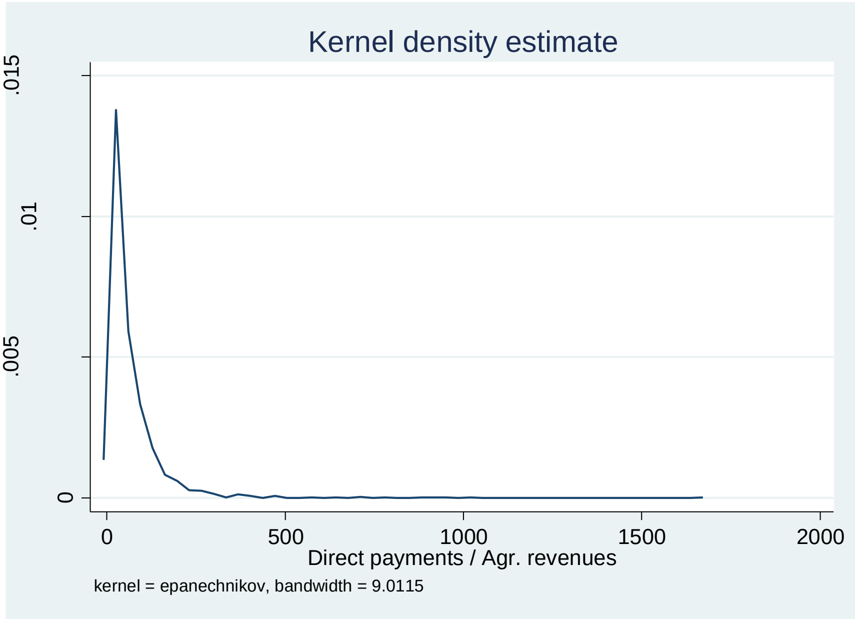
*Table 4.18 - Descriptive statistics: sample averages of the treatment, outcome and confounding variables for the truncated 2015-16 panel*

| Variable | UoM* | Obs* | Mean | Std. Dev.* | Min | Max |
|---|---|---|---|---|---|---|
| Dir.Payments/Agr.Revenues | % | 1453 | 51.00 | 41.42 | 0 | 199.38 |
| Agr.Costs/Agr.Revenues | % | 1453 | 57.89 | 48.72 | 0 | 993.93 |
| Usable Agr. Area (UAA) | Ha | 1453 | 25.75 | 16.15 | 0 | 194.66 |
| Livestock | N. | 1453 | 37.49 | 31.63 | 0 | 339.38 |
| ArableLand/UAA | % | 1446 | 25.25 | 27.88 | 0 | 98.69 |
| PermanentPasture/UAA | % | 1446 | 68.52 | 30.66 | 0 | 100 |
| PermanentCrops/UAA | % | 1446 | 4.57 | 17.21 | 0 | 100 |

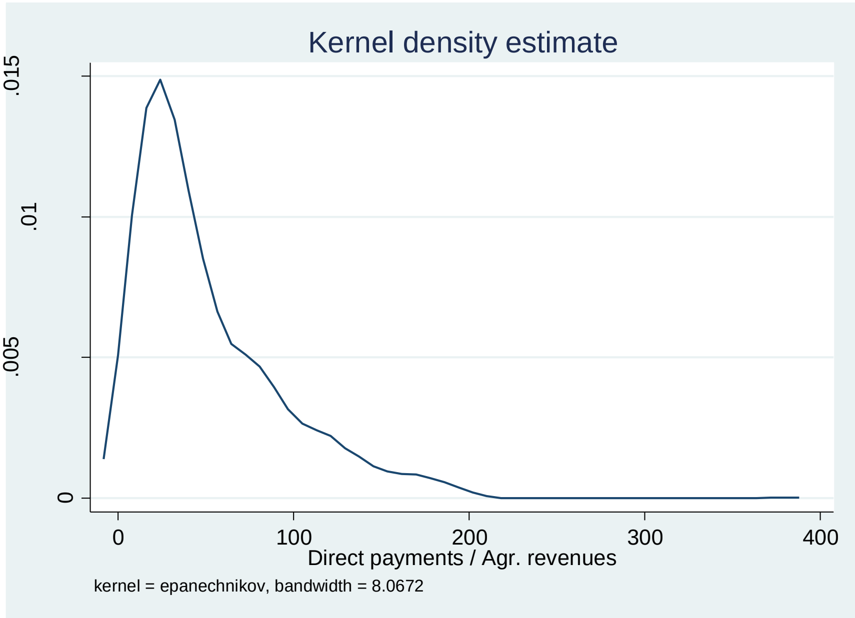
* UoM = unit of measurement; Obs = number of observations; Std. Dev. = Standard Deviation

*Figure 4.13 - Distribution of the continuous treatment variable: direct payments/agricultural revenues (in %; 2015-2016 averages) (a = whole sample; b = sample truncated at treatment >200%): Kernel density.*

(a)




(b)



### *4.3.2 Results for the 2015-16 panel*

With the only exception of the variable *arable land/UAA*, all the other confounding variables significantly affect the probability associated to the direct payments/agricultural revenues ratio in the 2015-16 period (Table 4.19)[46]. The sign of the estimated parameters confirms the results obtained in the previous analyses. A greater generalised propensity is associated with a higher share of permanent pastures on UAA, whereas a lower propensity score is associated with a higher presence of livestock and a higher share of permanent crops on UAA. The second step of the estimation procedure returns statistically significant parameters (Table 4.20) for all the variables: the response appears to be significantly affected by the treatment level (in both the level and its square), the GPS (in both the level and its square) and their interaction.

The average DRF displayed in Figure 4.14 has a positive monotonic concave shape that implies that, up to a treatment level of about 70%, a unit variation of the treatment level causes an increase in the outcome variable. Up to that level of treatment, the consequent estimated TE suggests that the effect is positive, less than proportional and decreasing to 0. This result is barely significant at the 0.05 confidence level but can be considered significant at the 0.10 confidence level. For treatment levels >70% the estimated treatment effect turns negative but it becomes not significantly different from zero at any significance level. Moreover, farms receiving this high treatment intensity are few.

On the basis of the above empirical evidence, the main conclusion is that **the increase of the intensity of support from direct payments has a positive impact on the ratio between agricultural costs (i.e. expenses for variable inputs) and agricultural revenues**. It is thus associated to an **intensification**, but this does not hold true **for highly supported farms** for which no significant response is found.

It is worth **comparing these results with those obtained for the 2010-2013 sample** (see § 4.1). In both exercises **the impact of support from direct payments concerns a constant policy regime**, thus it is investigated by comparing the behaviour of farms receiving a different intensity of such support. In practice, **the same behaviour should be expected in the two cases**.

By comparing Figure 4.2 at § 4.2 with Figure 4.14 below, some common features as well as interesting differences emerge. Both DRF are concave but not monotone over the whole range of variation of the treatment intensity. In both cases, however, if the attention is focused on farms with a higher than 20% but lower than 70% treatment level (i.e. the range where most of the two samples concentrate), **the results are clearly comparable as they both indicate a monotone increase in expenses for variable inputs** (measured against agricultural revenues as % ratio) **associated to a higher intensity of support from direct payments**. However, while in the 2010-2013 sample the TE stabilizes at a constant value, in the 2015-2016 sample the TE declines to 0, thus indicating a declining intensification effect. The main differences concern the left and right-hand tails of the two samples in terms of treatment variable. On the left-hand tail, the average DRF estimated for the 2015-2016 period does not display the initially decreasing shape that characterised the results for the 2010-2013 period though, in fact, these are not statistically significant. Moreover, in this latter case, this result concerns farms with a lower than 20% treatment, which represent a relatively limited portion (24%) of the sample itself. On the right-hand tail, the already mentioned declining DRF, and non-significant treatment effect in the 2015-2016 sample with larger than 70% treatment intensity can be observed. This was not observed in the assessment focusing on the 2010-2013 period. Even in this case, however, this peculiar behaviour for the 2015-2016 period concerns a relatively limited portion of the sample (26%), and this also explains the low statistical quality of this result.

[46] The reason for this might be that although the sum of these three variables does not amount exactly to 100% for each farm in the sample, most of the times their sum is close to 100%, raising an issue of collinearity, that causes one of these variables to be non-significant.

*Table 4.19 - Hirano-Imbens (2004) ML estimation of the linear GPS function (standard errors in parenthesis)[a]*

| | Coefficient | (std. err.) |
|---|---|---|
| Agricultural Area | 0.08464 | (0.005) * |
| Livestock | -0.0591372 | (0.003) * |
| ArableLand/UAA | -0.0159866 | (0.014) |
| PermanentPastures/UAA | 0.0363458 | (0.014) * |
| PermanentCrops/UAA | -0.0330224 | (0.014) * |
| Constant | 5.755181 | (1.384) * |

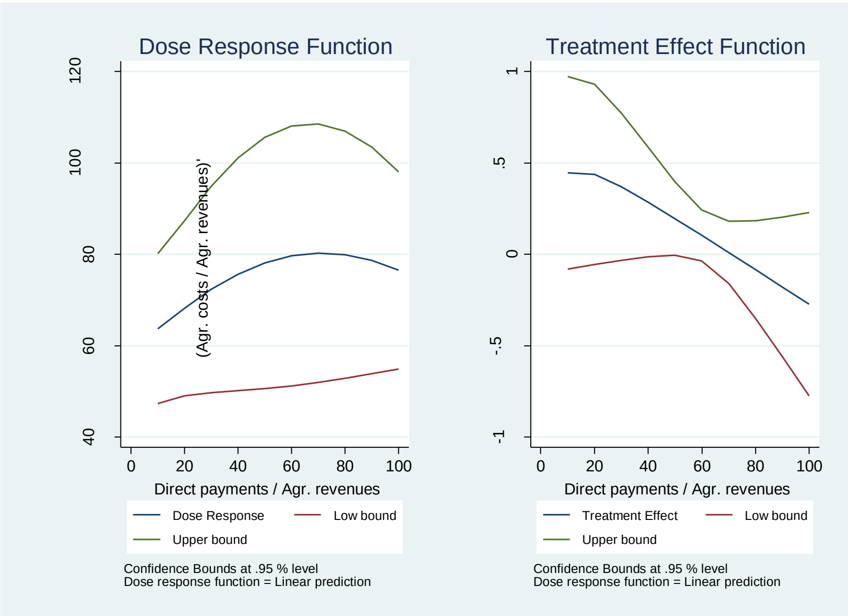
[a] The Box-Cox transformation of the treatment variable is used
*Statistically significant at 0.05 level

*Table 4.20 - Hirano-Imbens (2004) OLS estimation of the DRF[a]*

| Outcome: Agr.Costs/Agr.Revenues | Coefficient | (std. err.) |
|---|---|---|
| Dir.Payments/Agr.Revenues | 1.015353 | (0.180) * |
| Dir.Payments/Agr.Revenues$^2$ | -0.0044951 | (0.000) * |
| Gpscore | -0.0044951 | (152.1) * |
| Gpscore$^2$ | 2238.91 | (732.0) * |
| Dir.Payments/Agr.Revenues*Gpscore | -3.721037 | (0.856) * |
| Constant | 63.17551 | (8.091) * |
| $R^2$ | 0.0453 | |

[a] The BoxCox transformation of the treatment variable is used
*Statistically significant at 0.05 level

*Figure 4.14 - Hirano-Imbens (2004) DRF and ATE estimation [a,b]*




[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (*variable*)' indicates the first derivative of *variable*

## 4.4 Confronting the results of the empirical assessment with literature

The actual reliability of the results presented in this analysis, and of the consequent policy implications, can be assessed in two different ways. On the one hand, the same methodological approach can be applied to different datasets in order to answer the same policy question. This robustness check is performed here on the three different samples to identify a common response to policy support though observed in different periods and groups of farms. The conclusion that can be drawn in this respect is that for the majority of farms the response in terms of ratio between expenditure for variable inputs and agricultural revenues can be reasonably approximated by an upward sloping, almost-linear but less than proportional relationship.

A second order of reliability assessment consists in comparing these results with the existing literature on this topic. This is a challenging exercise. On the one hand, the empirical literature on the impact of direct payments on agricultural production and markets is quite rich. On the other hand, however, the results emerging from this literature "are remarkably varied, with the only uniform result being very weak ties between direct payments and the particular measure of impact" (Keeney, 2013, p. 2). More importantly, as already anticipated, most of this literature does not perform an ex-post assessment on farm-level data. In fact, it is prevalently made of results generated by simulation models as ex-ante assessment exercises. **In practice, in this literature it is not possible to find any micro-level ex-post assessment analogous to the present study.** Some recent studies have adopted similar datasets and methodologies for such an assessment, but on substantially different policy questions (for instance, the farm environmental performance in response to agro-environmental measures, or the change of the farm output mix after decoupling of support; see Esposti (2017a, 2017b) for a discussion).

Nonetheless, **simulation models used to anticipate the impact of possible policy reforms can still be useful as references, safe remaining that the comparison with the present results requires extreme caution**. This caution is needed because these models incorporate aggregate effects of direct payments that are by definition excluded from the present analysis. First of all, the possible effects on prices in the agricultural output and input markets. Secondly, the structural adjustments induced by these policies like, for instance, land abandonment, change in farm size and off-farm labour, etc. Although these effects may be relevant, in the present case they act as confusing factors with respect to the policy question under analysis. Such question concerns how Swiss farmers respond to direct payments in terms of willingness to pay for variable inputs, and therefore of variable input use. In order to answer this question a sort of *ceteris paribus* condition must be granted, that is, the prices and the agricultural structure should be considered as given. For this reason, the analysis is here performed on a balanced panel of farms and through a comparison among farms under the assumption of constant (or equal) prices.

Simulation models available in the literature can be divided in two major groups: micro (or farm-level) and macro simulation models. Despite the substantial differences in the way they model the response to direct payments, their results tend to agree with the conclusions above: complex market and structural feedbacks may almost entirely offset the *ceteris paribus* farm response, on the one hand, and this farm-level response is itself strongly heterogeneous across geographical contexts and farm types. This conclusion is clearly achieved by complex micro-simulation models like, for instance, the AgriPoliS model (Brady et al., 2017). In this case the *ceteris paribus* farm-level response to direct payments tends to be positive but the market level feedbacks and the activated structural adjustments (for instance, in terms of more or less land use and availability) may almost entirely offset this response. Micro-level simulations, however, also provide a more vivid picture on the large heterogeneity of this response. Applying the AgriPoliS model to the EU regional scale, it emerges that, while direct payments may imply a positive production response (thus also a positive response in terms of input use) overall, at the individual regional and farm level the outcome can be, in fact, the opposite. For instance, the elimination of direct payments in the EU would imply a larger production and input use in the most productive farms of highly productive EU regions. An application of this model to more homogenous geographical contexts confirms that the response across heterogeneous farms can not only take different magnitude, but also a different sign. Lobianco and Esposti (2010) apply a similar micro-simulation model to two Italian regions, strongly different between them but relatively homogenous within them, confirming that in both cases the aggregate results emerge from the combination of very different and even opposite responses across heterogeneous farms within the two areas.

It is worth noticing, however, that the evidence produced by these simulation models largely depends on the theoretical assumptions that they explicitly or implicitly make on the underlying response by farmers. Therefore, while they may be useful in comparing results under alternative assumptions, they can be hardly regarded as empirical evidence about the actual response of farmers, which is of main interest for this study. In this respect, ,an interesting micro-level analysis on farm production choices has been recently presented by DEFRA (DEFRA, 2018) on the possible impact of direct payments elimination in the United Kingdom in the post-2020 period. *Strictu sensu*, this analysis is not based on a micro-simulation model but on the farm-level accounting data and on the respective break-even conditions. Compared to the Swiss case under analysis here, it is worth noticing that UK farms present a lower direct payments/agricultural revenues ratio (about 10% on average, with the highest values reaching about 25%) but a similar variable input costs/agricultural revenues ratio (about 55% on average). The analysis shows that the elimination of direct payments is expected to have an extensification effect (in terms of reduction of expenses for variable inputs per unit of agricultural revenues) because this is needed by farms to restore the break-even condition. Eventually, it is a sort of "reversed financial effect" of direct payments – the opposite of the effect discussed at § 3 of this report - that translates, on average, into an about -10% reduction of the variable input costs/agricultural revenues ratio. However, for 10% of UK farms this reduction is expected to reach about -30%. In practice, these results can be interpreted as analogous to a 0.1-0.3 TE of the present study.

Macro-models investigate the impact of direct payments at the market and sectoral level, and not directly at the farm level. Nonetheless, their results can still be of interest for this study. CAPRI (Brady et al., 2017) and AGMEMOD (Chantreuil et al., 2012) are two interesting examples of this group of models. In these models, the farm response is just conjectured and enter the models as an assumption. What is usually assumed is that a direct payment has a multiplying effect on production. The assumed multiplier is close to 1 (or just 1) for fully coupled direct payments while it falls below 0.5 for decoupled payments. In AGMEMOD (Esposti et al., 2012, p. 41), for instance, a multiplier of 0.5 is assumed if the decoupling is defined on an historical basis, while the multiplier is of 0.3 if it is defined on a regional basis: the argument is that in the former case "…the appropriate production technologies have been already established on the farms", so no medium-long term adjustment is needed.

