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Financial literacy and food safety standards in Guatemala: The heterogeneous impact of GlobalGAP on farm income

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Abstract

The transformation of the global agrifood system is characterized by the increasing importance of food safety and quality standards. This trend is challenging farmers in countries like Guatemala, who often lack necessary skills and assets. We contribute to the ongoing discussion about the impact of standards on smallholder farmers by considering impact heterogeneity. By using propensity score matching techniques, we show that farmers with a higher level of financial literacy seem to benefit more from standard adoption than those with lower levels of financial literacy. Our results hold important practical implications for exporters, standard setters and development organizations.

Keywords: Food safety standards, financial literacy, developing countries, impact analysis, propensity score matching, impact heterogeneity

JEL Codes: Q14, Q12, Q16, O33, C31, I26

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1. Introduction

With the transformation of the global agri-food system, the role of organizational and process innovations in global agricultural value chains is gaining importance. The dominance of process related standards (public and private) that are applied in agricultural production and farm management is one characteristic of the ongoing dynamics.[1] There is a lot of discussion in development research and practice about the impact of the increasing standardization of agriculture on small farmers in developing countries. Two scenarios are discussed. First, it is argued that the increasing requirements on food quality and safety might challenge already marginalized producers in countries with weak quality infrastructure. Due to high compliance costs and missing capacities and skills, farmers might not be able to comply with the new requirements. This could lead to negative socioeconomic effects with consequences for rural poverty. The second scenario is more optimistic. It sees positive upgrading effects with benefits for farmers and the agricultural sector in general. The more stringent requirements could induce upgrading activities in the agricultural sector, helping farmers to increase productivity, decrease production costs, improve quality and safety and thus gain better access to international high-value chains and receive better prices and higher agricultural incomes.

Studies examining the economic impact of adopting food quality standards generally find that doing so has a positive effect (Asfaw et al. 2009; Holzapfel and Wollni 2014; Hansen and Trifković 2014b; Subervie and Vagneron 2013; Handschuch et al. 2013). This overall positive effect stems from special price arrangements, quality improvements, the use of contracts, tighter supplier-buyer relationships, and higher efficiency in farm input use. But even between certified farmers, the economic impact can vary with the institutional arrangements (Holzapfel and Wollni 2014), access to infrastructure (Subervie and Vagneron 2013) and/or farm size (Hansen and Trifković 2014). Capital endowment, access to resources and information, and farmer's capacities

[1] Standards like GlobalGAP address processes on the farm level, i.e. they require new pest management strategies, record keeping for traceability issues and specific training for the farmer and any farm employees. Process standards are an organizational innovation or technology that farmers choose to adopt as part of a farm investment decision. We use the terms innovation and technology in a broader sense that also embraces process standards. Process standards such as GlobalGAP are also part of the category of food safety and quality standards.

seem to influence the heterogeneity in how standards impact the economic situation of small farmers.

Process standards pose new challenges to farmers' skills: They require new techniques not only on the production level (like integrated pest management systems or soil and water management) but also in the management of the farm (safety and occupational health, control of input usage, environmental and risk management, etc.) (FAO 2014). Apart from asset endowment and access, other skills are required to comply with process standards. We have shown in earlier research that GlobalGAP[2] adopters and non-adopters differ in their level of financial literacy and that this difference explains some of the differences in adoption behavior (Müller and Theuvsen, 2014): Farmers with a higher level of financial literacy are ceteris paribus more likely to adopt GlobalGAP. Whether the economic impact of GlobalGAP differs according to the financial skill level of farmers is a question that has not been addressed yet. Keeping in mind the importance of impact heterogeneity, we address two questions in our research: What is the impact of GlobalGAP adoption on farm income? How does the economic impact of GlobalGAP on farm income differ in relation to the financial literacy level of farmers?

We study the case of GlobalGAP among small pea producers in the Guatemalan highlands. The region is dominated by small-scale fresh vegetable production. Peas are only produced for export and are therefore subject to stringent food safety and quality standards on international markets. Small farmers in the region are very poor. The public sector and non-profit organizations are interested in lifting farmers out of poverty through improved and sustainable market integration. Against this background, it is of high interest to understand in greater detail the impact of GlobalGAP certification on small farmers' economic situation.

We use a cross-section sample of 276 pea farmers. The data was collected in 2012 using a stratified random sampling strategy. Using matching techniques we show that GlobalGAP has a robust positive impact on the revenue of pea producers. The impact on total revenue from agricultural production and total household income is less robust but still positive. By stratifying the sample in low and high financially skilled farmers

[2] The correct spelling is GLOBALG.A.P. For better readability we use the spelling GlobalGAP throughout the paper.

we show that the impact of GlobalGAP on pea revenue is positive for financially skilled farmers, whereas there is no significant impact for farmers with low financial skills. Our research contributes to the ongoing debate about how food standards impact small farmers in developing countries. Considering the role of farmers' financial skills in the impact of innovations stresses the importance of capacity building for farmers.

The remainder of the paper is structured as follows: First, we review the relevant literature on innovation adoption and financial skills, which helped us to build our conceptual framework. Next, we provide information about the research context, data and sampling and about our variables of interest. Section four lays out our empirical methods. Section five describes our results. Section six discusses the results of the impact analysis of GlobalGAP on farm revenue and examines the heterogeneous impact of GlobalGAP on farm revenue considering financial literacy. The paper ends with our conclusions.

2. Literature review

Organizational innovations and their economic impact

With the on-going transformation of the global agri-food system, there has been a commensurate increase in research on the impact of organizational innovations, such as standards or contracts, on small farmers. The economic impact of private food quality and safety standards has gained special attention as they are becoming increasingly mandatory for accessing high-value chains.

Asfaw et al. (2009) show that adoption has a positive effect on net income for Kenyan fresh vegetable producers. The positive impact on net income also positively correlates to area under vegetable production and asset endowment. Holzapfel and Wollni (2014) study the net income effect of donor-supported GlobalGAP implementation. They find different impacts on farmers' income based on the management scheme used by the producer group and the size of the farm. There seems to be a significant income effect for producer-managed groups, whereas there is none for exporter-managed groups. Only for producers that pass a threshold of one hectare of farm size does GlobalGAP adoption seem to be profitable. By using quantile regressions to estimate the effect of food safety standards in pangasius production on the consumption expenditure of

Vietnamese farmers, Hansen and Trifković (2014) identify a "middle class effect". Only on larger farms do the standards have a positive and significant effect on expenditure. Smaller family farms do not benefit from the implementation. Subervie and Vagneron (2013) do not directly measure the income effects of GlobalGAP but use proxies for farm performance to assess the effect of certification on farmers in Madagascar. Using matching techniques, they find that GlobalGAP certification has a positive impact on the quantities sold and the prices received. The benefits are not homogeneously distributed among all certified farmers, however, but are concentrated among a small group of farmers that is able to transport the product themselves to the next marketing center. In the case of Chilean raspberry producers, Handschuch et al. (2013) find that, once farmers overcome the barrier of entry to certification, they benefit through positive effects on quality performance and farm net income. To control for possible selection bias through self-selection of the farmers into the standard scheme, they use a treatment effects model with an endogenous dummy variable.

Through their study on supermarkets and fresh vegetable farmers in Kenya, Rao and Qaim (2011) show that it is important to differentiate between groups when analyzing economic impacts since marketing channels are structurally different. The effect of variables such as off-farm income and vehicle ownership has different magnitudes among farmers depending on their use of traditional or modern marketing methods. Other variables have a significant effect on only one group; for example, land ownership only influences the income of traditional farmers. In contrast to some findings from the specific standard impact literature, Rao and Qaim (2011) find that small farmers benefit over-proportionally from participation and poor households benefit more than non-poor households. As small farmers are mainly subsistence farmers, the income gains through new marketing channels seem to be substantial. Delivering directly to the supermarket also offers more benefits for farmers as middlemen are avoided.

The literature discussed suggests that there is evidence of the positive impact of organizational changes in the agri-food system on farmers. Small farmers may benefit through special price agreements (premium price, fixed price or minimum price) as buyers have a high interest in locking in suppliers and securing guaranteed supplies. Often exporters have to make significant asset-specific investments in order to bring smallholder farmers to certification; this creates an interest in longer term relationships. Even if the farmers do not receive a higher gross price, they may receive higher net prices through resource-providing contracts or benefit from having lower marketing risks as adoption of a food safety standard leads to closer supplier-buyer relationships through formal or informal contract systems (Reardon et al. 2009). But it seems that these benefits are not homogeneously distributed among all farmers alike. The impact of organizational innovations might depend on resource endowment, access to resources and the institutional environment. This indicates the importance of adequately considering the heterogeneity of the groups with regard to, for instance, endowment and access when measuring the economic impacts of standards and other organizational innovations. Since successful adoption of innovations may depend not only on access to resources but also on farmers' knowledge and capabilities, taking into account farmers' skills could contribute to a better understanding of the heterogeneity in economic impacts of organizational innovations in food supply chains. But so far there is a lack of papers in the standards impact literature that argue from the perspective of farmers' skills.