As a matter of fact, besides the magnitude of these multipliers, they do not represent in any case the eventual impact of direct payments on production choices within these models. Multipliers enter just as exogenous drivers of the response, but these models are expected to capture all the respective market level adjustments, in particular price changes. A positive multiplier implies an increase in production that then activates a negative price response in the respective markets. This feedback, in turn, reduces the eventual production response to direct payments and can make it almost negligible (Brady et al., 2017). Moreover, even though in these macro-models there is no explicit analysis of the consequent change in input use, the implicit assumption in this respect is that any change in the output production level generates a proportional change in input use, evidently as a consequence of the capacity of the farms to immediately adjust all production factors without any quasi-fixity constraint. Therefore, the variable input costs/agricultural revenues ratio remains constant, and no intensification/extensification is present by assumption.

# 5 CONCLUSIONS

The study focused on the assessment of the **impact of support from direct payments on Swiss farmers' willingness to pay (WTP) for input goods and services**, in the light of the essential importance of direct payments in providing support to the Swiss agricultural sector.

To this end, the study assessed **whether and to what extent the observed effects of increased support from direct payments**, as emerged from the analysis of empirical data at farm level, were **consistent with theoretical expectations**. The empirical analysis made use of statistical methods to assess:

1. **whether support from direct payments** granted to Swiss farmers - technically defined as **"treatment"** - translates into **"responses" by the farmers** themselves in terms of **purchase of variable**[47] **inputs and/or services**;
2. in presence of the impact at point 1, **in which direction and to what extent different "intensity of support from direct payments"**[48] translates into **different responses by farmers in terms of expenses for variable inputs and/or services**.

**According to economic theory, a complex combination of factors potentially affects the decision to allocate support from direct payments to productive or non-productive uses**. Those factors are mainly related to conditions in product and input markets, to subjective conditions of individual farmers and to structural features of their farms.

From a purely theoretical standpoint, the response to direct payments in terms of variable input use – and hence of farmers' WTP for these inputs - can take two opposite directions or forms.

On the one hand, under the assumption that this response occurs with a given farm technology, product mix and endowment of quasi-fixed inputs (labour, capital, land), an increase in direct payments generates a **financial effect** that, especially under credit constraints, may allow farmers to intensify the use of variable inputs per unit of production or revenue (**intensification response**).

On the other hand, however, if it is admitted that direct payments also induce some adaptation of the farm technology, product mix and quasi-fixed input endowment, the response to an increase in direct payments may induce a reduction of variable input use (**extensification response**), thanks to the efficiency gains (in terms of technology and input allocation) implied by these adjustments.

The substantial costs which can be related to radical structural adjustment of farms (in terms of change of technology and/or production mix, investments in fixed inputs, etc.) should be reflected in a **decreasing response in terms of variable input use to an additional increase of the intensity of support from direct payments**.

Due to specific features of the two datasets of farm-level data from *Zentrale Auswertung von Buchhaltungsdaten* made available by Agroscope, the empirical assessment had to be broken down into:

1. An assessment for the period preceding the reform of the Swiss system of direct payments (2010-13), i.e. under a constant policy regime.
2. An assessment comparing the pre-reform period (2010-13) with the first year of application of the reform (2014), and hence focusing on the transition between two policy regimes.

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[47] The empirical assessment performed for the study does not cover expenses for fixed inputs such as machinery, equipment, farm buildings, etc.

[48] The "intensity of support from direct payments" is a measure of the different levels of support granted to individual farmers which is independent from farm size. The intensity of support is measured through the ratio between direct payments and "agricultural revenues": the latter correspond to the "value of raw output from agricultural production" in Agroscope's *Zentrale Auswertung von Buchhaltungsdaten*, which includes revenues from crop farming and animal farming, and excludes revenues from "para-agricultural activities" (e.g. on-farm sale of processed agricultural products) and – above all – direct payments.

3. An assessment for the 2015-16 period, i.e. once again under a constant policy regime.

The above approach offered the possibility to empirically assess whether and to what extent the observed response by farmers remained consistent with the theoretically expected one in three distinct samples and under different policy regimes.

It is important to note that the assessment methodology allowed to address the fact that factors other than direct payments (such as farm size, the different specialisation of farms, farmers' education, etc.) can contribute to explain observed effects in terms of variable input use.

The **assessment for the 2010-13 period** was carried out on a sample of 1,399 farms. It allowed to conclude that - except for farms with lower levels of support from direct payments - **the response to direct payments is a mild, less than proportional intensification of variable input use**, which is itself consistent with most of the literature and, therefore, theoretical expectations. The main policy implication of this result is that **lowering direct payments induces an extensification in the use of variable inputs** per unit of agricultural revenues. On the contrary, **higher direct payments, in practice, provide the funding for an intensification in variable input use** per unit of agricultural revenues**.** However, **caution should be applied in generalising the results of the assessment to any individual farm**, since farms are heterogeneous, and the response itself can be heterogeneous: it should be kept in mind that both intensification and extensification in variable input use are actually admitted by theory as responses to increased support from direct payments.

Always for the 2010-13 period, the assessment found that the response to increased intensity of support from direct payments in terms of expenditure for **insurances**, **fertilisers** and **work by third parties** (and also veterinarian services and drugs, even if the robustness of results is much lower in this case) was **positive and less than proportional**, consistently with the theoretically expected response. By contrast, the response in terms of expenditure for **concentrated feed** was found to be **negative.** A linkage with the higher importance of support from roughage feeders contribution, as well as support to livestock farming in difficult production conditions, animal friendly livestock housing systems and regular outdoor animal farming for farm types focusing on animal farming in the panel, may contribute to explain this observed extensification effect, as eligibility for support from these types of direct payments can be linked to animal husbandry techniques implying less intensive use of concentrated feed.

Two separate subsamples - one with farms experiencing a decrease in the intensity of support from direct payments with the transition to the new regime, and one with farms experiencing an increase in this respect - had to be analysed for the **comparative assessment between the 2010-13 period and 2014**. The much higher number of farms in the first subsample (1,066 vs. 333) and the probably high heterogeneity of the second subsample allowed to obtain robust enough results only for the case of decreased intensity of support from direct payments. The assessment **confirmed that a higher/lower intensity of support from direct payments is associated to an intensification/extensification of variable input use,** albeit with statistically weaker results than in the assessment for the 2010-2013 period.

As for the results of the **assessment for the 2015-16 period** (based on a sample of 1,453 farms), they basically confirmed - even with some limitations in terms of statistical robustness - that **increased intensity of support from direct payments has a positive impact on the ratio between expenses for variable inputs and agricultural revenues** (intensification effect). However, farms with higher intensity of support from direct payments did not show any response in terms of neither intensification nor extensification in variable input use.

A **comparison** was also made between **the results of the assessment for the 2015-16 period** and those of **the assessment for the 2010-2013 period**. Both assessments in fact concern the impacts of support from direct payments on expenditure for variable inputs in a constant policy regime. In theory, **the same behaviour should emerge from the two assessments**, and if this does not happen, this should be attributed either to changes in the features of the sample or to changes in the mechanisms for delivering support from direct payments between the two periods. The comparison found that **the results are clearly comparable,** as they **both indicate** – consistently with theoretical expectations - **an increase in the ratio between**

**expenses for variable inputs and agricultural revenues associated to a higher intensity of support from direct payments**. However, the results for the 2015-2016 period are statistically weaker.

To verify the actual reliability of the results of the empirical assessment carried out for the study, these were also assessed against the existing literature on the topic. Analogous micro-level ex-post assessments can be hardly found in the literature; however, **a comparison with a number of recent studies based on simulation models** - used to anticipate the impact of possible policy reforms – **basically confirmed the reliability of the obtained results** (even if such a comparison requires extreme caution).

Overall, **the results of the three separate empirical assessments** carried out were found to be **consistent with one another**. It is worth observing that, also considering the methodological challenges of the assessment and some limitations deriving from the available datasets, **such consistency does not represent a trivial outcome**.

The findings of the assessment hence allow to conclude that:

a. A **linkage between government support** and **Swiss farmers' willingness to pay for variable inputs and services does exist**, at least in the case of **one of the most important forms of policy support to the agricultural sector in Switzerland, i.e. direct payments**.
b. The **direction of the effect of support from direct payments** in terms of increased/decreased expenditure for variable inputs **varies according to the intensity of support** and to a number of other factors, but this effect is **mainly positive** (increased intensity of support from direct payments often translates into higher expenses for variable inputs per unit of agricultural revenue) and **always less than proportional.**

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# 7 ANNEXES

## 7.1 Details on the methodology for the empirical assessment of actual impacts of policy support on Swiss farmers' willingness to pay

### *7.1.1 The analysis of the impact of direct payments as a Multivalued Treatment Effect (MTE)*

The methodological approach followed in the study applies principles and techniques of the so-called **Treatment Effect (TE) econometrics**. In the last decade a rich toolkit for the identification and estimation of the TE even in the case of specific and complex treatments has progressively emerged (Imbens and Wooldridge, 2009; Esposti, 2017a,b). The aim of this study is to take advantage of these methodological improvements and to apply them to an original assessment of the DP impact on farm production choices.

The application of the TE logic to the assessment of farm response to direct payments (DP henceforth) requires counterfactual observations. In the case of DP, however, the lack of a suitable control group of farms not receiving the support is often considered a major difficulty (Key et al., 2005; Esposti, 2017a,b). DP are a non-selective generalised policy so they behave as a treatment applied to the large majority of farms. The only exceptions are those farms whose production choices implied a sort of self-exclusion from the treatment itself. Controlling for variables determining this self-exclusion is very challenging since the presence of relevant unobservables in this respect cannot be excluded (Esposti, 2017a,b).

In the case of the DP, however, there is another opportunity to identify the TE. The amount of decoupled support differs across farms and, consequently, the response to the DP as a TE can be identified by comparing production response of similar farms receiving a different intensity of support (expressed as "direct payments/agricultural revenues" ratio to make it independent from farm size). In practice, such identification strategy acknowledges that the DP actually behave as a multivalued treatment and the respective MTE identification and estimation strategy can be adopted accordingly.

Consider the sample of *N* farms. Let $Y_i$ indicate an outcome variable observed in the generic "i-th" farm (unit), *i = 1, … , N*. Assume that the treatment, in fact, is not binary but behaves as a continuous variable ( $p \in \mathbf{R}^+$ ). Therefore, the treatment intensity (*p*) varies across the treated units and the response of the outcome variable (*Y*) to the treatment is itself continuous. Assume also that the attribution of a treatment to the "i-th" farm does not affect the TE on the "j-th" farm, $\forall j \neq i = 0,\ldots,N$ . This assumption is called *stable-unit-treatment-value assumption (SUTVA)*.

Finally, let us assume that all variables eventually generating selection bias are known and observed. These *confounding variables* are all those pre-treatment (exogenous) variables **X** that affect at the same time the treatment assignment and the outcome. Once we control for all these confounding factors (or covariates) **X**, the different outcomes between the observations only depend on the treatment. Such assumption is known as *Conditional Independence Assumption* (CIA) or *Unconfoundedness Assumption*. Vector **X** is expected to contain all the pre-treatment variables that affect, at the same time, the treatment assignment and to the outcome variable.

When the treatment is continuous, the intensity of the treatment can be correlated to the magnitude of this response and this allows the identification and estimation of the TE without using the non-treated units. In fact, these latter are no more needed to observe how the *Y* varies with *p*|**X.** In fact, whenever we have a multivalued treatment, the critical empirical issue shifts from finding appropriate counterfactuals to properly define the functional relationship between *Y* and *p*|**X**: this is the *Dose-Response Function* (DRF).

As anticipated, the Average Treatment Effect (ATE) can be then easily estimated as the first order derivative of the estimated DRF. These DRF and ATE estimates provide evidence on the shape of farms' production response to DP. The related estimation approach is explained at § 7.1.2.

### *7.1.2 The Estimation Approach: Generalized Propensity Score (GPS), Dose-Response Function (DRF) and Average Treatment Effect (TE)*

The approach that follows this intuition has been originally proposed by Hirano and Imbens (2004) and it is based on the concept of *Generalized Propensity Score* (GPS). In a broad sense, it can be considered a generalisation of the conventional matching estimation based on the Propensity Score Matching (PSM). The **Hirano-Imbens approach** can be described as the **sequence of three steps**.

Assume that for any treated unit *i = 1, … , N*, we observe the covariates $\mathbf{X}_i$, the treatment level $p_i$, the outcome variable $Y_i$. We define, $\forall i$, a set of *potential outcomes* $\{Y_i(p)\}_{p\in\Xi}$ where $\Xi$ is the set of potential treatment levels and $Y_i(p)$ is a random variable that maps, for the "i-th" unit, a particular potential treatment, *p*, to a potential outcome. Evidently, of these potential outcomes, only one is observed, that associated with the actual treatment $p_i$. Hirano and Imbens (2004) refer to $Y_i(p)$ as the *unit-level Dose-Response Function* (*uDRF*). In fact, we are interested in the *average Dose-Response Function* (*aDRF*), $aDRF(p) = E[(Y(p)]$ since it is, in our case, the empirical expression of the functions depicted in Figure 3.3 at § 3.3.

The **first estimation step** consists in the estimation of the $GPS_i$, i.e., the probability that the "i-th" unit is assigned the treatment level *p* given its observed characteristics $\mathbf{X}_i$: $GPS_i = r(p_i, \mathbf{X}_i)$, where $r(p, \mathbf{X})$ is the *propensity function*, that is, the conditional density of the actual treatment given the observed covariates. For the GPS to be meaningful in the calculation of the TE, the following condition must be satisfied within the sample: units with statistically equivalent values of **X** are expected to show, around a given interval of *GPS*, both treatment levels lower and higher than a given level *p*. This is also known as the *balancing condition*. Hirano and Imbens (2004) demonstrate that if this condition is respected, and CIA assumed, the assignment to treatment is unconfounded, given the estimated GPS[49]. Therefore, the different *Y* observed across units showing the same estimated *GPS*|**X** can be fully attributed to the different treatment level *p*.

Once the propensity function is estimated, the **second step** consists in estimating the conditional expectation of the potential outcome as a function of two scalar variables, the estimated *GPS* and *p*: $g(G\hat{P}S, p) = E\left[Y \middle| G\hat{P}S, p\right]$.

The **third and final step** estimates the *aDRF* as $aDRF(p) = E[(\hat{g}(p)]$, $T \in \Xi$, that is, by averaging the estimated conditional expectation $\hat{g}(G\hat{P}S, p)$ over the *GPS* at any level of the treatment we are interested in.

The above estimation steps imply **arbitrary assumptions**.

The **first arbitrary assumption** concerns the specification of the distribution of $p_i$ conditional on $\mathbf{X}_i$ to compute its conditional density. The common practical implementation of the methodology, also followed here, assumes a normal distribution for the treatment given the covariates:

[49] In the continuous treatment case, Hirano and Imbens (2004) actually call the CIA "Weak Unconfoundedness Assumption", since it only requires conditional independence to hold for each value of the treatment, rather than joint independence of all potential outcomes.

(1) $r(p_i, \mathbf{X}_i) = p_i | \mathbf{X}_i \sim N(\boldsymbol{\beta}'\overline{\mathbf{X}}_i, \sigma^2)$

where $\boldsymbol{\beta}$ is a vector of unknown parameters. Therefore, the assumption is that the propensity function is linear in unknown parameters that can be thus estimated by OLS[50]. In fact, while the normality assumption can be tested, the empirical specification of equation (1) remains arbitrary. In particular, it seems questionable here to assume a linear relationship between $p$ and some set of conditioning variables **X**. Nonetheless, this problem can be prevented by using $\overline{\mathbf{X}}$ instead of $\mathbf{X}$, where $\overline{\mathbf{X}}$ includes transformations (e.g. polynomial terms) of $\mathbf{X}$ and/or interactions terms across variables in $\mathbf{X}$, in such a way that $\overline{\mathbf{X}}$ satisfies both the normality assumption and the balancing condition.

The estimated GPS is thus calculated as:

(2) $$G\hat{P}S_i = \frac{1}{\sqrt{(2\pi\hat{\sigma}^2)}} \exp\left\{ -\frac{1}{2\hat{\sigma}^2} \left(p_i - \boldsymbol{\beta}'\overline{\mathbf{X}}_i\right)^2 \right\}$$

A **second and, probably, more critical arbitrary assumption** concerns the specification of the *uDRF*, $g(G\hat{P}S, p) = E\left[Y | G\hat{P}S, p\right]$, that is, the conditional expectation of the potential outcome with respect to *p* and the estimated *GPS*. The often adopted specification of the conditional expectation is a fully interacted flexible function of its two arguments providing a good approximation of the underlying unknown relationship:

(3) $$g(G\hat{P}S, p) = E\left[Y | G\hat{P}S, p\right] = \alpha_0 + \sum_{k=1}^{K} \alpha_k (p)^k + \sum_{h=1}^{H} \gamma_h (G\hat{P}S)^h + \sum_{k=1}^{K}\sum_{h=1}^{H} \lambda_{kh} (p)^k (G\hat{P}S)^h$$

where $\alpha_0, \alpha_k, \gamma_h, \lambda_{kh}$ are unknown parameters to be estimated[51]. The observed $Y_i$, $p_i$ and the estimated $GPS_i$ are used to estimate the unknown parameters of relationship (3) by OLS. The empirical approach can start with the general form (3) and then adopt the best fitting specification according to the usual Akaike Information Criterion (AIC).

The final estimation step thus uses these estimated parameters to compute the average potential outcome at a given treatment level, *p*, i.e. $aDRF(p) = E[(\hat{g}(p)]$:

(4) $$aDRF(p) = E[(\hat{g}(p)] = \frac{1}{N} \sum_{i=1}^{N} \left[ \hat{\alpha}_0 + \sum_{k=1}^{K} \hat{\alpha}_k (p)^k + \sum_{h=1}^{H} \hat{\gamma}_h (G\hat{P}S_i)^h + \sum_{k=1}^{K}\sum_{h=1}^{H} \hat{\lambda}_{kh} (p)^k (G\hat{P}S_i)^h \right]$$

The entire *aDRF* can be thus obtained by computing this average potential outcome for each level of the treatment, i.e. $\forall p \in \Xi$.

[50] Evidently, it is possible to assume other distributions, to adopt different (even non-parametric) specifications other than the linear regression and to estimate the GPS by other methods such as MLE. Following Bia and Mattei (2008), a MLE instead of a OLS estimation of parameters $\boldsymbol{\beta}$ can be performed.

[51] Hirano and Imbens (2004) emphasize that there is no direct meaning (i.e. economic interpretation) of the estimated coefficients in equation (4), except that testing whether all coefficients involving the GPS are equal to zero can be interpreted as a test of whether the covariates introduce any bias.

Bootstrap methods can be adopted to obtain standard errors of the estimated $a\hat{DRF}(p)$ taking into account the estimation of parameters in equations (1) and (3) (i.e., the entire estimation process is bootstrapped).

Eventually, the ATE being the first order derivative of (4) with respect to the various treatment levels *p*, it is estimated as: $ATE(p, p+\Delta) = \{E[Y(p+\Delta, \mathbf{X})] - E[Y(p, \mathbf{X})]\}$.

### *7.1.3 References*

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## 7.2 Supporting empirical evidence

### 7.2.1 Panel 2010-2013

*Figure 7.1 – Distribution of the continuous treatment: direct payment on UAA (in CHF/Ha): Kernel density (avg. over 2010-2013 period).*

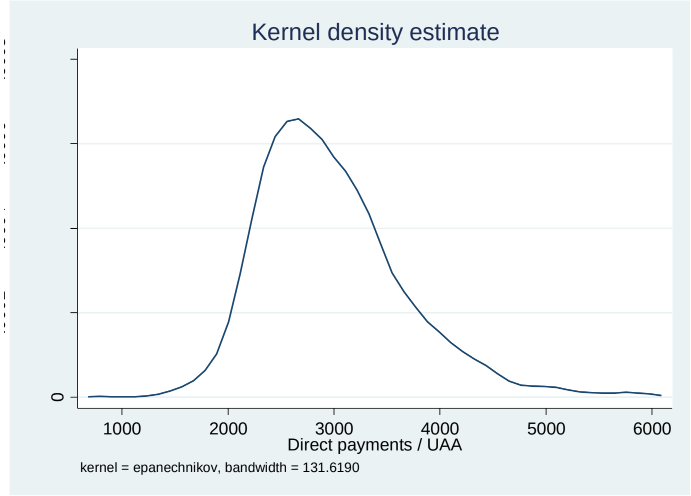



*Figure 7.2 – Distribution of the continuous outcome: agricultural costs on agricultural revenues (in %): Kernel density (avg. over 2010-2013 period).*

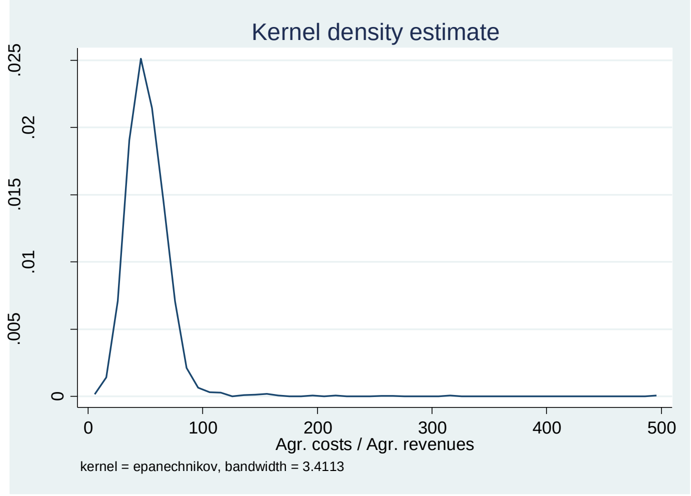


*Figure 7.3 – Distribution of the continuous outcome: agricultural costs on UAA (in CHF/Ha): Kernel density (avg. over 2010-2013 period).*

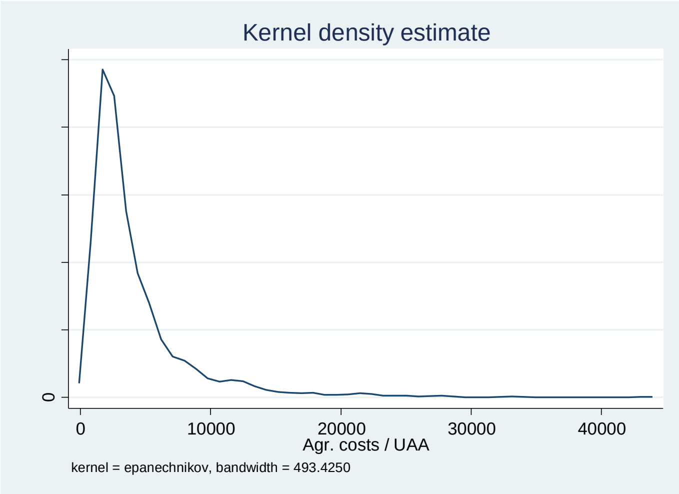



*Figure 7.4 – Distribution of the continuous outcome: costs for plant protection on agricultural revenues (in %): Kernel density (avg. over 2010-2013 period).*

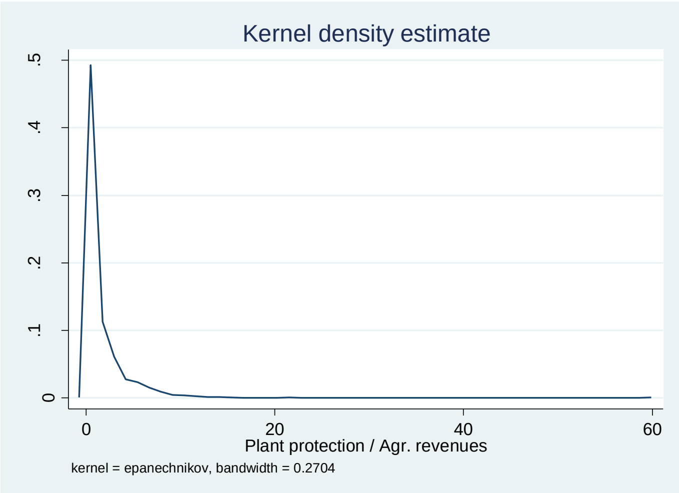



*Figure 7.5 – Distribution of the continuous outcome: costs for concentrated feed on agricultural revenues (in %): Kernel density (avg. over 2010-2013 period).*

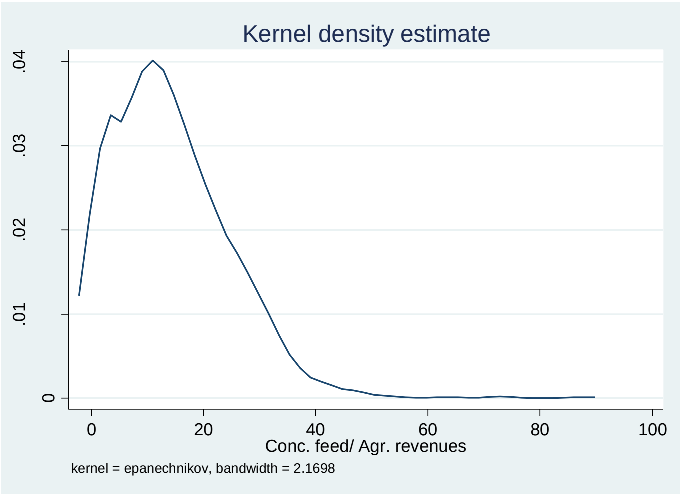


*Figure 7.6. Distribution of the continuous outcome: costs for veterinary services / drugs on agricultural revenues (in %): Kernel density (avg. over 2010-2013 period).*

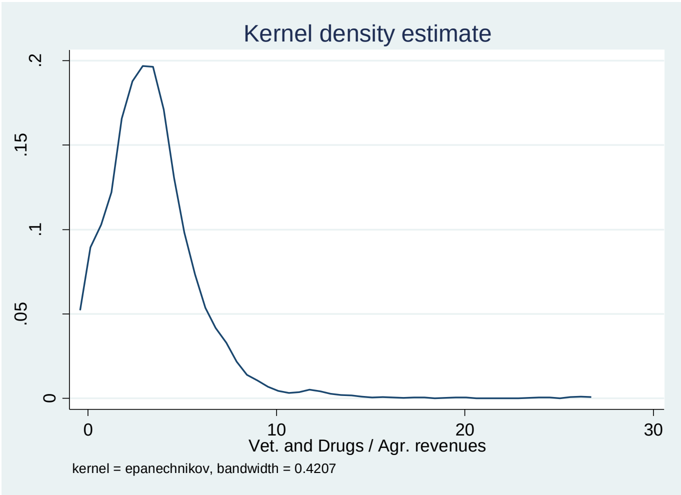



*Figure 7.7 – Distribution of the continuous outcome: costs for work by third parties on agricultural revenues (in %): Kernel density (avg. over 2010-2013 period).*

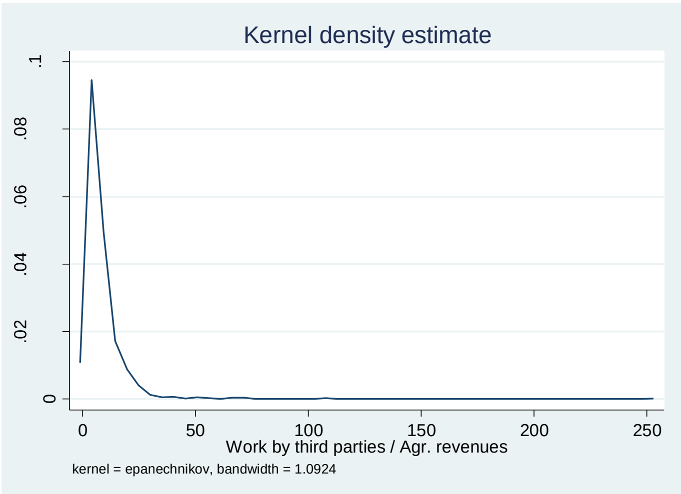



*Figure 7.8 – Distribution of the continuous outcome: costs for insurances on agricultural revenues (in %): Kernel density (avg. over 2010-2013 period).*

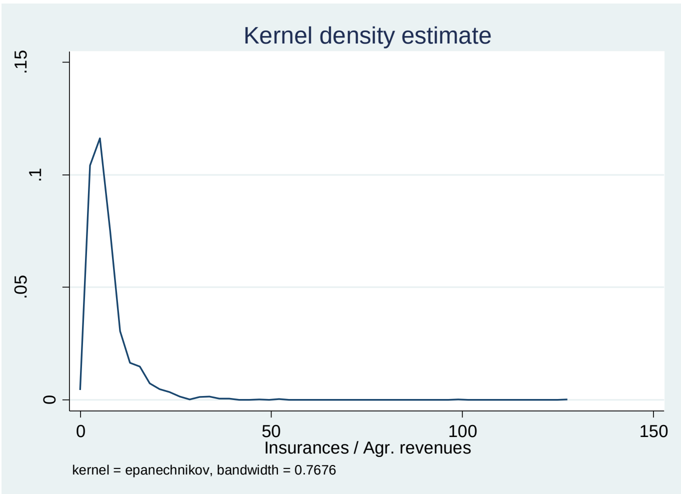


*Figure 7.9 – Distribution of the continuous outcome: costs for fertilisers on agricultural revenues (in %): Kernel density (avg. over 2010-2013 period).*

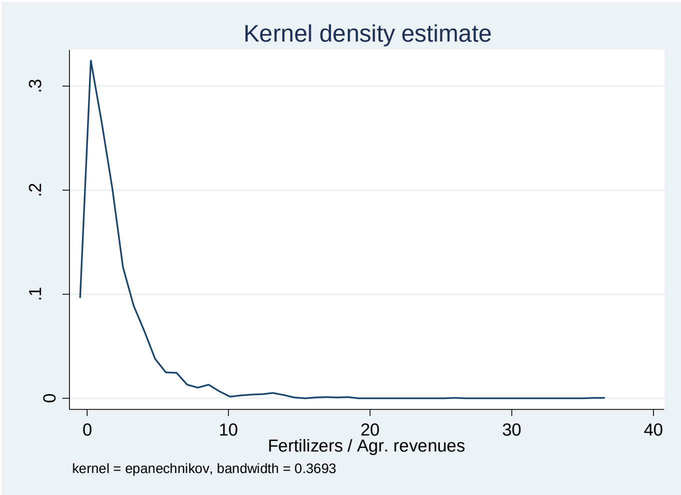



*Figure 7.10 – Distribution of the continuous confounding variable: agricultural area (in Ha): Kernel density (avg. over 2010-2013 period).*

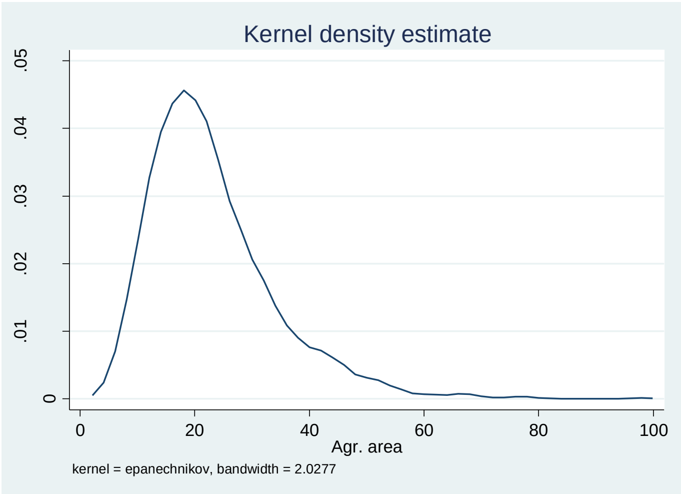



*Figure 7.11 – Distribution of the continuous confounding variable: altitude (in meters above sea level): Kernel density (avg. over 2010-2013 period).*

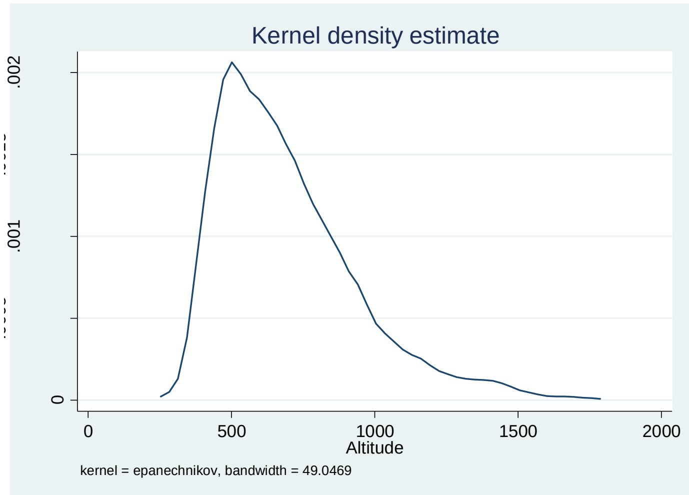


*Figure 7.12- – Distribution of the continuous confounding variable: livestock (in n.): Kernel density (avg. over 2010-2013 period).*