Financial literacy and the impact of new technologies

With regard to the successful adoption of innovations, farmers' financial literacy is a crucial competence due to, for instance, the growing requirements with regard to documentation and other bookkeeping. Despite this crucial role, the literature on financial literacy and the economic impact of agricultural technologies in developing countries is scarce so far. In order to understand how financial literacy can influence the impact of agricultural innovations at the farm level, we look at the broader literature on the role of cognitive skills and education for economic well-being. Financial literacy can be seen as one component of cognitive skills acquired through formal and informal education, experience, family, peers and culture (van Rooij et al. 2011; Lusardi and Mitchell 2014)

The positive effect of education on agricultural outcomes is attributed to increases in productivity (Appleton and Balihuta 1996) and farm efficiency (Lockheed et al. 1980). But research also indicates that the positive effect of education depends on situational characteristics and that education might be more useful for specific farmers. Alene and Manyong (2007), for instance, find a heterogeneous effect of education and production technology: For cowpea producers in Nigeria, there is a positive and significant effect on productivity only when they produce with modern technologies. They explain the positive effect as a result of the improved use of inputs by better educated farmers to produce a given set of outputs (efficiency perspective).

Education is often measured as attainment in school (Appleton and Balihuta 1996; Jamison and Moock 1984). But this might be misleading and incomplete in explaining differences in economic outcomes (Hanushek and Woessmann 2008). Number of years of schooling does not imply quality and does not necessarily lead to the development of relevant job skills. Skills are formed by formal schooling and education, but also through informal learning like learning-by-doing or learning from others (Bandura 1971). Family and peers influence skills, as do culture and context in general (Jamison and Moock 1984; Jolliffe 1998). Considering skills in explaining economic outcomes therefore has more explanatory power and shifts the attention from pure attendance in school, schooling years or participation in extension activities to the skills attained.

For a better understanding of the effect of skills on economic outcomes, skills can be differentiated into cognitive and non-cognitive skills (Appleton and Balihuta 1996). Cognitive skills refer to directly measurable skills, such as mathematical skills, numeracy or financial literacy. Non-cognitive skills refer to attitudes and behaviors, such as openness, self-discipline or ambition. There is strong empirical evidence that cognitive skills have a positive effect on farm performance.

In the case of US dairy farmers, Jackson-Smith et al. (2004) find a link between the understanding of financial concepts and greater financial returns. Hanushek and Woessmann (2008) evaluate a number of studies and come to the conclusion that cognitive skills (rather than schooling attainment) are strongly related to individual earnings in developing countries. Jolliffe (1998) finds that, for a sample of Ghanaian farmers, average scores in English and mathematics have a positive and significant effect on total and off-farm income but not on farm income. But there is also empirical evidence that skills are highly relevant for successfully performing agricultural activities. In the case of wheat production in Nepal, Jamison and Moock (1984) find that numeracy has a positive and significant influence on productivity. Due to increasing knowledge requirements, education might play an even bigger role in modern agriculture than in traditional agriculture (Alene and Manyong 2007).

Conceptual framework

Considering the literature on the economic impact of standards and cognitive skills, we assume that the impact of GlobalGAP on farm performance is positive and heterogeneous among different levels of financial literacy. We propose that financially literate farmers might benefit more from the positive income effects of GlobalGAP adoption than those farmers with lower levels of financial literacy.

Referring to the theoretical arguments for the effect of skills and education on farm income outlined above, we derive several arguments to underpin our proposition. Financial literacy as a cognitive skill may help farmers to improve their farm management. Due to their skills, they may have more efficient financial and improved input management and may be more efficient in implementing extension advice. Overall financial literacy might also help them in continuous standards compliance and thus may contribute to secured sales. Working with a certain standard scheme often comes with formal or informal credit schemes that help farmers to pre-finance their production. Good financial skills improve credit management and may also influence the overall risk management of the farm. All these aspects may help farmers to improve farm performance through increased efficiency, higher productivity and secured high quality production. Financial literacy could also influence farm performance through non-cognitive effects. By learning about the positive effects on price and income when producing consistently according to a certain quality level, farmers might be more willing to change their production practice; for example, they might apply integrated approaches to pest management that are required for GlobalGAP certification. Financial literacy could also discipline farmers by making them acquainted with continuous labor efforts (Kieser 1998) and make individuals more open to new ideas and changes in working routines.

In short, cognitive and non-cognitive skills are important for adapting to a changing environment and new technological requirements (Alene and Manyong 2007). They help to allocate farm resources in an efficient manner and thus increase a farm's allocative and technical efficiency and improve the farmer's ability to acquire, decode and use information (Jamison and Moock 1984). Farmers with a higher level of financial literacy, therefore, might adjust more successfully, apply organizational and technical innovations more efficiently and hence benefit more from new technologies than less skilled farmers.

3. Research background

3.1 GlobalGAP and food safety in Guatemala

We focus on GlobalGAP as this is the most widespread standard system in the fresh fruit and vegetable trade affecting developing countries. GlobalGAP is a pre-farm gate and process-standard that requires the implementation of good agricultural practices and various quality and food safety measures. The private standard is non-mandatory in nature and was established in 1999 by several European retailers.[3] The standard has a quasi-mandatory character, as many retail chains invariably require compliance in their fresh fruit and vegetable assortment. GlobalGAP compliance is not signaled to the final consumers and there are no regulations about the price and the supporting mechanisms (FAO 2014). GlobalGAP is sometimes criticized for not being smallholder friendly as investments in production changes and certification are high (Willems et al. 2005). To address this concern there are two certification options: Option 1 is for individual certification; option 2 is for group certification. With option 2, certification producer groups run a joint quality management system and can share some investments (like a collection center and auditing costs). In the recertification process, a random fraction of the group is audited, which significantly reduces the recertification costs. Within the producer group, whether to opt for certification is an individual decision. GlobalGAP obliges the farmer to have a contract with the buyer and to market certified products exclusively through the group (GLOBALG.A.P. 2013).

Guatemala has a very low institutional capacity in food safety and quality, and corresponding problems have been widespread (Julian et al. 2000). This challenges public and private compliance efforts and increases compliance costs (Henson 2007). Pea exports in particular have suffered from high detention rates due to microbiological contamination and pesticide residues (Henson 2007). In an export-oriented sector that is dominated by capital-poor smallholders, non-conformance with international food quality and safety regulations has considerable economic effects. Fresh peas are

[3] Detailed information about the standard can be found at http://www.Globalgap.org.

produced mainly for export to the United States and Europe; a negligible fraction of the crop stays within the country.

To improve the competitive position of pea production, public and private actors work on improving the food quality and safety system in Guatemala. For several years now, the non-traditional export sector has been using GlobalGAP increasingly as an instrument to reach conformance with international norms. It remains the most important food safety and quality standard for Guatemala. In August 2012 there were 1,233 certified farmers in Guatemala, over 800 of them fresh pea producers (GLOBALG.A.P. 2013). This reflects the importance of the product among fresh vegetable exports as well as the small-scale structure of the sector and the vulnerability of pea exports to export detentions. Even though GlobalGAP certification is increasingly demanded, exporters still source non-certified product for export. The certification of small farmers has not developed quickly enough that the demand for fresh peas can be met with certified products.

In the case of small pea farmers in Guatemala, exporters bear the major part of the certification costs. Apart from costs for audits, training and extension services, significant on-farm investments have to be undertaken. It is very difficult to quantify the recurrent and non-recurrent costs that farmers face due to certification. The impression from the field is that costs come mainly in the form of opportunity costs of attending trainings and extension service activities. Exporters seem to modify their price schemes in order to recover part of their investment, like deducting a small fraction from the product price for refinancing the investments in GlobalGAP certification. But again, there is no systematic and valid quantitative information on the costs of GlobalGAP certification since neither farmers nor farmer groups have much knowledge about the costs of certification and the way exporters deal with them.

3.2 Data and Sampling

In this study, we use a sample of 276 fresh pea farmers who were surveyed in the departments of Chimaltenango and Sacatepéquez in the Guatemalan highlands between August and October 2012. Around 90% of the national pea production is concentrated in these two departments. Both departments are adjacent to the capital city and the metropolitan area and dispose over a good road infrastructure. This favors the production of export crops due to better access to modern infrastructure and lower transportation and transaction costs.

We gathered data on the socio-demographic and socio-economic situation of the farm households as well as on agricultural production and marketing, certification and financial literacy. The data refers to all agricultural and non-agricultural activities that happened between August 2011 and July 2012. The financial literacy section is based on widely used survey questions (OECD INFE 2011; Atkinson and Messy 2012). Six multiple choice questions cover general knowledge of numeracy (percentage calculation and division) and more specific financial skills like inflation and interest calculation. We presented the questions as a small quiz rather than a test to the farmers to make them feel more comfortable. If a farmer was not able to answer the two general numeracy questions, we did not perform the financial literacy test. The test questions were then coded as “does not know”.

We contacted farmer groups through the help of two exporters and one non-governmental organization. We interviewed farmers from 16 farmer groups and used a stratified random sampling strategy. Our treatment group consists of 152 certified farmers who are members of a farmer group. Our first control group consists of 64 non-certified farmers who are also members of the same farmer groups. Within the farmer group, we randomly selected the certified and non-certified interviewees from the member list. GlobalGAP certification within the farmer group is still an individual decision. The second control group consists of 60 non-certified and non-organized farmers. This group sells to intermediaries or the spot market, where no standardized quality selection of the product takes place. We decided to include this group to be able to control for group level effects. The second control group was selected using the random walk method. Additionally, we used secondary data on transportation costs provided by the International Food Policy Research Institute.

3.3 Measurement of the outcome variables

Our treatment variable GlobalGAP takes the value 1 if a farmer has ever been certified by GlobalGAP We happen to have producers in our sample that had been certified for some time but did not manage recertification. We treat them as certified producers as we assume that they are more similar to certified producers in terms of endowment, access and marketing situation.

The outcome variables used in our model are total household income, revenue from pea production and revenue from total agricultural production. We use three different outcome variables as it might be that GlobalGAP adoption adversely affects revenue from agricultural production and total household income. GlobalGAP certification might increase revenue from pea production and thus foster reallocation of labor and capital towards pea production (specialization), which may go to the cost of non-pea and off-farm earnings. Therefore, we consider it important to look at the different income components of the household in order to better understand the impact of the certification standard.

Revenue from pea production is measured as the total revenue generated by the commercialization of the pea production in the recall period. Total household income is the sum of revenue from agriculture and off-farm activities. We do not consider income from rents, remittances or social transfer programs. We chose revenue from pea production as our cost data do not contain enough information to calculate the net income from pea production. Farmers often receive inputs to pre-finance their harvest. We do not know whether the buyer considers this in the price or not. Nevertheless, the impact on revenue indicates a tendency about how GlobalGAP and financial literacy influence the economic situation of farmers. Mendola (2007) also uses gross agricultural income as a proxy for household economic well-being and argues that the differences in production costs depend on farmers' production capacity, which is already taken into account when assessing the impact of an innovation on household income.

4. Methods

4.1 Matching

The counterfactual problem

In economic impact evaluation, researchers have to deal with a causal inference problem (Gertler et al. 2011). Establishing a causal relationship is not straightforward when assessing the effect of innovation adoption on an outcome of interest. An individual's income might have increased even without the innovation. An ideal impact evaluation rules out all the confounding factors to establish the unbiased and true relationship between treatment and outcome.[4] In the case of our research question - *What is the impact of GlobalGAP on farm income* - the basic impact evaluation equation is this:

$$(1) \qquad \alpha = (Y \mid GG = 1) - (Y \mid GG = 0),$$

where α is the individual treatment effect of GlobalGAP certification GG on the outcome Y, measured as the difference between the outcome for the <u>same</u> unit of observation (in our case farmers) with and without certification. The impact evaluation ideal confronts us with the counterfactual problem: In our state of the world, it is simply not possible to observe one individual's outcome both with and without treatment.

In order to deal with this counterfactual problem, we have to establish a valid non-treated control group that is as similar as possible to the treatment group. This can be done by evaluating pre- and post-treatment characteristics or by comparing treated and untreated subjects (Gertler et al. 2011).

Given the cross-sectional data available to us, we measured the following average treatment effect on the individuals that actually received the treatment (ATT):

$$(2) \qquad ATT\text{: } E\,(Y_i \mid GG = 1) = E(Y_{i1} \mid GG = 1) - E\,(Y_{i0} \mid GG = 0),$$

where $(Y_{i1} \mid GG = 1)$ is the outcome for subjects who have adopted GlobalGAP and $E\,(Y_{i0} \mid GG = 0)$ is the outcome for those who have not adopted GlobalGAP.

However, comparing treated and untreated subjects still might not reveal the real treatment effect of innovation adoption. We have to take into account selection on observable and unobservable characteristics of the subjects.

Selection on observable characteristics means that outcome and treatment are independently conditional on the covariates X. Characteristics X that are observed by the researcher determine whether a subject receives the treatment or not (e.g. farm assets) and differs between the two groups. We can control for this bias by including the necessary covariates in our model.

[4] In the impact assessment literature, the term treatment is commonly used. The treatment in our case is GlobalGAP certification.

Bias arising from selection on unobservable characteristics is more difficult to control for, as those are characteristics not measured by the researcher. It means that the outcome is independent of the treatment conditional on the covariates X and characteristics “hidden” in the error term. Some unobserved characteristics, such as ambition or laziness, may influence an individual’s participation in a treatment and the outcome alike. Hidden bias is likely to influence the estimated treatment effect.

$$(3) \qquad ATT: E\ (\ Y_i \mid GG = 1) =$$

$$E(Y_{i1}|GG = 1) - E\ (Y_{i0}|GG = 0)\ +\ E\ (Y_{0i}|GG = 1) - E\ (Y_{0i}|GG = 0),$$

where $E(Y_{i1}|GG = 1) - E\ (Y_{i0}|GG = 0)$ is the ATT we want to measure and $E\ (Y_{0i}|GG = 1) - E\ (Y_{0i}|GG = 0)$ is the selection bias arising from unobserved variables. Without controlling for selection on unobservable characteristics, we would measure the biased treatment effect as displayed in equation (4) (Caliendo and Kopeinig 2005). Only if the second term of equation (3) equals zero can we measure the real ATT. One solution to this problem would be an experimental research design with the random assignment of the treatment (randomized control trials) and data on pre-treatment characteristics of the subjects. We do not have this data, so we have to find a way to deal with the selection problem.

Matching techniques

One common approach to controlling for selection on observables in the absence of experimental data without random assignment of the treatment is the use of matching techniques. Matching techniques create a counterfactual group for observational data by matching each treated subject with one (or more) untreated subjects with similar observed characteristics. As it is almost impossible to find a match that is equal in all covariates, it is more efficient to match a single-index variable - the *propensity score* of being treated (Becker and Ichino 2002).

Propensity Score Matching (PSM) on observable characteristics helps to reduce the bias caused by unobservable factors but does not eliminate it (Becker and Ichino 2002). The assumption behind this is that, by matching individuals on their observable characteristics, we are also doing so—to a certain degree—for the unobservable characteristics. Bias can only be completely eliminated if the exposure to treatment is completely random among the individuals who have the same propensity score.

The propensity score is the conditional probability of receiving the treatment given pretreatment characteristics (Becker and Caliendo 2007):

$$(4) \qquad p\,(X) = \Pr(GG = 1\,|X\,) = E\,(GG\mid X).$$

GG = {0, 1} is an indicator of exposure to the treatment (in our case GlobalGAP certification) and X is a multidimensional vector of pretreatment characteristics.

In order to identify the true ATT with PSM, two assumptions have to be met: the conditional independence assumption (CIA) and the overlap assumption.

The CIA requires that selection into treatment be based only on observable characteristics. Apart from the characteristics that are observed by the researcher and that influence treatment and outcome alike, there should be no confounding unobservable characteristics that influence selection into treatment (Caliendo and Kopeinig 2005). With non-experimental data (where the assignment to treatment is endogenous), we cannot test directly whether the CIA has been met. If the assumption has not been met, we would have unobserved variables that simultaneously affect selection into treatment and the outcome, leading to biased estimates. PSM is not robust to this hidden bias (Becker and Caliendo 2007).

Several measures can be undertaken in order to address this problem (Abebaw and Haile 2013): Conditioning on several covariates in the propensity score model to minimize omitted variable bias, implementing matching in the region of common support and calculating Rosenbaum bounds. Rosenbaum bounds provide evidence of the degree to which any significant result is dependent on this assumption. The bounds estimate the degree to which an unmeasured variable must influence the selection process in order to undermine the results of the matching analysis (Caliendo and Kopeinig 2005). If the results are sensitive, one has to rethink the identification strategy. This approach uses the odds ratio of participation in a treatment between two matched individuals to evaluate whether the odds differ due to hidden bias (Rusike et al. 2014).