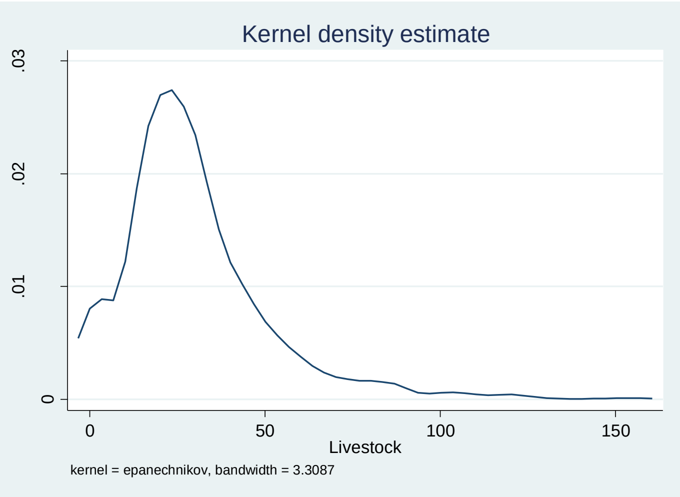



*Figure 7.13 – Distribution of the continuous confounding variable: farmer's age (in years): Kernel density (avg. over 2010-2013 period).*

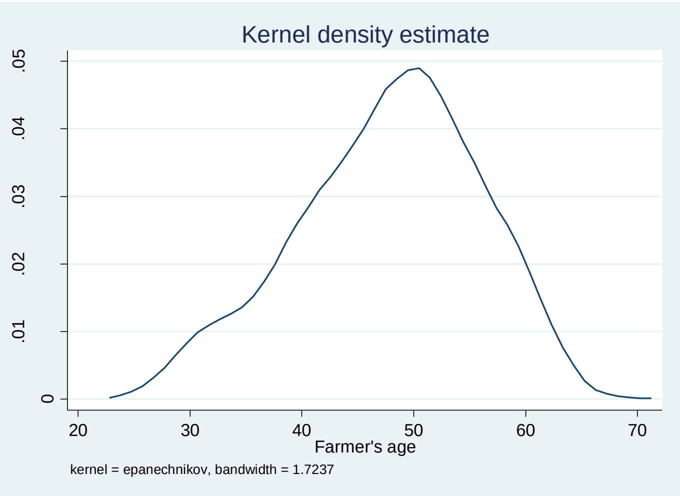



*Figure 7.14 – Distribution of the discrete confounding variable: farmer's education (in levels): bar chart (avg. over 2010-2013 period).*

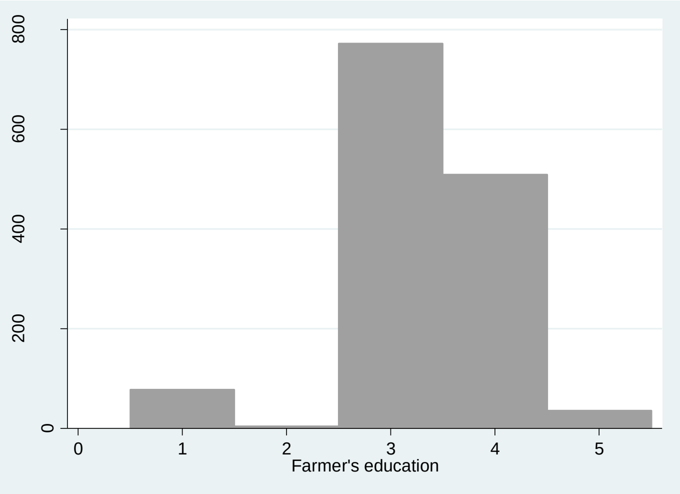


*Figure 7.15 – Distribution of the continuous confounding variable: arable land on UAA (in %): Kernel density (avg. over 2010-2013 period).*

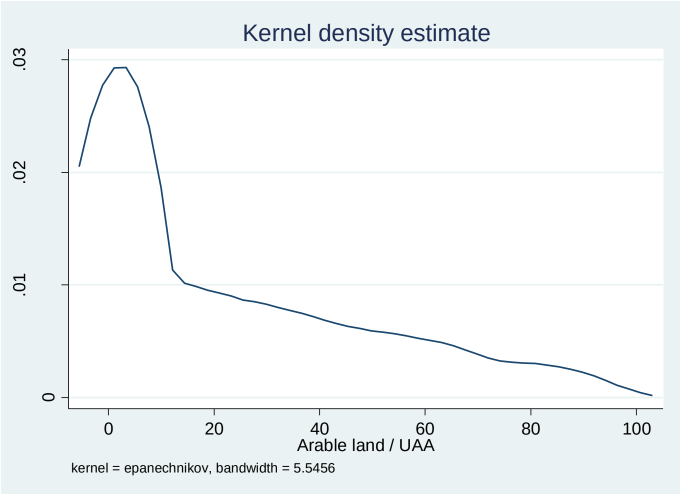



*Figure 7.16 – Distribution of the continuous confounding variable: permanent pastures on UAA (in %): Kernel density (avg. over 2010-2013 period).*

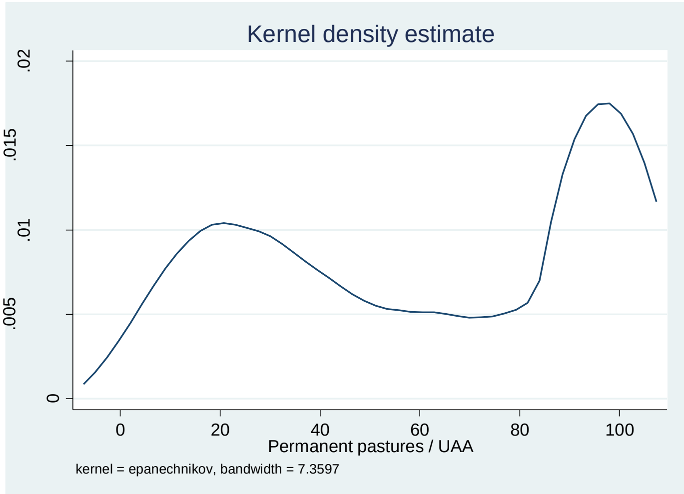



*Figure 7.17 – Distribution of the continuous confounding variable: permanent crops on UAA (in %): Kernel density (avg. over 2010-2013 period).*

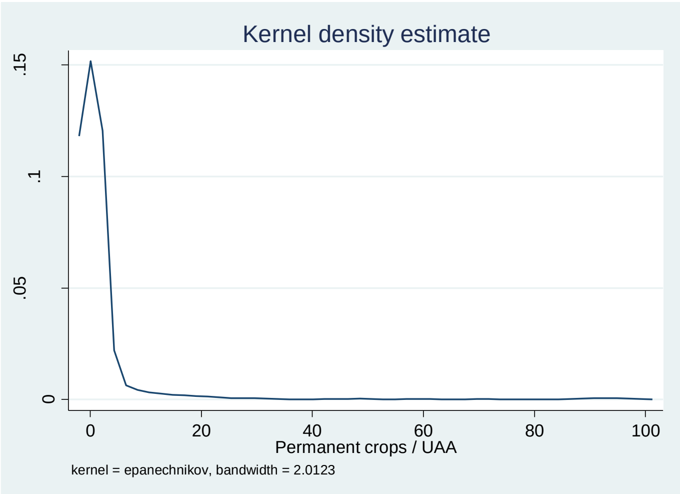


*Table 7.1 – Hirano-Imbens (2004) DRF parameter estimates[a]*

| Outcome: `FertilisersAgrRevenues` | Coefficient | (std. err.) |
|---|---|---|
| DirectPaymentsAgrrevenues | 0.0368111 | (0.005) * |
| DirectPaymentsAgrrevenues_sq | -0.000069 | (0.000) * |
| pscore | -0.2389307 | (0.866) |
| pscore_sq | 0.6763431 | (0.470) |
| DirectPaymentsAgrrevenues_pscore | -0.0259462 | (0.003) * |
| _cons | 1.294222 | (0.405) * |

[a] The BoxCox transformation of the treatment variable is used
*Statistically significant at 0.05 level

*Table 7.2 – Hirano-Imbens (2004) DRF parameter estimates[a]*

| Outcome: `InsurancesAgrRevenues` | Coefficient | (std. err.) |
|---|---|---|
| DirectPaymentsAgrrevenues | 0.132696 | (0.008) * |
| DirectPaymentsAgrrevenues_sq | -0.0000832 | (0.000) * |
| pscore | -3.66439 | (1.496) * |
| pscore_sq | 2.659827 | (0.813) * |
| DirectPaymentsAgrrevenues_pscore | -0.0336424 | (0.006) * |
| _cons | 2.181338 | (0.700) * |

[a] The BoxCox transformation of the treatment variable is used
*Statistically significant at 0.05 level

*Table 7.3 – Hirano-Imbens (2004) DRF parameter estimates[a]*

| Outcome: `VetDrugsAgrRevenues` | Coefficient | (std. err.) |
|---|---|---|
| DirectPaymentsAgrrevenues | 0.0109906 | (0.004) * |
| DirectPaymentsAgrrevenues_sq | 0.0000254 | (0.000) * |
| pscore | 1.375739 | (0.742) |
| pscore_sq | -0.3349861 | (0.403) |
| DirectPaymentsAgrrevenues_pscore | 0.0037982 | (0.003) |
| _cons | 1.309664 | (0.347) * |

[a] The BoxCox transformation of the treatment variable is used
*Statistically significant at 0.05 level

*Table 7.4 – Hirano-Imbens (2004) DRF parameter estimates[a]*

| Outcome: `WorkIIIAgrRevenues` | Coefficient | (std. err.) |
|---|---|---|
| DirectPaymentsAgrrevenues | 0.2174917 | (0.016) * |
| DirectPaymentsAgrrevenues_sq | -0.0002406 | (0.000) * |
| pscore | -6.744688 | (3.044) * |
| pscore_sq | 7.23131 | (1.654) * |
| DirectPaymentsAgrrevenues_pscore | -0.1522401 | (0.012) * |
| _cons | 3.302243 | (1.424) * |

[a] The BoxCox transformation of the treatment variable is used
*Statistically significant at 0.05 level

*Table 7.5 – Hirano-Imbens (2004) DRF parameter estimates*[a]

| Outcome: `PlantProtAgrRevenues` | Coefficient | (std. err.) |
|---|---|---|
| DirectPaymentsAgrrevenues | 0.0250197 | (0.005) * |
| DirectPaymentsAgrrevenues_sq | -0.0000518 | (0.000) * |
| pscore | -2.776242 | (0.864) * |
| pscore_sq | 1.821559 | (0.470) * |
| DirectPaymentsAgrrevenues_pscore | -0.0251302 | (0.003) * |
| _cons | 2.422865 | (0.404) * |

[a] The BoxCox transformation of the treatment variable is used
*Statistically significant at 0.05 level

*Table 7.6 – Hirano-Imbens (2004) DRF parameter estimates*[a]

| Outcome: `ConcentratedFeedAgrRevenues` | Coefficient | (std. err.) |
|---|---|---|
| DirectPaymentsAgrrevenues | -0.1106527 | (0.018) * |
| DirectPaymentsAgrrevenues_sq | 0.0002051 | (0.000) * |
| pscore | -6.001926 | (3.314) |
| pscore_sq | 2.565845 | (1.801) |
| DirectPaymentsAgrrevenues_pscore | 0.0317965 | (0.013) * |
| _cons | 20.75543 | (1.550) * |

[a] The BoxCox transformation of the treatment variable is used
*Statistically significant at 0.05 level

### *7.2.2 Panel 2010-2014*

#### 7.2.2.1 Subsample with negative variations

*Figure 7.18 – Distribution of the continuous treatment: direct payments on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

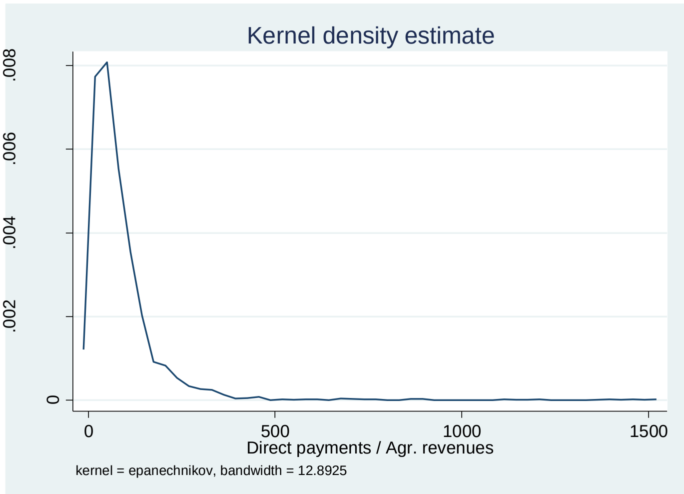


*Figure 7.19 – Distribution of the continuous treatment: direct payments on UAA (in CHF/Ha): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

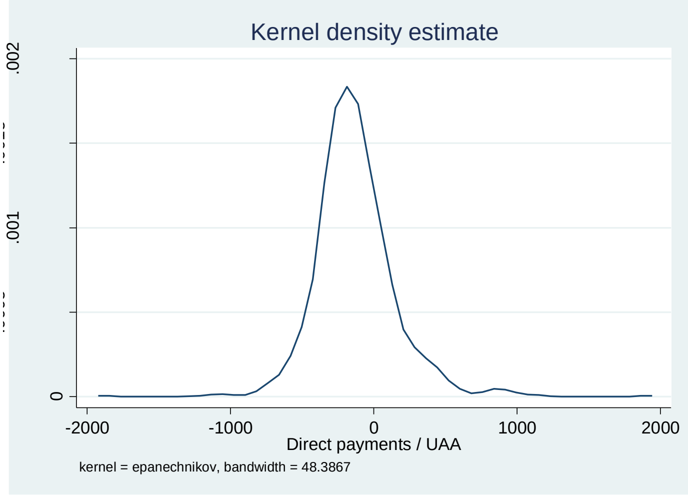



*Figure 7.20 – Distribution of the continuous outcome: agricultural costs on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

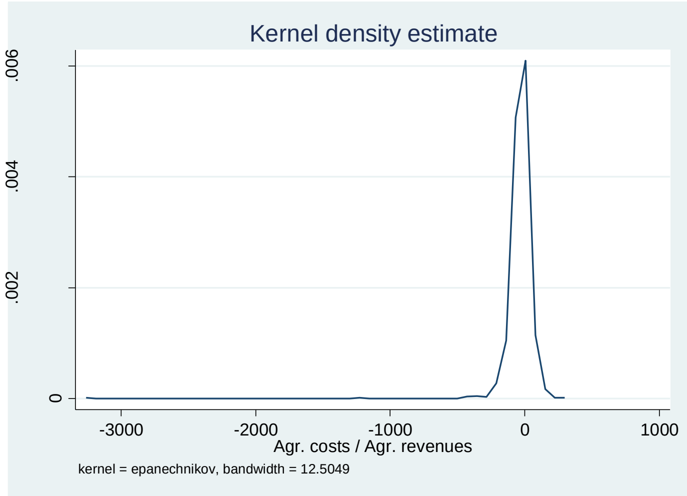



*Figure 7.21 – Distribution of the continuous outcome: agricultural costs on UAA (in CHF/Ha): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

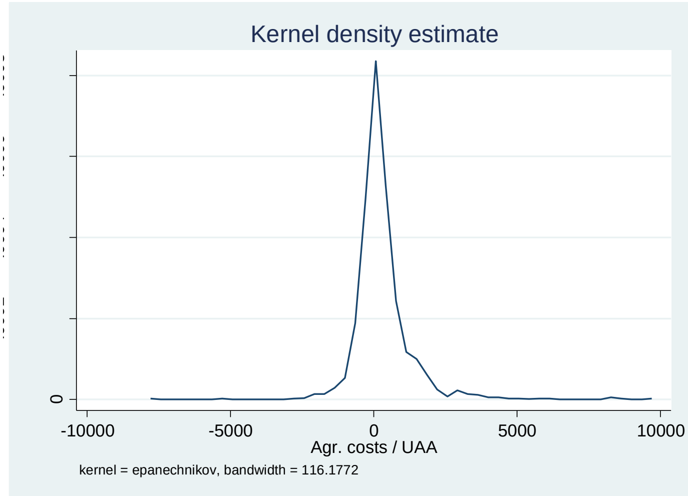


*Figure 7.22 – Distribution of the continuous confounding variable: agricultural area (in Ha): Kernel density (2014).*

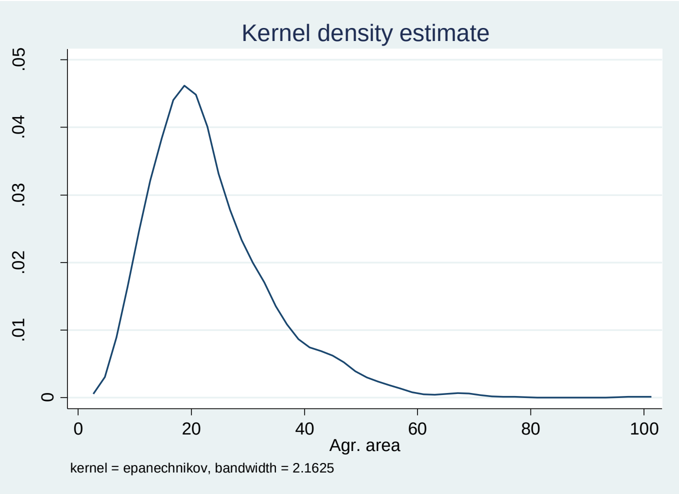



*Figure 7.23 – Distribution of the continuous confounding variable: altitude (in meters above sea level): Kernel density (2014).*

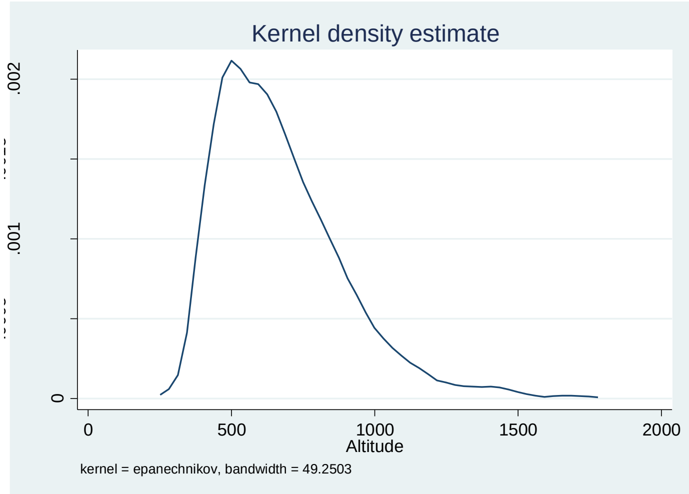



*Figure 7.24 – Distribution of the continuous confounding variable: livestock (in n.): Kernel density (2014).*

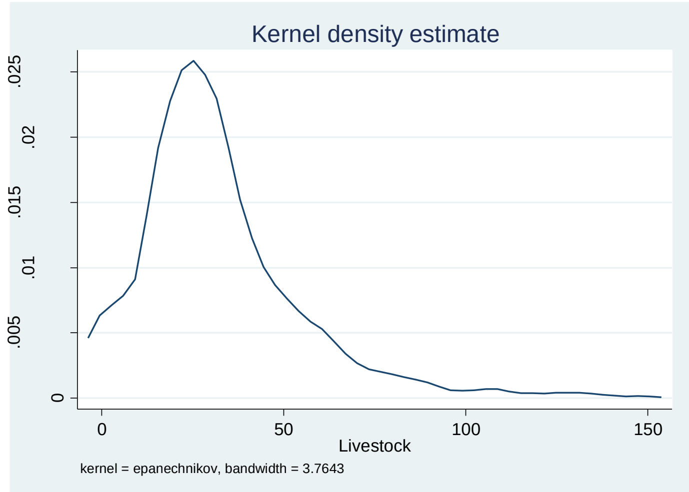


*Figure 7.25 – Distribution of the continuous confounding variable: farmer's age (in years): Kernel density (2014).*

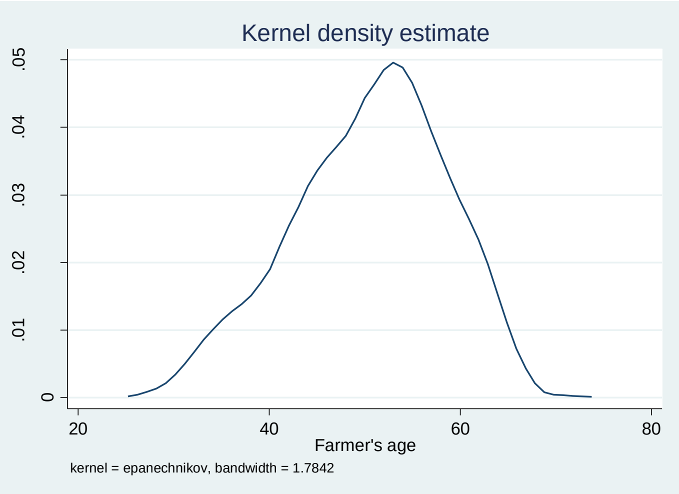



*Figure 7.26 – Distribution of the discrete confounding variable: farmer's education (in levels): Kernel density (2014).*

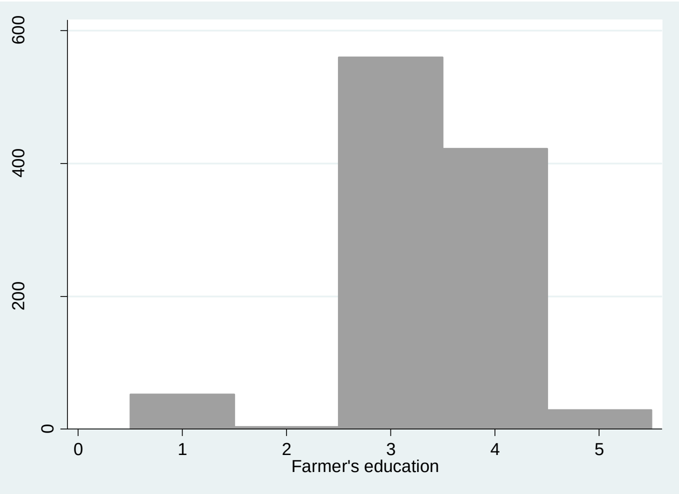



*Figure 7.27 – Distribution of the continuous confounding variable: arable land / UAA (in %): Kernel density (2014).*

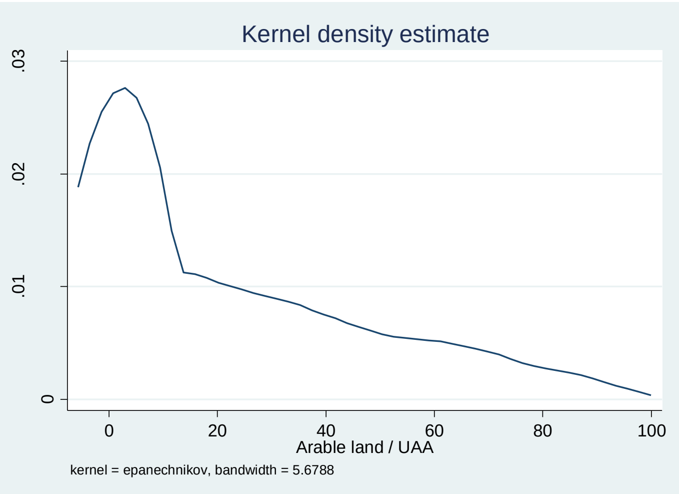


*Figure 7.28 – Distribution of the continuous confounding variable: permanent pastures / UAA (in %): Kernel density (2014).*

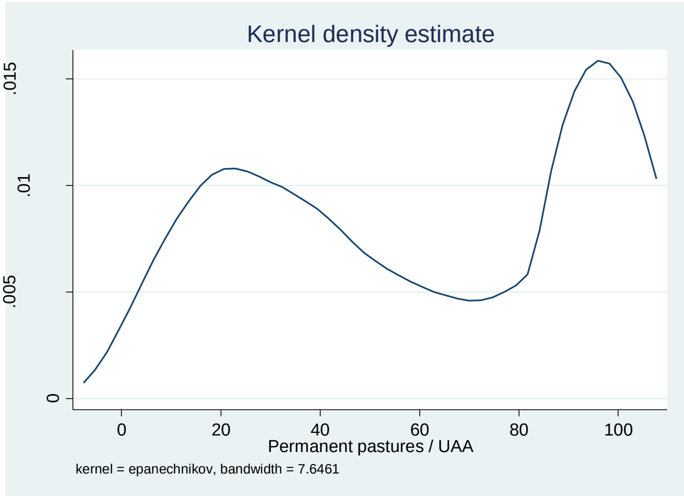



*Figure 7.29 – Distribution of the continuous confounding variable: permanent crops / UAA (in %): Kernel density (2014).*

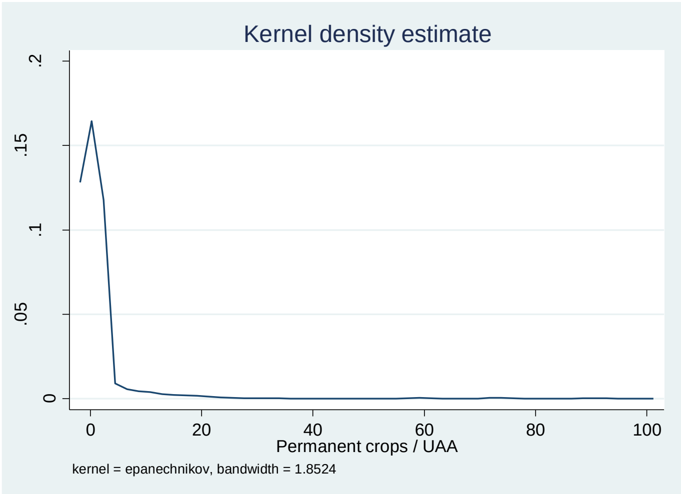



*Figure 7.30 – Distribution of the continuous outcome: costs for plant protection on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

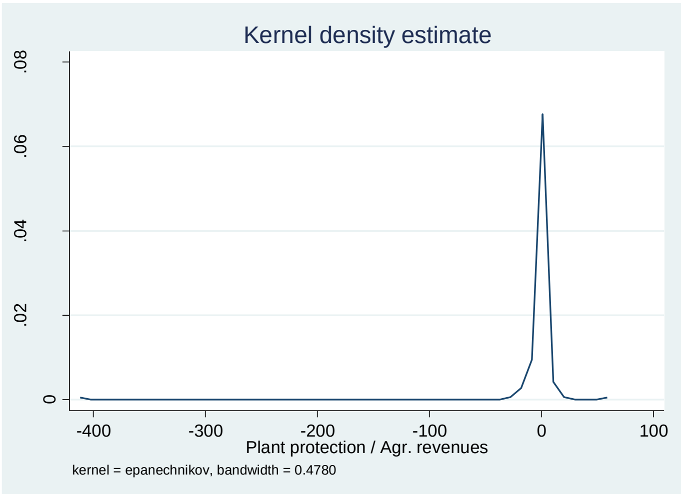


*Figure 7.31 – Distribution of the continuous outcome: costs for concentrated feed on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

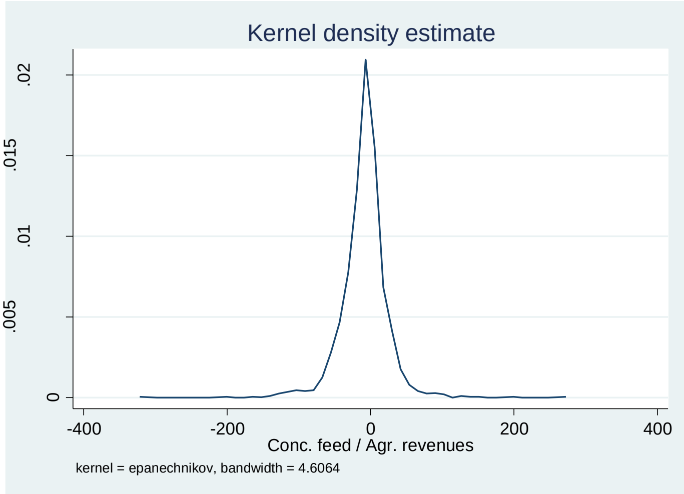



*Figure 7.32 – Distribution of the continuous outcome: costs for veterinary services / drugs on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

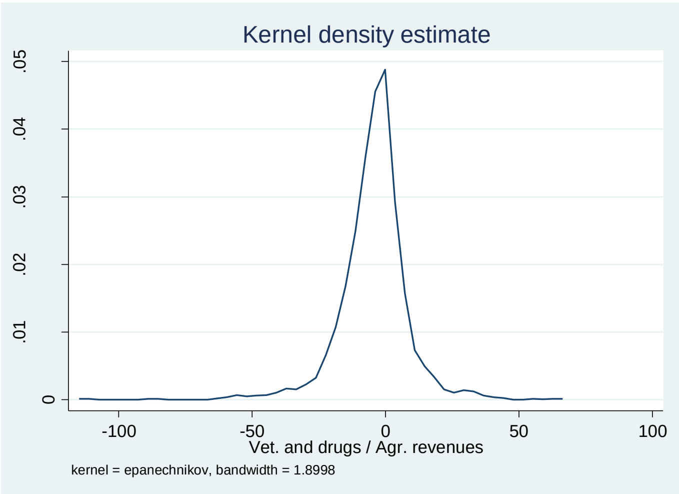


*Figure 7.33 – Distribution of the continuous outcome: costs for work by third parties on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

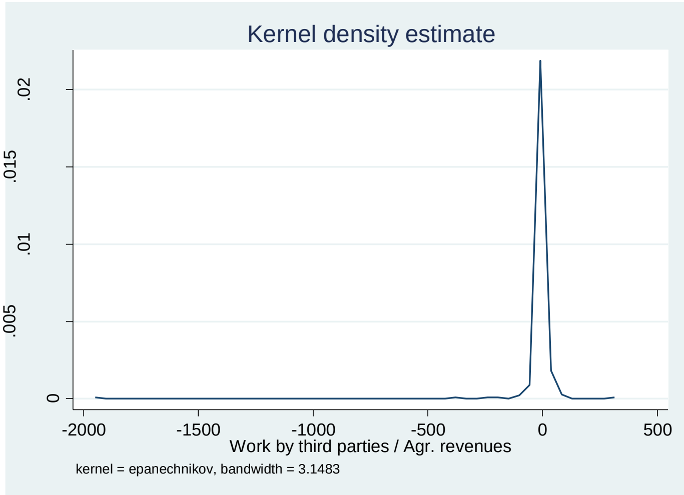



*Figure 7.34 – Distribution of the continuous outcome: costs for insurances on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

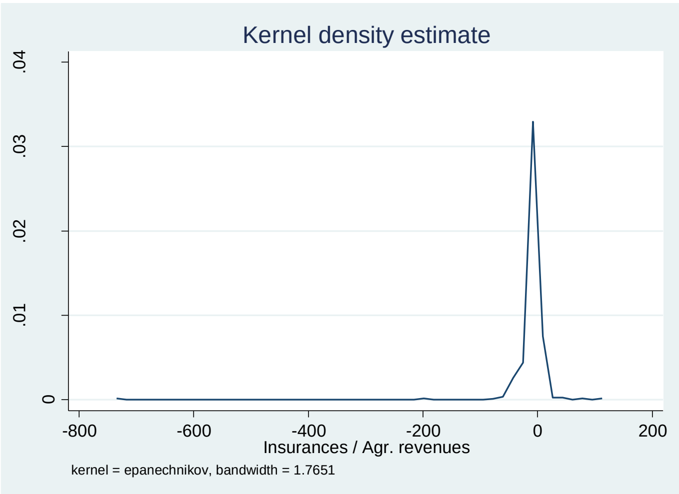


*Figure 7.35 – Distribution of the continuous outcome: costs for fertilisers on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

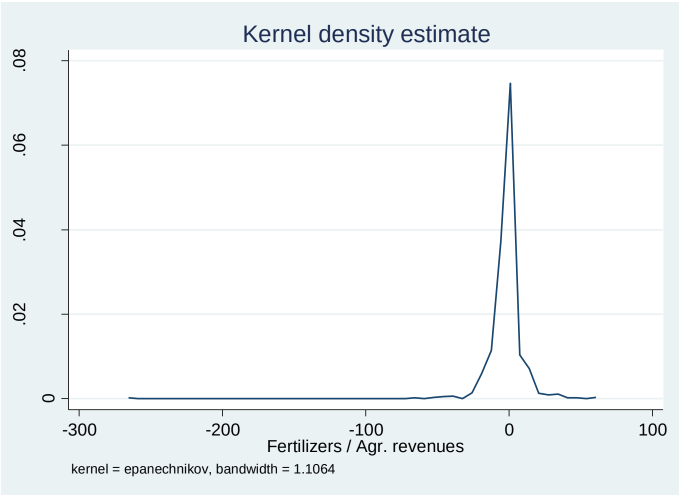


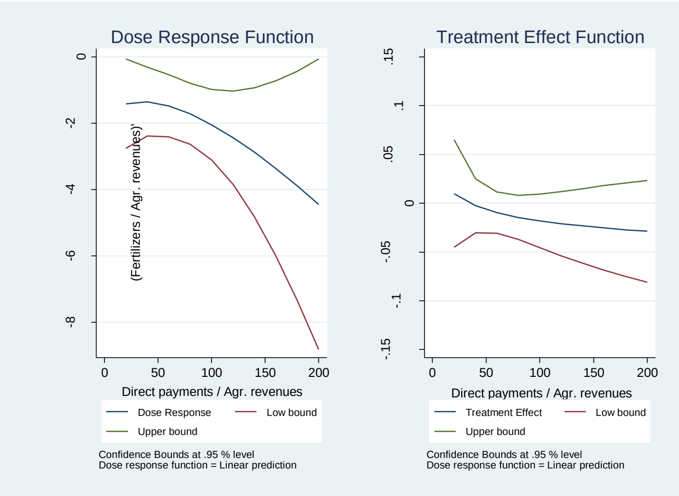

*Table 7.7 – Hirano-Imbens (2004) DRF parameter estimates[a]*

| Outcome: ΔFertilisersAgrRevenues | Coefficient | (std. err.) |
|---|---|---|
| ΔDirectPaymentsAgrrevenues | 0.0020253 | (0.011) |
| ΔDirectPaymentsAgrrevenues_sq | -0.0000311 | (0.000) * |
| pscore | 7.315752 | (34.92) |
| pscore_sq | 14.30268 | (135.4) |
| ΔDirectPaymentsAgrrevenues_pscore | -0.0985967 | (0.095) |
| _cons | -1.886314 | (2.092) |