The overlap assumption (also known as the balancing property or common support condition) requires that subjects with the same X values in the covariates have a positive probability of being both participant and non-participant (Caliendo and Kopeinig 2005). Observations with the same propensity score must have the same distribution of observable (and unobservable) characteristics independent of their actual treatment status.

To test whether the overlap assumption holds true, the distribution of the propensity scores can be plotted by treatment and by control group. Another method is to calculate the normalized differences between the treatment and the control group (Cunguara and Darnhofer 2011).

If the propensity score p (X) is known and the assumptions are met, then the PSM estimator for the ATT is as follows (Caliendo and Kopeinig 2005):

$$(5) \qquad \tau\frac{PSM}{ATT} = E_{P(x)|GG=1}\{E[Y(1)|GG=1, P(X)] - E\,[Y(0)|GG \quad = 0, p\,(X \quad)]\}.$$

The PSM estimator is the mean difference in outcomes under the condition of common support, weighted by the propensity score distribution of the subjects in the sample (Caliendo and Kopeinig 2005).

Matching estimator

According to Caliendo and Kopeinig (2005) a good matching estimator does not eliminate too much of the original observations while at the same time it yields statistically equal covariate means for the observations in the treatment and control groups. In practice, different matching algorithms are used to test the robustness of the results. We employ three different matching estimators.

With the nearest neighbor matching (NNM) estimator, every treated unit is matched with a control unit. For each GlobalGAP adopter, the closest observation with similar observable characteristics is chosen from the non-adopters and compared. The effect of adoption on our variable of interest is computed as the average difference in income between each pair of matched observations (Mendola 2007). The disadvantage of this estimator is that, since the nearest neighbor might still have a very different propensity score, some matches can be very poor. NNM can be applied either with or without replacement (with replacement: one control unit is matched with several treated units).

With the radius matching (RM) estimator, each treated unit is matched with all the comparison observations that fall in a predefined neighborhood (caliper) (Caliendo and Kopeinig 2005). The advantage of RM lies in the use of additional observations if good matches are not available. RM allows the use of more information to construct the counterfactual by oversampling. This reduces the variance and avoids the bias caused by bad matches (Caliendo and Kopeinig 2005).

With kernel-based matching (KBM), the counterfactual is constructed using the weighted average of all households in the non-treated observations. KBM is a non-parametric estimator and more flexible than the NNM estimator (Mendola 2007). The advantage of KBM is that it uses more information, resulting in lower variance; however, bias might be increased since bad matches are also used to create the counterfactual (Caliendo and Kopeinig 2005).

The quality of any matching estimator is improved by imposing the common support restriction. When choosing a matching estimator, the trade-off between bias and variance has to be evaluated, especially in small samples (Caliendo and Kopeinig 2005). We employ the three matching estimators discussed in this chapter.

4.2 Principal Component Analysis

Principal component analysis (PCA) is a multivariate statistical technique to reduce a number of variables that describe the same latent variable to smaller dimensions. From an initial set of *n* correlated variables, PCA creates uncorrelated components that account for most of the variance in the data. Each component is a linearly weighted combination of the initial variables. The number of components extracted equals the same number as the initial set of variables, whereas the first component accounts for most of the variance in the data (Kolenikov and Angeles 2004). For a set of variables X_1 to X_n the principal components are

$$(6) \quad PC_1 = a_{11}X_1 + a_{12}X_2 + \cdots + a_{1n}X_n$$

$$\ldots$$

$$(7) \quad PC_m = a_{m1}X_1 + a_{m2}X_2 + \cdots + a_{mn}X_n \,,$$

where a_{mn} represents the weight for the *m*th component and the *n*th variable (Vyas and Kumaranayake 2006). The eigenvector of the correlation matrix is the weights of the principal components. The eigenvalue of the eigenvector is the amount of variance that is explained by the component (Vyas and Kumaranayake 2006; van Rooij et al. 2011). The first principal component always explains the largest amount of the underlying information of the variables used and is a linear index of all the variables used. The following components are not correlated with the first component and explain additional variance but a smaller part of the variation in the data.

We used unrotated PCA to construct a financial literacy index and a farm asset index. Using an index is a common approach in financial literacy research (van Rooij et al. 2011; Behrmann et al. 2010) and for wealth indices (Vyas and Kumaranayake 2006). The advantage over just summing up the number of correct answers in the financial literacy test or the number of assets is that PCA assigns weights to the variables according to their importance in contributing to the whole variation in the data - meaning its contribution in explaining the underlying latent phenomenon, which in our case is financial literacy or farm wealth (Langyintuo and Mungoma 2008).

For financial literacy, the first extracted component accounts for almost 70% of the variation in the data (table A-1 in the appendix). The factor loadings for the first component all have the same sign and are almost equal in magnitude (table A-2, appendix). We estimated the Kaiser-Meyer-Olkin (KMO) criterion of sampling adequacy to check whether the data used is suitable for PCA (see table A-3 in the appendix). The overall KMO score is higher than 0.8, which is considered a very good value. Bartlett's test of sphericity tests whether the correlations between the variables used are significant. The test indicates that we can reject the null hypothesis of zero correlations between the variables (see table A-4 in the appendix). We used the first component to construct the financial literacy index.

We performed the same procedure with 13 variables that are associated with farm assets. According to the KMO results, we can perform factor analysis, albeit with 0.56 it is lower than in the financial literacy index. Bartlett's test indicates that the data correlates sufficiently to perform PCA (see tables A-5 to A-7 in the appendix). Our farm asset index is proxy for the asset endowment of the farm. We do not have enough information in our dataset to create a wealth index.

5. Descriptive results

5.1 Descriptive statistics

In table 1 we display the descriptive statistics for the variables we are using in the propensity score model. For a detailed explanation of the variables used in table 1, see table A-8 in the appendix. We present the means for the entire sample and for the groups of certified and non-certified farmers. A t-test is used to reveal systematic differences in the mean between certified and non-certified groups.

Table 1 Sample characteristics

	Whole sample	sd	Certified	sd	Non-certified	sd	Differ-ences[a]
Socioeconomic characteristics							
Age	44.366	12.502	45.118	12.433	43.444	12.574	-1.67
Gender	0.953	0.212	0.941	0.238	0.968	0.177	0.03
Education	4.648	2.83	4.691	2.852	4.597	2.814	-0.09
MembersOnFarm	3.728	2.045	3.770	2.114	3.677	1.965	-0.09
Mother tongue	0.062	0.241	0.059	0.237	0.065	0.247	0.01
Conditional cash transfer	0.199	0.400	0.191	0.394	0.210	0.409	0.02
Formal credit access	0.344	0.476	0.355	0.48	0.331	0.472	-0.02
Farm characteristics							
Ha owned before 2009	0.805	1.745	1.005	2.076	0.560	1.187	-0.44**
Land title	0.743	0.438	0.783	0.414	0.694	0.463	-0.09*
Irrigation	0.199	0.400	0.224	0.418	0.169	0.376	-0.05
BuyerFFV	0.857	0.349	0.841	0.366	0.877	0.327	0.04
LocalMarket	0.385	0.485	0.391	0.039	0.377	0.043	-.014
FarmX	-0.021	1.335	0.195	1.463	-0.286	1.109	-0.48***
Livestock_NR	0.909	0.793	1.013	0.797	0.782	0.771	-0.23**
Exporter before 2009	0.304	0.461	0.428	0.496	0.153	0.362	-0.27***
Experience pea production	11.619	7.922	11.187	7.476	12.148	8.436	0.96
Specialization	37.371	18.215	37.589	16.834	37.104	19.843	-0.48
T_costs	0.005	0.003	0.004	0.003	0.005	0.003	0.00*
Financial abilities							
FLX	0.011	2.021	0.391	1.862	-0.455	2.117	-0.85***
Observations	276		152		124		

[a] Differences in mean between certified and non-certified farmers; significance at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Certified and non-certified farmers do not differ in their socioeconomic characteristics such as age, education, available farm labor force and participation in a conditional cash transfer program. There are statistically significant differences between the two groups in land holdings patterns (ha owned before 2009 and land title), asset endowment (farm assets and number of livestock owned), experience with an exporter (exporter before

2009), access indicator (transportation costs) and financial literacy. Certified farmers are better endowed with land and assets, have more experience with exporters, have better access to markets and perform better in financial literacy.