[a] The BoxCox transformation of the treatment variable is used

*Statistically significant at 0.05 level

*Figure 7.36 – Hirano-Imbens (2004) DRF and ATE estimation[a,b]*




[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (variable)' indicates the first derivative of variable

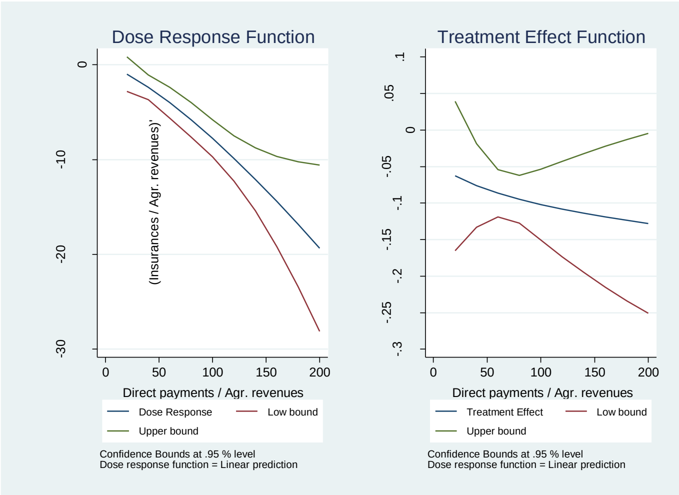
*Table 7.8 – Hirano-Imbens (2004) DRF parameter estimates[a]*

| Outcome: ΔInsurancesAgrRevenues | Coefficient | (std. err.) |
|---|---|---|
| ΔDirectPaymentsAgrrevenues | -0.0372687 | (0.019) * |
| ΔDirectPaymentsAgrrevenues_sq | -0.0000987 | (0.000) * |
| pscore | -6.542559 | (58.65) |
| pscore_sq | 68.13764 | (227.4) |
| ΔDirectPaymentsAgrrevenues_pscore | -0.2609389 | (0.160) |
| _cons | 0.172282 | (3.513) |

[a] The BoxCox transformation of the treatment variable is used

*Statistically significant at 0.05 level

*Figure 7.37 – Hirano-Imbens (2004) DRF and ATE estimation*[a,b]




[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (variable)' indicates the first derivative of variable

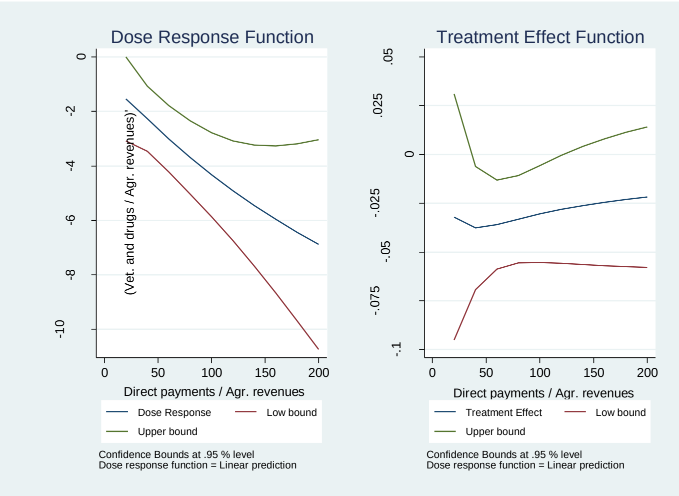
*Table 7.9 – Hirano-Imbens (2004) DRF parameter estimates*[a]

| Outcome: ΔVetDrugsAgrRevenues | Coefficient | (std. err.) |
|---|---|---|
| ΔDirectPaymentsAgrrevenues | -0.0506736 | (0.011) * |
| ΔDirectPaymentsAgrrevenues_sq | 0.000013 | (0.000) |
| pscore | 24.4759 | (34.17) |
| pscore_sq | -155.4745 | (132.5) |
| ΔDirectPaymentsAgrrevenues_pscore | 0.1350546 | (0.093) |
| _cons | -1.419142 | (2.046) |

[a] The BoxCox transformation of the treatment variable is used

*Statistically significant at 0.05 level

*Figure 7.38 – Hirano-Imbens (2004) DRF and ATE estimation[a,b]*




[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (variable)' indicates the first derivative of variable

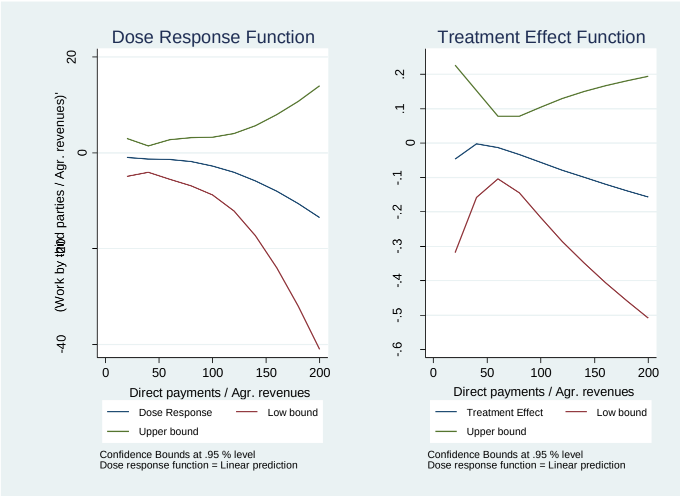
*Table 7.10 – Hirano-Imbens (2004) DRF parameter estimates[a]*

| Outcome: ΔWorkIIIAgrRevenues | Coefficient | (std. err.) |
|---|---|---|
| ΔDirectPaymentsAgrrevenues | 0.176202 | (0.051) * |
| ΔDirectPaymentsAgrrevenues_sq | -0.0004046 | (0.000) * |
| pscore | -166.6753 | (160.9) |
| pscore_sq | 796.2794 | (623.7) |
| ΔDirectPaymentsAgrrevenues_pscore | -0.9060125 | (0.438) * |
| _cons | 3.26787 | (9.636) |

[a] The BoxCox transformation of the treatment variable is used

*Statistically significant at 0.05 level

*Figure 7.39 – Hirano-Imbens (2004) DRF and ATE estimation*[a,b]




[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (variable)' indicates the first derivative of variable

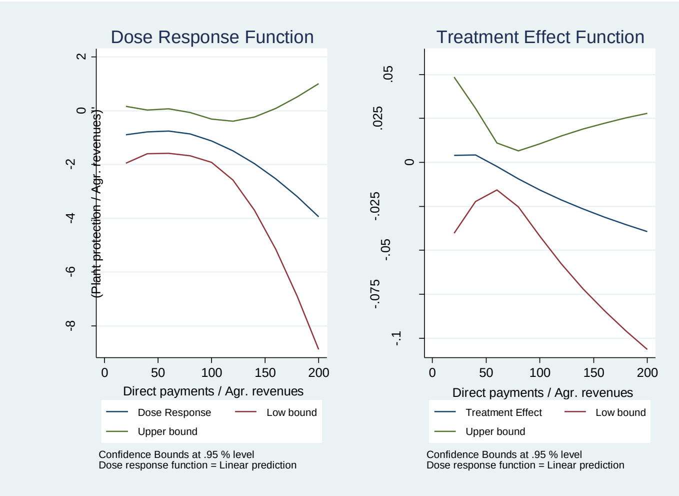
*Table 7.11 – Hirano-Imbens (2004) DRF parameter estimates*[a]

| Outcome: ΔPlantProtAgrRevenues | Coefficient | (std. err.) |
|---|---|---|
| ΔDirectPaymentsAgrrevenues | 0.0463445 | (0.012) * |
| ΔDirectPaymentsAgrrevenues_sq | -0.0000809 | (0.000) * |
| pscore | -29.44459 | (36.26) |
| pscore_sq | 175.1099 | (140.6) |
| ΔDirectPaymentsAgrrevenues_pscore | -0.2809711 | (0.099) * |
| _cons | -0.4884082 | (2.172) |

[a] The BoxCox transformation of the treatment variable is used

*Statistically significant at 0.05 level

*Figure 7.40 – Hirano-Imbens (2004) DRF and ATE estimation[a,b]*




[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (variable)' indicates the first derivative of variable

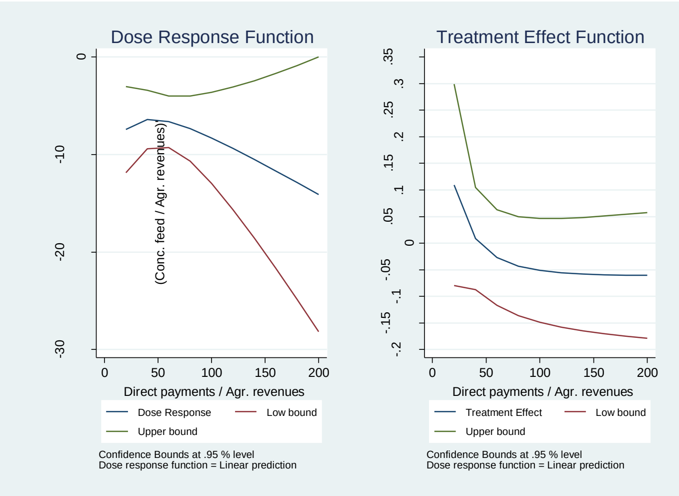
*Table 7.12 – Hirano-Imbens (2004) DRF parameter estimates[a]*

| Outcome: ΔConcentratedFeedAgrRevenues | Coefficient | (std. err.) |
|---|---|---|
| ΔDirectPaymentsAgrrevenues | 0.0183363 | (0.030) |
| ΔDirectPaymentsAgrrevenues_sq | -0. 0000227 | (0.000) |
| pscore | 137.1194 | (94.60) |
| pscore_sq | -521.9293 | (366.7) |
| ΔDirectPaymentsAgrrevenues_pscore | -0.3186537 | (0.258) |
| _cons | -13.43487 | (5.666) * |

[a] The BoxCox transformation of the treatment variable is used

*Statistically significant at 0.05 level

*Figure 7.41 – Hirano-Imbens (2004) DRF and ATE estimation[a,b]*




[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (variable)' indicates the first derivative of variable

### 7.2.2.2 Subsample with positive variations

*Figure 7.42 – Distribution of the continuous treatment: direct payments on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

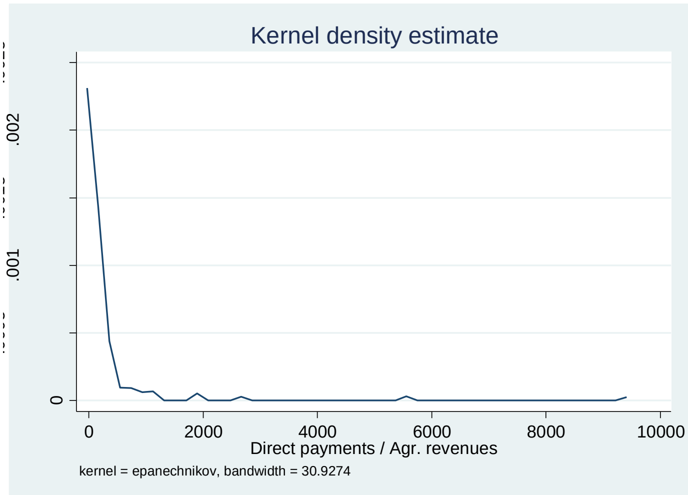


*Figure 7.43 – Distribution of the continuous treatment: direct payments on UAA (in CHF/Ha): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

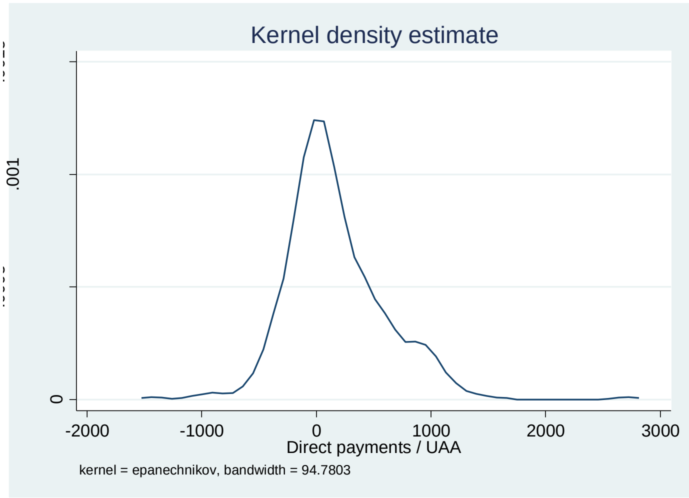



*Figure 7.44 – Distribution of the continuous outcome: agricultural costs on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

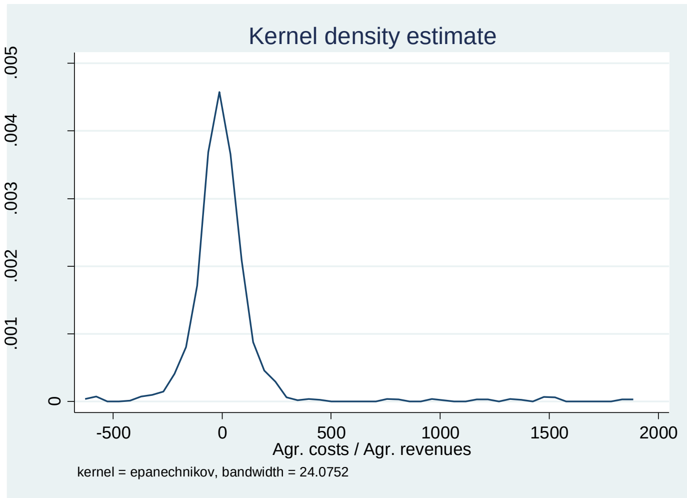



*Figure 7.45 – Distribution of the continuous outcome: agricultural costs on UAA (in CHF/Ha): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

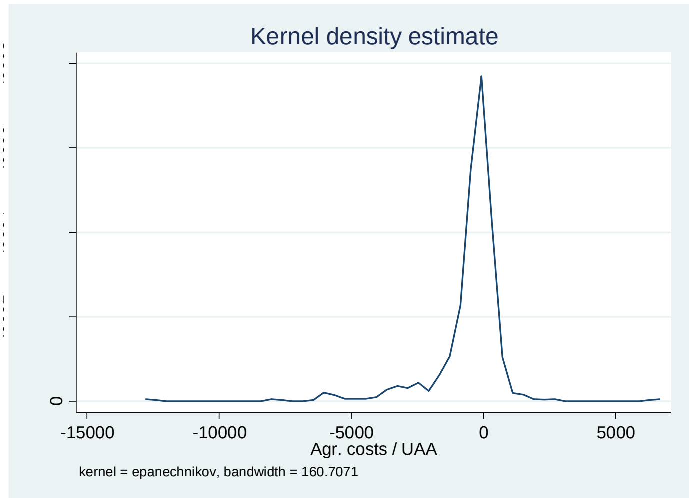


*Figure 7.46 – Distribution of the continuous confounding variable: agricultural area (in Ha): Kernel density (2014).*

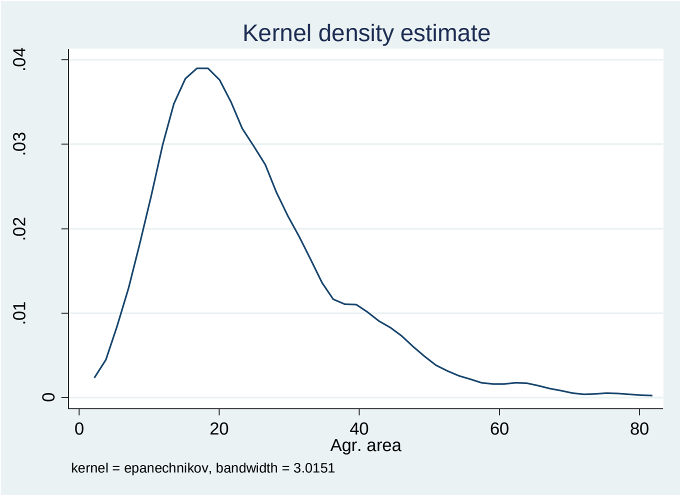



*Figure 7.47 – Distribution of the continuous confounding variable: altitude (in meters above sea level): Kernel density (2014).*

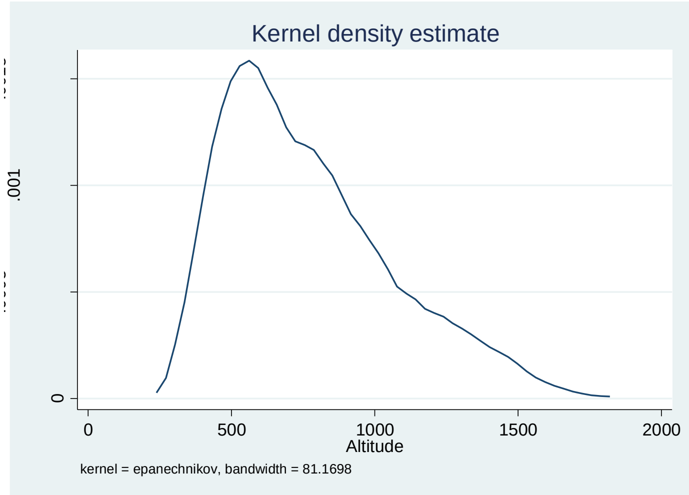



*Figure 7.48 – Distribution of the continuous confounding variable: livestock (in n.): Kernel density (2014).*

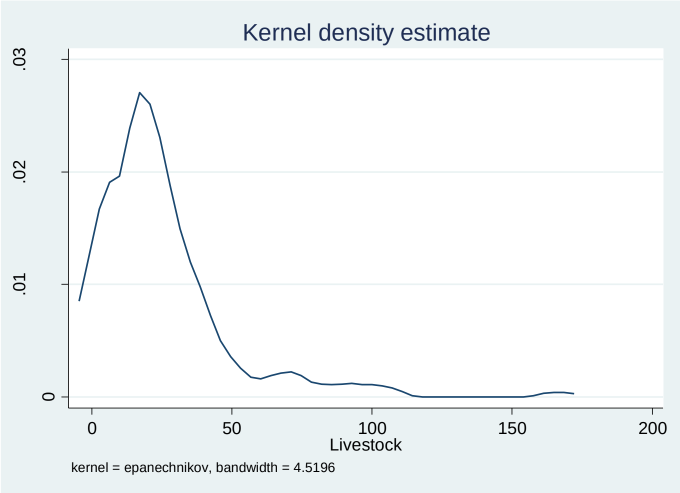


*Figure 7.49 – Distribution of the continuous confounding variable: farmer's age (in years): Kernel density (2014).*

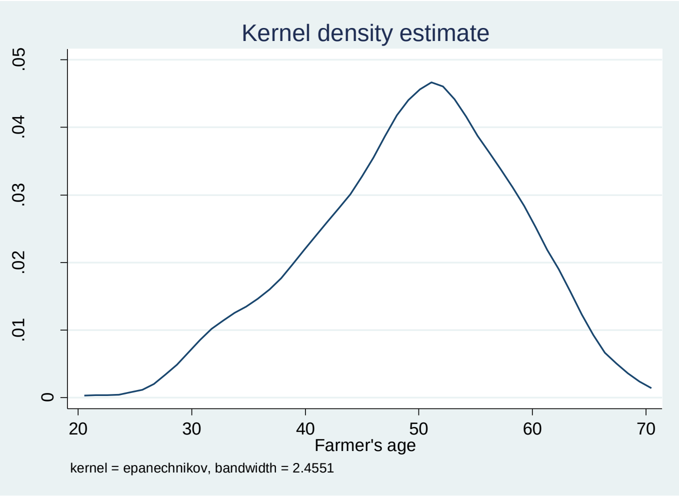



*Figure 7.50 – Distribution of the discrete confounding variable: farmer's education (in levels): Kernel density (2014).*

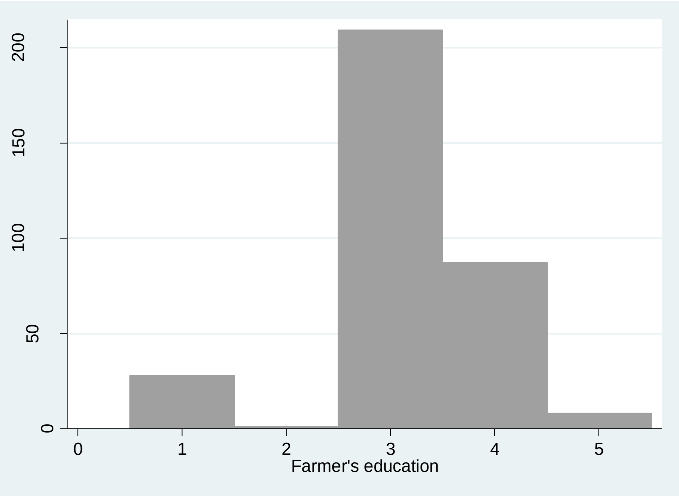



*Figure 7.51 – Distribution of the continuous confounding variable: arable land / UAA (in %): Kernel density (2014).*

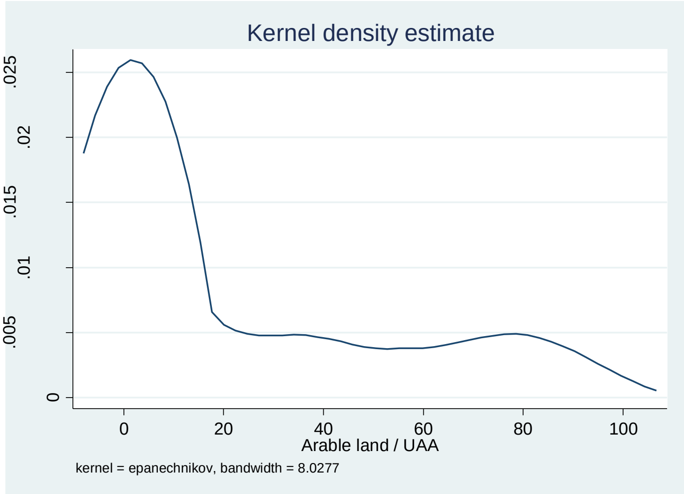


*Figure 7.52 – Distribution of the continuous confounding variable: permanent pastures / UAA (in %): Kernel density (2014).*

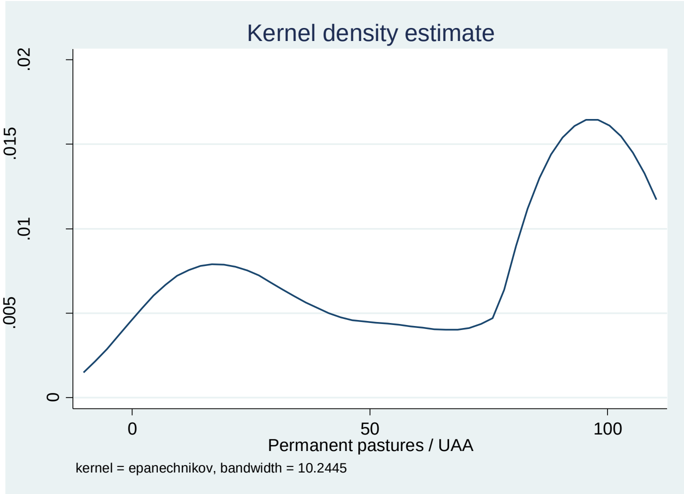



*Figure 7.53 – Distribution of the continuous confounding variable: permanent crops / UAA (in %): Kernel density (2014).*

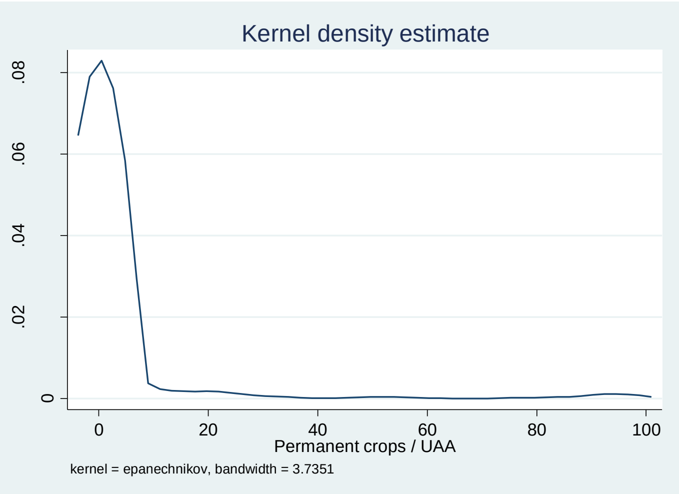



*Figure 7.54 – Distribution of the continuous outcome: costs for plant protection on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

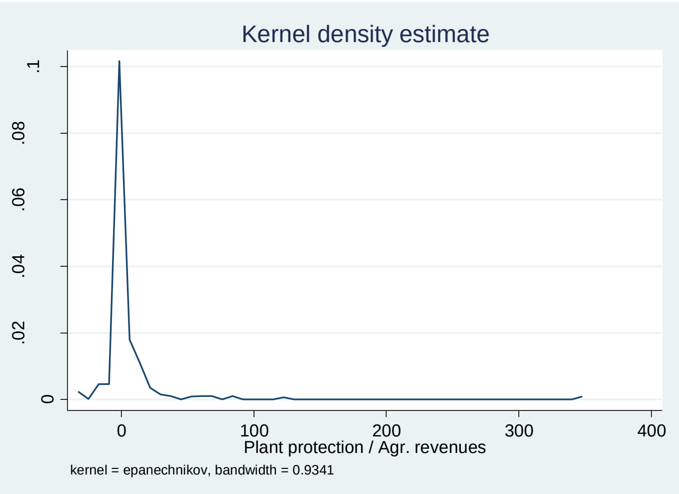


*Figure 7.55 – Distribution of the continuous outcome: costs for concentrated feed on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

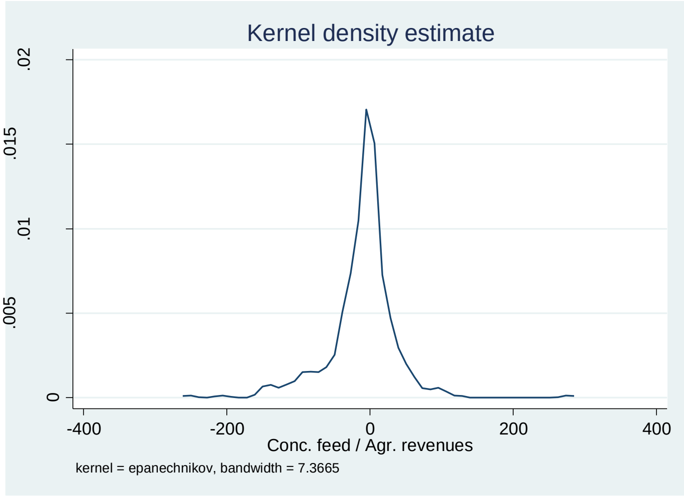



*Figure 7.56 – Distribution of the continuous outcome: costs for veterinary services / drugs on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

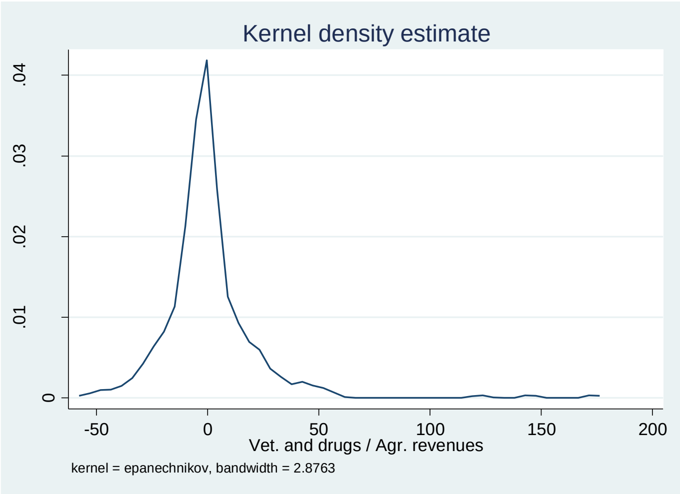


*Figure 7.57 – Distribution of the continuous outcome: costs for work by third parties on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

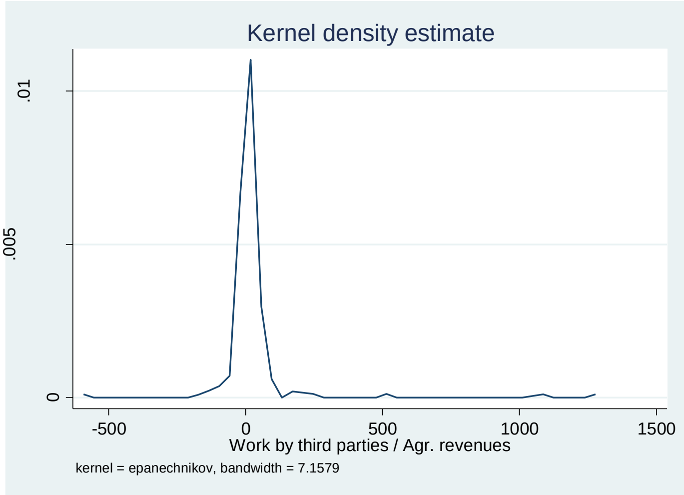



*Figure 7.58 – Distribution of the continuous outcome: costs for insurances on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

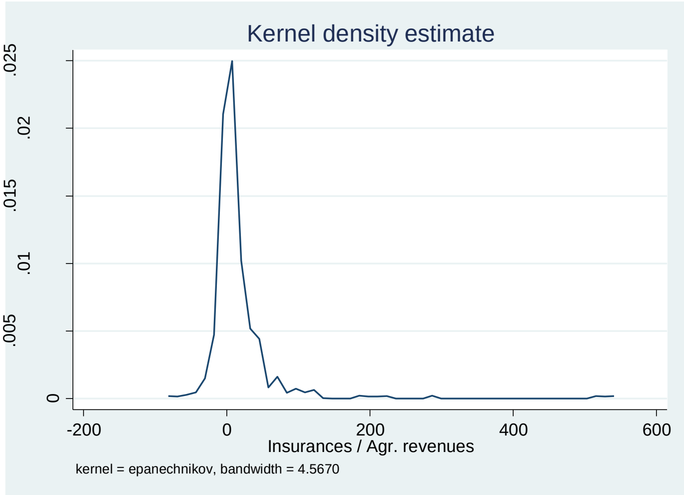


*Figure 7.59 – Distribution of the continuous outcome: costs for fertilisers on agricultural revenues (in ‰): Kernel density (difference between the value in 2014 and the average over 2010-2013 period).*

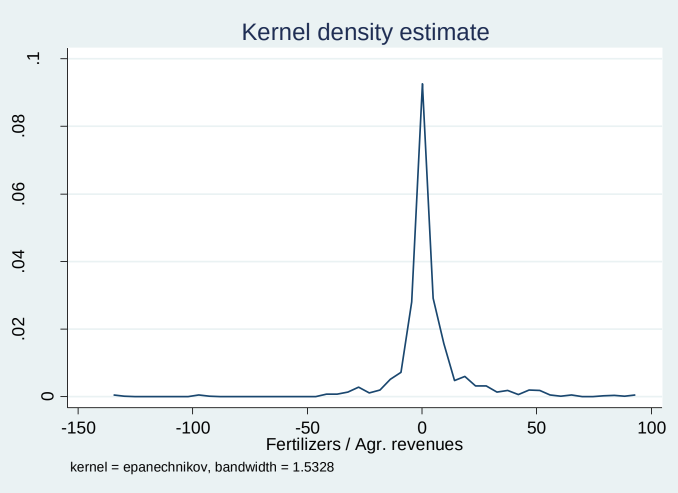


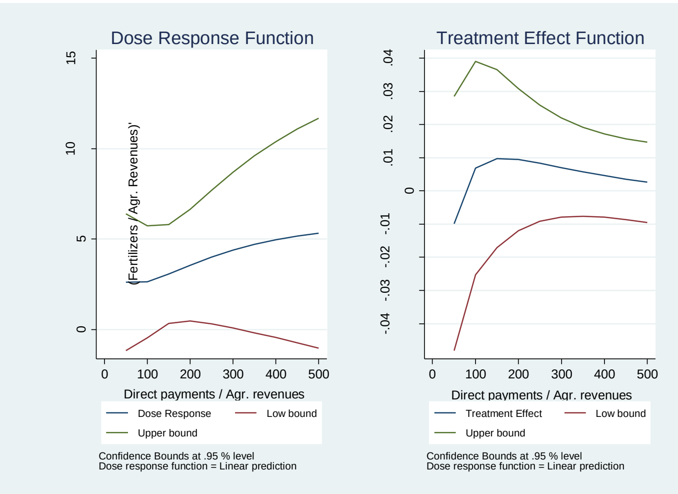

*Table 7.13 – Hirano-Imbens (2004) DRF parameter estimates[a]*

| Outcome: ΔFertilisersAgrRevenues | Coefficient | (std. err.) |
|---|---|---|
| ΔDirectPaymentsAgrrevenues | -0.0102576 | (0.005) * |
| ΔDirectPaymentsAgrrevenues_sq | 5.19e-08 | (0.000) |
| pscore | 28.60776 | (79.99) |
| pscore_sq | -209.1735 | (310.3) |
| ΔDirectPaymentsAgrrevenues_pscore | 0.1041902 | (0.059) |
| _cons | 3.654166 | (4.672) |