Commercialization

As we want to assess the economic impact of GlobalGAP adoption, we decided to first acquire a descriptive overview of aspects of commercialization in the sample (see table 2). This will help us to understand under which conditions the farmers market their products and how this might influence their economic situation. We asked the farmers to report the average price they received for peas from their buyers during the reporting time as well as the lowest and highest prices. In general, certified farmers receive a higher average price than non-certified farmers. The lowest price received is significantly lower for non-certified farmers than for certified farmers. Interestingly, there is no statistically significant difference between the two groups when it comes to the highest price received. According to the price information, it seems that certified farmers experience fewer "price peaks" than non-certified farmers and receive more for their product on average. GlobalGAP certification does not foresee a price premium for compliance. To make certification more attractive for the farmers (and to avoid side-selling), exporters offer certain price schemes. In our sample, 40% of the certified farmers market their product under a fixed price scheme which represents a significant difference to non-certified farmers. Fixed price schemes are not necessarily attached to certification schemes. Even non-certified farmers supplying exporters engage in fixed price schemes. Of course, fixed price schemes are not always good for the farmer. If the market price is higher than the fixed price, there is room for arbitrage, and the farmer could have earned more with the market price. This creates incentives for side-selling. To avoid this, exporters often rely on a minimum price scheme, that is, they agree upon a minimum price they always pay. If the market price is higher than the minimum price, they pay the market price. We do not have information on minimum price schemes in our sample.

Non-certified farmers have to wait significantly fewer days until they get paid than do certified farmers. Farmers told us that the long waiting period for payment is one disadvantage for them when it comes to supplying an exporter under a certification scheme. Farmers in our sample have very few sources of cash income. Especially during harvest, when they have to finance labor and equipment, disposing over cash is critical. Qualitative evidence suggests that the long payment periods are also one reason for side-selling to the spot market, which persists even among certified farmers.

Table 2 Commercialization

	Whole sample	sd	Cer-tified	sd	Non-Certified	sd	Differences
Average price GTQ[a] / Quintal[b]	268.24	90.38	289	83.47	240.48	92.35	-48.52***
Lowest price GTQ / Quintal[b]	210.01	114.67	235.41	105.69	178.06	117.89	-57.35***
Highest price GTQ[a] / Quintal[b]	335.93	132.16	340.60	110.97	330.23	155.75	-10.37
FixPrice (1 = Fix price)	0.36	0.48	0.40	0.49	0.31	0.46	-0.09*
Days until payment received	12.64	8.72	13.88	9.66	10.94	6.91	-2.94***
Delivery per season/Quintal[b]	61.712	102.36	68.25	120.71	49.16	53.69	-19.09*
Observations	317		180		136		

Significance level at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

a GTQ= Guatemalan quetzal, for the time period July 2011 to August 2012 1 GTQ equaled on average 0.10 Euros[5]

b Quintal is a volume metric used in Guatemala; one quintal equals about 46 kg[6]

Both groups differ significantly in terms of volume supplied to buyers. Certified farmers deliver more on average. Above, we showed that certified and non-certified farmers allocate on average the same share of land to pea production (around one third of their land). The higher commercialized volume of certified farmers might be explained through higher yield or through better marketing opportunities (lower rejection rate, always able to find a buyer) enjoyed by certified farmers.

Buyers

5 http://www.oanda.com/lang/de/currency/historical-rates/, checked 20.10.2014.

6 http://sizes.com/units/quintal.htm, checked 20.10.2014.

Almost 60% of the buyer-supplier relationships in the sample are with an exporter (see table 3).[7] Looking at certified and non-certified farmers gives us a more detailed picture. For certified farmers, more than 70% of trade relationships are with an exporter; for non-certified farmers, relationships with exporters constitute 40% of their supply relationships. Half of non-certified farmers' trade relationships are with intermediaries; in comparison, for farmers participating in the GlobalGAP standard, 15% of trade relationships are with intermediaries. We ran a chi^2 test of independence to see whether buyer and certification status are statistically related. The result suggests that certification status and buyer are indeed statistically related. This result is not surprising: Certification only makes sense when the product is commercialized through an exporter. More surprising is that a fraction of the certified farmers still sell to intermediaries. This might indicate side-selling. In both groups there are farmers who sell their product to a cooperative. In these cases, the cooperative can be seen as an intermediary that delivers the product collectively to the exporter.

Table 3 Buyer

Buyer	Whole Sample No.	%	Never certified %	Ever certified %
Intermediary	96	30.3	50	15.6
Cooperative	29	9.1	8.1	10
Wholesale market	4	1.3	1.5	1.1
Exporter	188	59.3	40.4	73.3
Total	316	100	100	100

Pearson $chi^2(3) = 44.8043$ Pr = 0.000

Over 50 % of the buyer-supplier relationships in the sample are regulated through a formal, written contract (see table 4). In almost 20% of the cases, there is an oral agreement between buyer and farmer, and in 26% of the cases there are spot market relationships (meaning no written or oral agreement). Almost 70% of trade relationships of certified farmers take place under a written contract compared to 33% of non-

[7] On average, every farmer supplies to more than one buyer, so we have more observations on supply relationships than we have individual farmers.

certified supplier-buyer relationships. On the other hand, almost half of non-certified trading happens on a spot-market basis.

Table 4 Contractual arrangements

Type of contract	Total	Total	Non-certified	Certified
	No.	%	%	%
No agreement	81	26.6	44.7	12.8
Oral agreement	59	19.4	22	17.4
Written agreement	164	53.9	33.3	69.8
Total	304	100	100	100

Pearson $chi^2(2) = 47.7004$ Pr = 0.000

GlobalGAP requires a contract between the farmer and the buyer. Contracts are seen as an important instrument for improving farmers' planning security and economic situation. In the case of pea producers in Guatemala, contracts with exporters come mainly in the form of a resource-providing contract and define specific components of the trading relationship, like price, volume, quality, input and extension service. Qualitative evidence suggests that farmers view contractual relationships with a preferred buyer with mixed feelings: They are aware of the advantages mentioned but also stress the disadvantage of being dependent on one buyer (buyer lock-in), who controls all the market and price information they need.

Farm income

Our outcome variables of interest are the revenues farmers receive from pea production, total agricultural income and total household income. As our income data is not normally distributed but highly right skewed, we took the natural logarithm of the income variables for our analysis. Taking the logarithm of income smoothes the income distribution and makes it less sensitive to outliers. Certified and non-certified farmers differ significantly in economic terms. Certified farmers have on average higher revenue from pea production, total agricultural production and total household income (see table 5). If we look at the absolute values of income in table 6, income from pea production is - on average - the main contribution to total household income for both certified and non-certified farmers. This underlines the importance of pea production for the small farmers in our study region. We do not see any significant differences in mean for the untransformed income variables. This stems from the distribution of the income variables for the two groups. The variables have a much higher variance for certified farmers than for non-certified farmers.

Table 5 Descriptive statistics for log transformed outcome variables

	Whole sample	sd	Certified	sd	Non-certified	sd	Diff-erences
Total HH income (log)	9.962	0.911	10.009	1.211	9.734	1.266	-0.28*
Total agricultural revenue (log)	9.473	0.994	9.622	0.949	9.294	1.026	-0.33***
Total pea revenue (log)	9.089	1.086	9.290	1.051	8.843	1.088	-0.45***
Observations	276		152		124		

Significance level at * p < 0.10, ** p < 0.05, *** p < 0.01

Table 6 Descriptive statistics for outcome variables

	Whole sample	sd	Certified	sd	Non-certified	sd	Diff-erences
Total HH income	32360.4	45724.1	35798.9	51726.6	27951.2	36860.8	-7847.7
Total agricultural revenue	22206.1	41538.7	25055.1	47248.4	18713.6	33087.9	-6341.5
Pea revenue	16990.2	38365.1	19743.1	43006.7	13704.4	31615.6	-6038.7
Obser-vations	276		152		124		

Significance level at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5.2 Descriptive statistics for financial literacy groups

As we are interested in the heterogeneous impact of GlobalGAP with respect to the financial literacy level, we split our sample into high and low financially literate farmers.[8] We see that, regardless of their certification status, farmers with a higher level of financial literacy are on average younger and better educated. They also have better access to buyers in their village, which indicates that they benefit from better marketing conditions. Furthermore, farmers with a higher level of financial literacy are on average better endowed with farm assets. The same pattern holds true if we look only at certified farmers with high and low levels of financial literacy (see table 7).

Table 7 Sample characteristics for financial literacy groups (whole sample)

	Whole sample			Certified farmers		
	High FL	Low FL	Differences	High FL	Low FL	Differences
Socioeconomic characteristics						
Age	42.900	45.671	2.77^{*}	43.571	47.029	3.46^{*}
Gender	0.954	0.952	-0.00	0.964	0.912	-0.05
Education	5.492	3.897	-1.60^{***}	5.452	3.750	-1.70^{***}
MembersOnFarm	3.777	3.685	-0.09	4.012	3.471	-0.54
Conditional cash transfer	0.192	0.205	0.01	0.214	0.162	-0.05
Mother tongue	0.069	0.055	-0.01	0.071	0.044	-0.03
Formal credit access	0.300	0.384	0.08	0.298	0.426	0.13
Farm Characteristics						
Ha owned before 2009	0.910	0.711	-0.20	1.185	0.782	-0.40
Land title	0.777	0.712	-0.06	0.810	0.750	-0.06
Irrigation	0.223	0.178	-0.04	0.250	0.191	-0.06
BuyerFFV	0.931	0.795	-0.14^{***}	0.893	0.779	-0.11^{*}
LocalMarket	0.411	0.361	-0.05	0.433	0.338	-0.09
FarmX	0.182	-0.202	-0.38^{**}	0.401	-0.060	-0.46^{*}
Livestock_NR	0.946	0.877	-0.07	1.024	1.000	-0.02
Exporter before 2009	0.346	0.267	-0.08	0.452	0.397	-0.06
Experience pea production	11.724	11.525	-0.20	11.761	10.478	-1.28
Specialization	39.215	35.728	-3.49	39.203	35.595	-3.61
T_costs	0.005	0.005	0.00	0.004	0.004	-0.00
Observations	130	146		84	68	

Significance level at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[8] The cut-off point is the median score in the financial literacy index. Farmers with a score below the median are classified as having low financial literacy; farmers with a score above the median are classified as having high financial literacy. Considering just two categories is very broad and might result in incomplete proxies for the different levels of financial literacy. However, considering more categories would result in very small subsamples, and matching estimators perform better with larger samples (Caliendo and Kopeinig 2005). It is more difficult to detect a treatment effect as standard errors increase.

Looking at marketing patterns in respect to financial literacy groups, we see in table 8 that farmers with better financial skills have more GlobalGAP certificates than those with poorer financial skills; they receive on average a significantly better average price and a significantly higher lowest price. Significantly more highly financially literate farmers have a contract and deliver more to the buyer. These differences disappear when we look only at certified farmers: The only difference between high and low financial literacy among certified farmers is in the average highest price they receive. Certified farmers with a higher financial literacy seem to receive higher prices for their product.

Table 8 Commercialization for financial literacy groups

	Whole sample			Certified farmers		
	High FL	Low FL	Differences	High FL	Low FL	Differences
GlobalGAP	0.646	0.466	-0.18***			
Average price GTQ / Quintal[a]	295.928	246.169	-49.76***	296.905	294.721	-2.18
Lowest price GTQ / Quintal[a]	245.267	182.966	-62.30***	243.467	247.517	4.05
Highest price GTQ / Quintal[a]	338.957	331.849	-7.11	351.429	323.468	-27.96*
Fix Price (1= Fix price)[a]	0.395	0.331	-0.06	0.393	0.397	0.00
Contract (1 = Contract)	0.875	0.565	-0.31***	1.583	1.545	-0.04
Delivery per season (Quintales)[b]	79.786	53.637	-26.15**	84.161	57.397	-26.76
Rejection rate (average)	12.854	12.595	-0.259	12.849	12.862	0.01
Observations	130	146		84	68	

Significance level at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

a Only for most important buyer; GTQ= Guatemalan quetzal, for the time period July 2011 to August 2012 1 GTQ equaled on average 0.10 Euros.[9] Quintal is a volume metric used in Guatemala; one quintal equals about 46 kg.[10]

[9] http://www.oanda.com/lang/de/currency/historical-rates/, accessed 20.10.2014

10 http://sizes.com/units/quintal.htm, accessed 20.10.2014

6. Propensity Score Matching Results

6.1 The impact of GlobalGAP on farm income

Estimation of the Propensity Scores

The propensity scores of GlobalGAP adoption are estimated with a probit model.[11] Socioeconomic factors, such as age, education and members working on farm, do not influence the propensity to adopt GlobalGAP. Moreover, some farm characteristics play no role these include hectares owned, land title and irrigation system. Whether the farmers have farm assets and experience working with an exporter before 2009, influences positively GlobalGAP adoption. Conversely, experience in pea production and transportation costs negatively influence its adoption. Financial literacy positively influences the propensity to adopt. The results are displayed in table 9. For a description of the variables used in the model see table A-8 in the appendix.

Table 9 Estimated propensity scores of GlobalGAP adoption

Propensity of certification	Coefficient	Standard error
Age	-0.0348	(0.044)
Age2	0.001	(0.001)
Education	0.0518	(0.081)
Education2	-0.006	(0.006)
MembersOnFarm	0.026	(0.043)
Ha owned before 2009	0.05	(0.055)
Land title	0.156	(0.205)
Irrigation	-0.027	(0.244)
BuyerFFV	-0.264	(0.246)
FarmX	0.179**	(0.071)
Livestock_NR	0.096	(0.108)
Mother tongue	-0.234	(0.409)
Exporter before 2009	0.815***	(0.192)
Formal credit access	0.249	(0.172)
Experience pea production	-0.024**	(0.012)
Specialization	0.004	(0.005)
T_costs	-48.71**	(23.90)
FLX	0.128***	(0.044)
Constant	0.492	(1.012)
Observations	276	

Robust standard errors in parentheses, significance level at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Common support

[11] For an explanation for the variables used in the model see table A-8 in the appendix.

To test whether the overlap assumption is met, we plot the distribution of the propensity scores of GlobalGAP adoption for GlobalGAP adopters and non-adopters in figure 1. The distributions are almost identical and only a few observations are outside the region of common support. There is sufficient overlap in the propensity scores of adopters and non-adopters to perform the matching in the region of common support. To test the quality of the matching, we performed a balancing test with the propensity score based on the nearest neighbor matching estimator for pea revenue (see table 10). After the matching, there are no systematic and statistically significant differences in observed characteristics between adopters and non-adopters. Matching is considered successful if it results in a standardized difference in the mean values less than 25% (Imbens and Wooldridge 2009). Our data meets this criterion after matching. Both tests suggest that we have a good quality of matching and that the overlap assumption is met. Conditional independence cannot be tested directly. We condition on a range of observable covariates to control for selection on observable characteristics.

Sensitivity test

To test the sensitivity of the results towards hidden bias, we calculate Rosenbaum bounds (see table 11). Rosenbaum bounds estimate a critical value of gamma at which the treatment effect becomes insignificant. For significant treatment effects, the critical values are between 1.5 and 1.9. This means that matched farmers with the same observed characteristics would have to differ in unobserved characteristics by a factor of 1.5 to 1.9, or by 50% to 90%, in order to question the significance of the identified ATT (Chiputwa et al. 2013; Abebaw and Haile 2013). There is no reference for a critical threshold under which the results become unstable. But, after assessing the magnitude by which the farmers would have to differ in unobserved characteristics, we consider our results quite robust with regard to hidden bias.

Table 10 Balancing test

	Treated	Control	%bias[a]
Age	43.985	45.203	-9.7
Age2	2088.7	2215.1	-10.9
Education	4.649	4.687	-1.3
Education2	30.216	31.757	-3.9
N_On_farm	3.836	3.687	7.3
land_owned_before2009	0.872	0.751	7.2
all_title3	0.769	0.746	5.1

irri_dummy	0.194	0.209	-3.8
BuyerFFV	0.849	0.852	-0.7
AssetScore2	0.037	0.008	2.2
Livestock_NR	0.940	0.987	-5.9
Mothertongue	0.059	0.059	0
Exporter_before_2009	0.358	0.375	-3.9
AccessCreditFormal	0.366	0.334	6.7
mean_exp	11.162	11.395	-2.9
share_peas	38.384	39.544	-6.3
cost_to_market_dollarxkg	0.005	0.004	6.8
FLX	0.249	0.112	6.9

a Normalized difference; Whole sample (n=276); based on nearest neighbor matching (4)

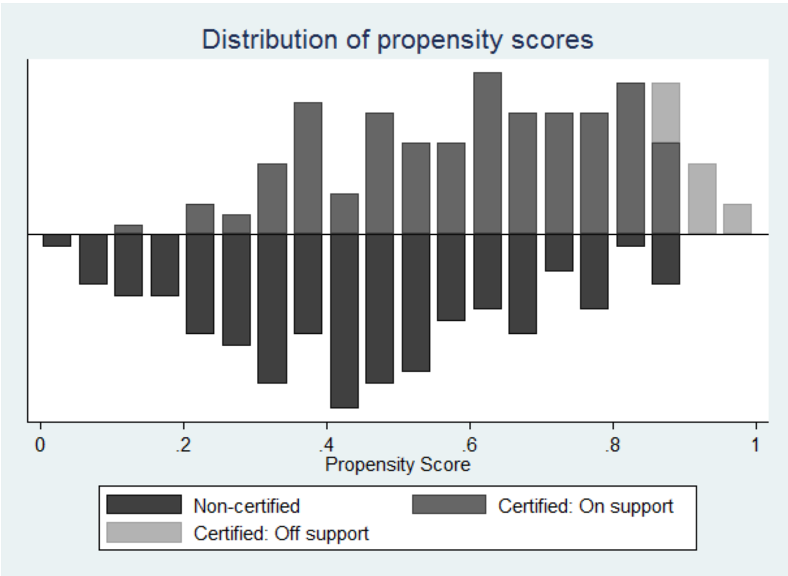

Figure 1 Distribution of the propensity scores for the whole sample (N=276)