[a] The BoxCox transformation of the treatment variable is used

*Statistically significant at 0.05 level

*Figure 7.60 – Hirano-Imbens (2004) DRF and ATE estimation[a,b]*



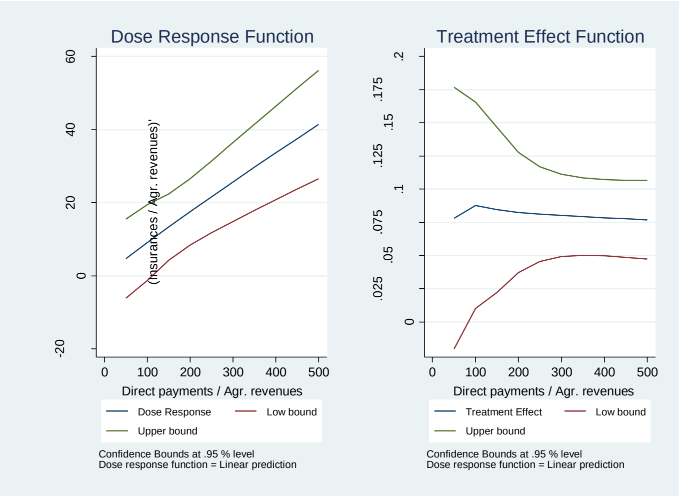

[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (variable)' indicates the first derivative of variable

*Table 7.14 – Hirano-Imbens (2004) DRF parameter estimates[a]*

| Outcome: ΔInsurancesAgrRevenues | Coefficient | (std. err.) |
|---|---|---|
| ΔDirectPaymentsAgrrevenues | 0.0559214 | (0.011) * |
| ΔDirectPaymentsAgrrevenues_sq | -1.14e-06 | (0.000) |
| pscore | -440.5384 | (190.6) * |
| pscore_sq | 1389.748 | (739.5) |
| ΔDirectPaymentsAgrrevenues_pscore | 0.1624369 | (0.141) |
| _cons | 33.30142 | (11.13) * |

[a] The BoxCox transformation of the treatment variable is used
*Statistically significant at 0.05 level

*Figure 7.61 – Hirano-Imbens (2004) DRF and ATE estimation[a,b]*




[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (variable)' indicates the first derivative of variable

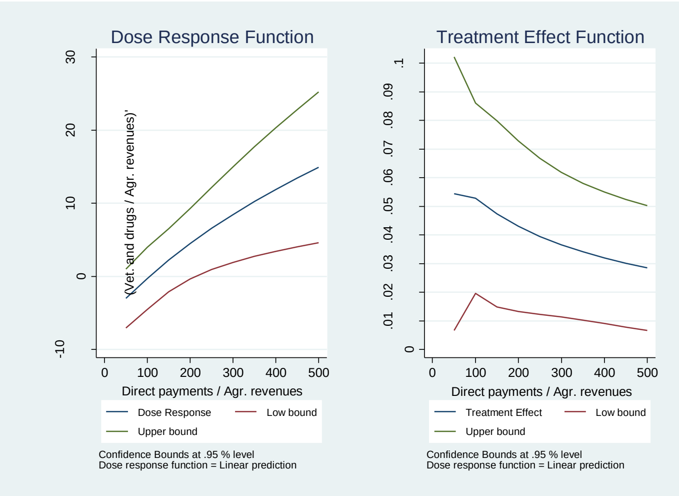
*Table 7.15 – Hirano-Imbens (2004) DRF parameter estimates[a]*

| Outcome: ΔVetDrugsAgrRevenues | Coefficient | (std. err.) |
|---|---|---|
| ΔDirectPaymentsAgrrevenues | -0.0061258 | (0.006) |
| ΔDirectPaymentsAgrrevenues_sq | 2.06e-06 | (0.000) * |
| pscore | -139.9562 | (97.89) |
| pscore_sq | 453.599 | (379.9) |
| ΔDirectPaymentsAgrrevenues_pscore | 0.3106459 | (0.073) * |
| _cons | 4.704285 | (5.719) |

[a] The BoxCox transformation of the treatment variable is used

*Statistically significant at 0.05 level

*Figure 7.62 – Hirano-Imbens (2004) DRF and ATE estimation[a,b]*




[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (variable)' indicates the first derivative of variable

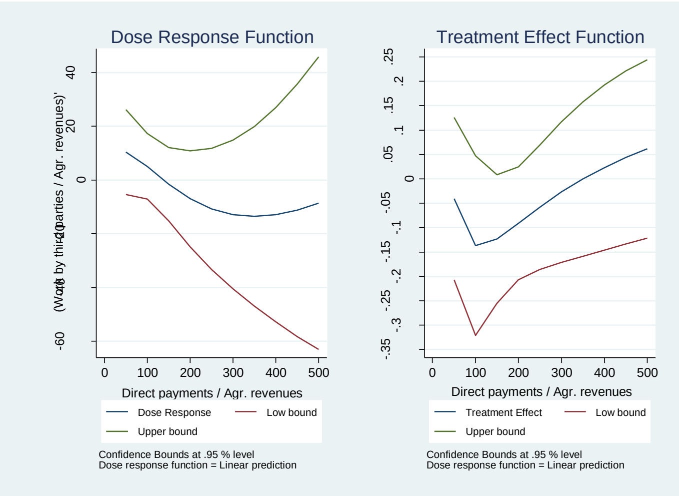
*Table 7.16 – Hirano-Imbens (2004) DRF parameter estimates[a]*

| Outcome: ΔWorkIIIAgrRevenues | Coefficient | (std. err.) |
|---|---|---|
| ΔDirectPaymentsAgrrevenues | 0.4228195 | (0.025) * |
| ΔDirectPaymentsAgrrevenues_sq | -0.0000387 | (0.000) * |
| pscore | -163.4749 | (437.6) |
| pscore_sq | 1359.425 | (1698) |
| ΔDirectPaymentsAgrrevenues_pscore | -3.054644 | (0.325) * |
| _cons | 2.055129 | (25.56) |

[a] The BoxCox transformation of the treatment variable is used

*Statistically significant at 0.05 level

*Figure 7.63 – Hirano-Imbens (2004) DRF and ATE estimation[a,b]*




[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (variable)' indicates the first derivative of variable

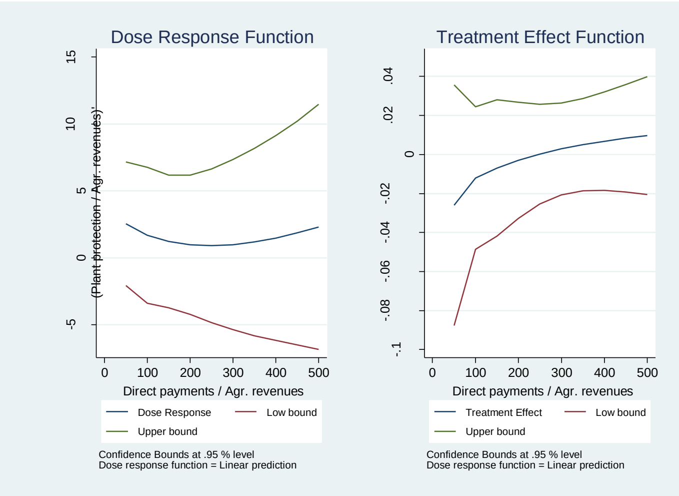
*Table 7.17 – Hirano-Imbens (2004) DRF parameter estimates[a]*

| Outcome: ΔPlantProtAgrRevenues | Coefficient | (std. err.) |
|---|---|---|
| ΔDirectPaymentsAgrrevenues | 0.0339682 | (0.008) * |
| ΔDirectPaymentsAgrrevenues_sq | -3.25e-06 | (0.000) * |
| pscore | -153.4614 | (134.7) |
| pscore_sq | 437.4957 | (552.6) |
| ΔDirectPaymentsAgrrevenues_pscore | -0.2433887 | (0.099) * |
| _cons | 15.69672 | (7.868) * |

[a] The BoxCox transformation of the treatment variable is used

*Statistically significant at 0.05 level

*Figure 7.64 – Hirano-Imbens (2004) DRF and ATE estimation[a,b]*




[a] Bootstrap confidence bounds (1000 replications)
[b] The notation (variable)' indicates the first derivative of variable

*Table 7.18 – Hirano-Imbens (2004) DRF parameter estimates[a]*

| Outcome: ΔConcentratedFeedAgrRevenues | Coefficient | (std. err.) |
|---|---|---|
| ΔDirectPaymentsAgrrevenues | -0.0206615 | (0.013) |
| ΔDirectPaymentsAgrrevenues_sq | 5.17e-06 | (0.000) * |
| pscore | -272.6669 | (223.5) |
| pscore_sq | 1024.747 | (867.5) |
| ΔDirectPaymentsAgrrevenues_pscore | 0.1884593 | (0.166) |
| _cons | 2.449536 | (13.06) |

[a] The BoxCox transformation of the treatment variable is used

*Statistically significant at 0.05 level

### *7.2.3 Panel 2015-2016*

*Figure 7.65 – Distribution of the continuous outcome: agricultural costs on agricultural revenues (in %): Kernel density (avg. over 2015-2016 period).*

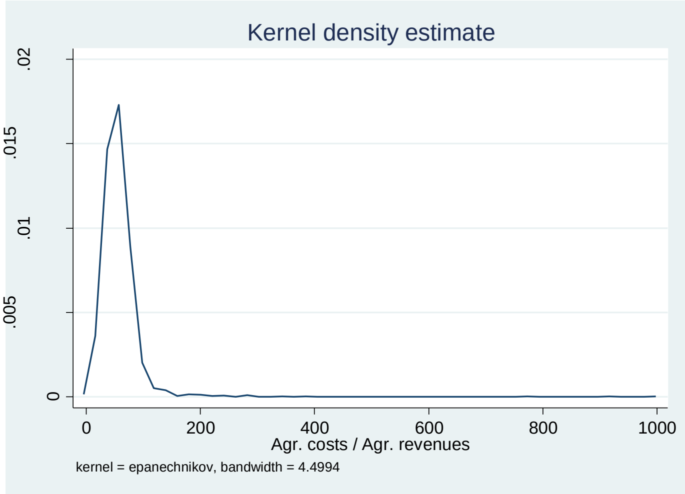



*Figure 7.66 – Distribution of the continuous confounding variable: agricultural area (in Ha): Kernel density (avg. over 2015-2016 period).*

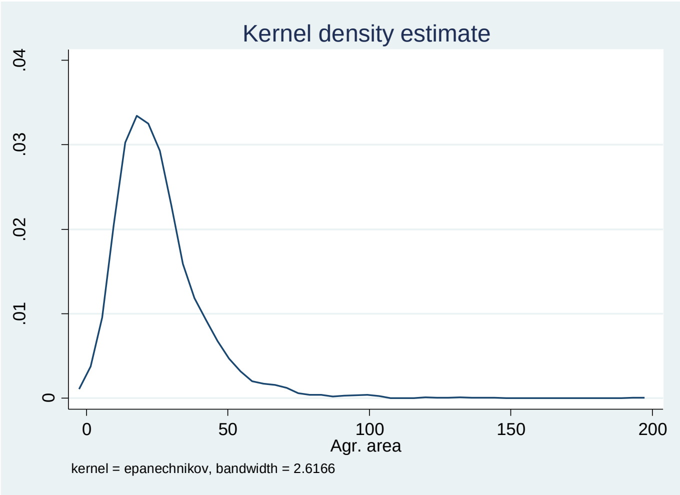


*Figure 7.67- – Distribution of the continuous confounding variable: livestock (in n.): Kernel density (avg. over 2015-2016 period).*

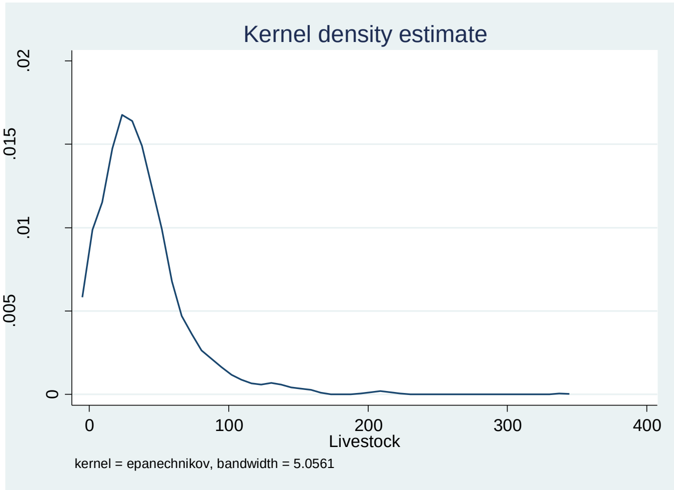



*Figure 7.68 – Distribution of the continuous confounding variable: arable land on UAA (in %): Kernel density (avg. over 2015-2016 period).*

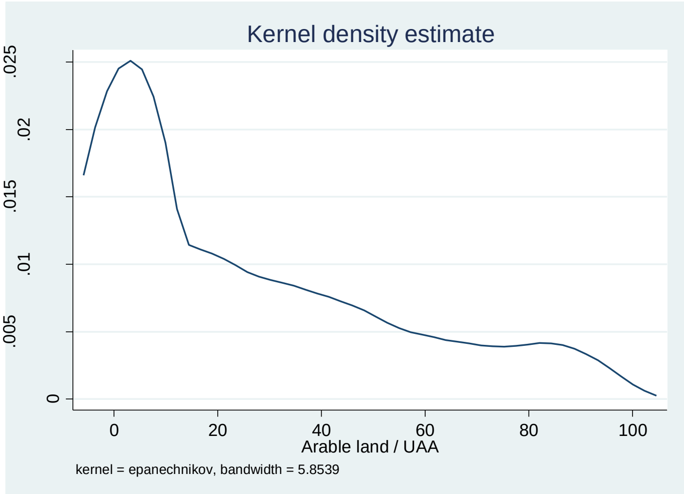



*Figure 7.69 – Distribution of the continuous confounding variable: permanent pastures on UAA (in %): Kernel density (avg. over 2015-2016 period).*

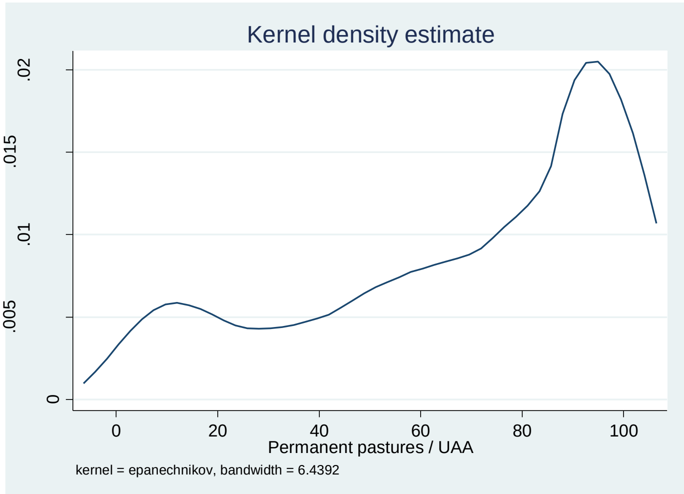
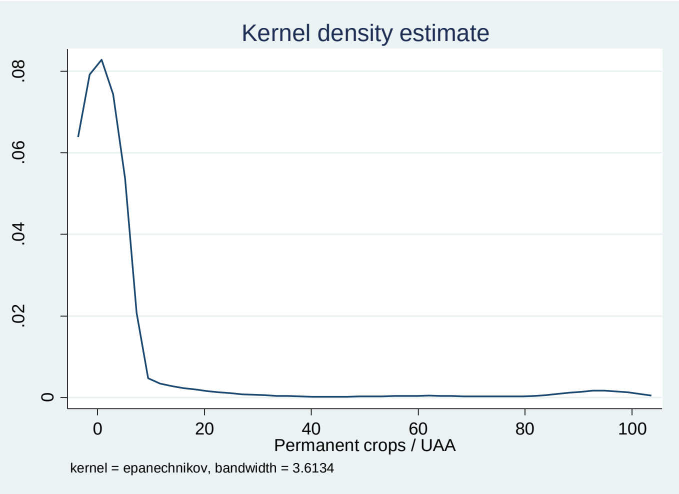


*Figure 7.70 – Distribution of the continuous confounding variable: permanent crops on UAA (in %): Kernel density (avg. over 2015-2016 period).*



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**02.2019**
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