Table 11 The impact of GlobalGAP

	Pea revenue	Bound[b]	Effect	Total agricultural revenue	Bound[b]	Effect	Total Income	Bound[b]	Effect
NNM (4) [a]	0.417*** (0.134)	1.9–2.0	52.2 %	0.304* (0.158)	1.5–1.6	35.48%	0.306** (0.134)	1.5–1.6	35.6 %
RM (calipe	0.338**	1.6–1.7	46.2 %	0.108	1		0.148	1.1–1.2	

r 0.05)[c]	(0.158)			(0.157)		(0.148)	
KBM (band-width 0.06)[c]	0.342** (0.158)	1.6–1.7	40.5 %	0.181 (0.145)	1	0.161 (0.161)	1.1–1.2

Significance level at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

a Bias adjusted standard errors; common support imposed
b Bounds are calculated based on the results of the -psmatch2- command, which does not take into account estimated propensity scores for standard errors
c Radius and kernel matching on the region of common support; no bias-adjusted standard errors

The impact of GlobalGAP adoption

To identify the ATT of GlobalGAP adoption on our outcomes of interest, we employ three different matching estimators, i.e. total household income, revenue from pea production and revenue from total agricultural production. All three matching estimators report a positive and significant treatment effect of GlobalGAP adoption on pea revenue (see table 11). The ATT for GlobalGAP adoption on total household income is only significant with the nearest neighbor estimator. The interpretation of the estimated coefficients is not straightforward since we are using the natural logarithm of income as an outcome variable. We want to assess the effect of the change from not being certified to being certified.[12] The increase in revenue from pea production due to GlobalGAP adoption ranges from 40.5% with the kernel-based estimator to 52.2% with the nearest neighbor estimator. Total agricultural revenue and total household income are increasing by about 35% through GlobalGAP certification. This result is less robust as only the NNM estimator identifies a significant treatment effect. The results confirm our initial assumption that adoption has a positive ATT on farmers' pea revenues. The positive effect of GlobalGAP adoption on total household income cannot be completely confirmed.

Impact pathways

Which impact pathways explain the impact of GlobalGAP on pea revenue? The GlobalGAP scheme does not include a price premium for compliance. But our

[12] If the treatment variable GlobalGAP switches from 0 to 1, the percentage impact needs to be interpreted with care as our outcome variables are log-transformed. According to Halvorsen and Palmquist (1980), the effect of GlobalGAP on the outcome of interest is calculated as follows: 100*[exp*(coefficient) – 1].

descriptive results show that certified farmers benefit from a more beneficial pricing scheme. Exporters offer premium prices and minimum or fixed price schemes in order to make certification more attractive and avoid side-selling. Certified farmers benefit from higher average prices, but prices do not fluctuate as much. The positive impact of GlobalGAP on pea revenue might therefore result from a price effect. Still, we also see that GlobalGAP producers generally deliver more to their exporters. On average, non-certified farmers have smaller farms than certified farmers. But the farmers do not differ in their specializations - both groups assign around 37% of their cultivated land to pea production. The higher volume delivered may be due to higher absolute cultivation land or to higher yields resulting from better production management, more efficient input use and better extension service. Improvement in farmers' marketing situation might also explain the volume effect. First, GlobalGAP comes with a contract scheme. These contracts often define the volume demanded by the exporter. Second, the improvement in product quality through GlobalGAP may lead to a lower rejection rate. Hence, the higher revenue from pea production for GlobalGAP certified farmers might also result from a volume effect.

But why does the strong ATT on pea revenue not translate into an increase in total agricultural revenue and total household income? Albeit the specialization in pea production is the same for certified and non-certified farmers (see table 1), standard adoption might require more capital and labor, which comes at the cost of producing other crops (intensification vs. diversification of the production base). GlobalGAP compliance is time and labor intensive; this might also come at the cost of lower engagement in off-farm activities, for example. Around one-third of the certified farm households do not report any off-farm income during the period surveyed. Qualitative evidence from the field supports this impact pathway: Farmers state that they do not necessarily feel a quantitative improvement in their overall economic situation, but that they do benefit from more economic security and stability.

6.2 The impact of GlobalGAP and financial literacy

Other studies have shown the importance of considering the heterogeneity of farmers when assessing the impact of standards/innovations on the economic situation of small farmers (Holzapfel and Wollni 2014; Mendola 2007; Hansen and Trifković 2014). In our study we consider heterogeneous financial literacy skills in the assessment of the income effect of GlobalGAP adoption. We assume that the impact of GlobalGAP depends on the individual farmer's financial skills. Furthermore, higher financial literacy might allow a farmer to better translate certification into economic benefits.

Estimation of the propensity score

The probit model for estimating the propensity scores for both subsamples is specified without financial literacy as a covariate. Another covariate is dropped (BuyerFFV) due to multicollinearity problems in the subsample. We replace the variable with a dummy that indicates whether there is a local market in the village where the farmer lives. This is a proxy for access to marketing opportunities, which is similar to the BuyerFFV-variable. The determinants of GlobalGAP adoption differ between the two groups (see table 12). For farmers with a higher level of financial literacy, the only significant determinant is whether they were already working with an exporter before 2009. For the low financial literacy group, assets, exporter before 2009, transportation costs and experience significantly influence GlobalGAP adoption.

Table 12 Propensity scores of GlobalGAP adoption for high and low financial literacy subsample

	GlobalGAP High FL subsample		GlobalGAP Low FL Sample	
Age	0.055	(0.086)	-0.0615	(0.059)
Age2	-0.0001	(0.001)	0.001	(0.001)
Education	0.08	(0.125)	-0.023	(0.133)
Education2	-0.008	(0.008)	0.0019	(0.014)
MembersOnFarm	0.094	(0.068)	-0.039	(0.068)
Ha owned before 2009	0.279	(0.177)	-0.03	(0.082)
Land title	0.118	(0.333)	0.168	(0.274)
Irrigation	0.037	(0.374)	0.038	(0.339)
FarmX	0.216	(0.132)	0.204*	(0.106)
Livestock_NR	0.088	(0.179)	0.195	(0.158)
LocalMarket	0.363	(0.303)	0.054	(0.269)
Mother tongue	0.225	(0.672)	-0.437	(0.516)
Exporter before 2009	0.930***	(0.309)	0.825***	(0.271)
Formal credit access	0.191	(0.300)	0.264	(0.238)
Experience pea production	-0.019	(0.019)	-0.034**	(0.017)
Specialization	0.001	(0.007)	0.001	(0.007)
T_costs	-2.271	(43.67)	-65.53*	(36.20)
Constant	-1.840	(1.876)	1.127	(1.371)

Observations	130	146

Standard errors in parentheses * p<0.10, ** p<0.05, *** p<0.010

Common support

As we did for the complete sample, we test whether the overlap assumption holds for the two subsamples by performing matching and displaying the distributions of the propensity scores. According to the distribution of the propensity scores of GlobalGAP adoption for GlobalGAP adopters and non-adopters in the high and low financial literacy subsamples, we have sufficient overlap and very few observations outside the region of common support (see figures 2 and 3). There is sufficient overlap in the propensity scores of adopters and non-adopters to perform the matching on the region of common support. To test the quality of the matching, we performed a balancing test with the propensity score for the subsamples based on the NNM estimator for pea revenue (see table 13). After matching, there are no significant differences between the treatment and control group for both subsamples. The standardized difference in the mean values is less than 25% for both groups. The overlap assumption is met for both subsamples, so we can do the propensity score matching.

Table 13 Balancing test for subsamples (based on NNM for nearest 4 neighbor estimator)

	High levels of FL			Low levels of FL		
	Treated	Control	%bias	Treated	Control	%bias
Age	41.918	41.902	0.1	46.695	47.174	-3.5
Age2	1864	1850.1	1.4	2380.4	2432.2	-4
Education	5.279	4.918	11.5	3.576	3.958	-16
Education2	36.852	29.484	13.8	18.525	22.873	-18.9
MembersOnFarm	3.869	3.844	1.1	3.610	3.542	3.6
Ha owned before 2009	0.460	0.479	-1.1	0.691	0.810	-7.6
Land title	0.771	0.783	-2.9	0.712	0.703	1.9
Irrigation	0.180	0.159	5	0.169	0.174	-1.1
LocalMarket	0.433	0.438	-1.2	0.339	0.367	-5.8
FarmX	-0.027	-0.058	2.3	-0.146	-0.018	-10.3
Livestock_NR	0.918	0.979	-7.7	0.881	0.788	12.1
Mother tongue	0.049	0.025	9.7	0.051	0.098	-20.5
Exporter before 2009	0.344	0.295	11.2	0.305	0.284	4.9
Formal credit access	0.328	0.295	7.1	0.407	0.386	4.3
Experience pea production	11.316	10.792	6.8	10.475	11.154	-8.4
Specialization	41.528	41.262	1.4	35.834	39.272	-19.5

T_costs	0.004	0.004	8.6	0.004	0.004	18.7

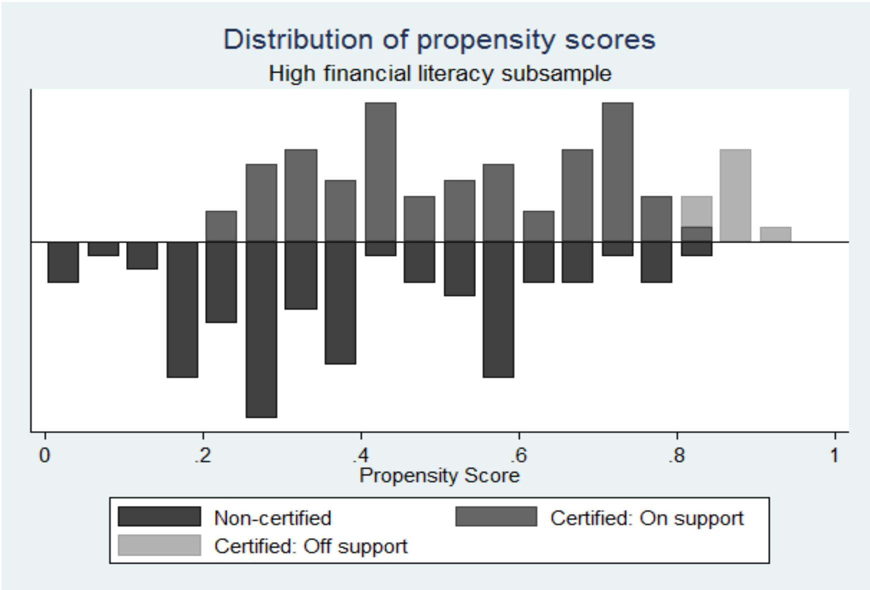

Figure 2 Distribution of propensity scores: High financial literacy subsample

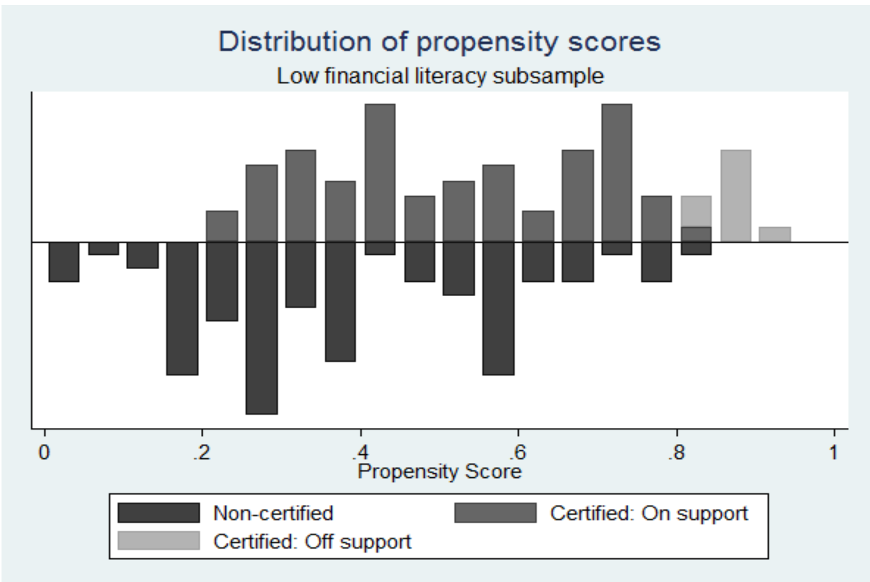

Figure 3 Distribution of propensity scores: Low financial literacy subsample

Matching and sensitivity test

We use three different matching estimators again to test the robustness of the results. The NNM, the RM and the KBM estimators all yield similar results for the identified ATT (see table 14). Thus, we identify a significant and positive impact of GlobalGAP adoption on income from pea production for the high financial literacy subsample. The Rosenbaum bounds confirm the stability of the results: The farmers would need to differ by 100%–120% in unobservable characteristics in order to invalidate the results. Certification increases revenue by 67%–78% for farmers with higher financial literacy skills. For the low financial literacy group adoption has no significant treatment effect. This result suggests that the impact of GlobalGAP on farm revenue is indeed different for different financial literacy levels. Farmers benefit only from the standard if they have a high level of financial literacy. Even if farmers undertake the efforts of standard adoption, this does not automatically lead to an improvement in their economic situation. The farmers in our sample with low financial literacy levels do not benefit from GlobalGAP adoption. This indicates that private standards such as GlobalGAP are exclusive in that farmers need to have a certain cognitive level in order to benefit from compliance.

Table 14 The impact of GlobalGAP on pea revenue acoording to financial literacy groups

Pea revenue	NNM (4)[a]			RM (caliper 0.05)[b]			KBM (bandwidth 0.06)[b]		
	Coeff (sd)	Effect	Bou-nds	Coeff (sd)	Ef-fect	Bo-unds	Coeff (sd)	Ef-fect	Bo-unds
High FL (n=107)	0.519** (0.207)	67,9 %	2–2.1	0.578** (0.224)	78.2 %	2–2.1	0.58** (0.225)	78.6 %	2.1–2.2
Low FL (n=136)	0.225 (0.239)			0.203 (0.227)			0.184 (0.234)		

Significance level at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

a Bias-adjusted standard errors; common support imposed

b results based on -psmatch2-command; common support imposed; no corrected standard errors

We also calculated the heterogeneous impact of GlobalGAP on total household income and revenue from agricultural production. The ATT on our outcome variables in the two financial literacy categories is not significant for the three matching estimators employed, so we do not report it in this paper. It seems that overall the strong positive effect of GlobalGAP on financially literate farmers does not translate into an overall effect on total household income.[13]

Impact pathways

Financially literate farmers seem better able to translate GlobalGAP adoption into economic benefits through their cognitive skills. But what can explain the strong and heterogeneous impact of GlobalGAP on pea revenue? Referring to our conceptual framework (outlined in section 2), financial literacy might influence the impact through cognitive and non-cognitive effects.

The cognitive effect of financial literacy on farm income may work through different channels. In the descriptive results, we saw that highly financially literate farmers are on average better educated. Due to their higher educational and higher financial literacy levels, they may be more used to applying numerical or financial concepts in their farm management. This would help them in the efficient use of farm inputs, credits and capital. They might also be more able to adequately use the information provided by the standard, the standard setter and the extension environment. This would lead to better management of the farm processes and closer compliance, which in turn might allow farmers to produce more consistently high quality products. Better and more consistent quality might lead to better prices. It may also be that exporters have to invest less into the compliance of financially literate farmers and reward this with a higher price. As we have seen in the descriptive results, on average farmers with higher scores on the financial literacy index receive a better price, deliver more produce and have more contracts compared to farmers with a low level of financial literacy. If we look at the certified sample only, those with a higher financial literacy level receive the same average price as farmers with a low financial literacy level, but they have higher price ranges.

The non-cognitive effect of financial literacy may influence the income through farmers` attitude and their bargaining ability. Highly financial literate farmers tend to be younger, so they may be more open towards new technologies and more flexible in their way of thinking. Another impact pathway of financial literacy on economic outcomes may be through farmers' bargaining ability. Having more accurate knowledge of the

[13] Results upon request.

financial situation of their own farm businesses and understanding prices, interest and inflation may improve farmers' bargaining position. This may lead to higher prices for their products.

Our descriptive results also show that those with a high financial literacy level have easier access to marketing options for their product and work in an environment with more competition among buyers. This might lead to better prices with the exporter. Exporters might have an incentive to pay more or go with the market price to avoid side-selling. Having a livelier commercial environment in the village may also offer more learning opportunities for farmers, so that they can further improve their financial abilities.

7. Conclusions

Smallholder farmers from developing countries are confronted with complex regulations and requirements for their products and production processes. High quality, safe and healthy food and sustainable production processes are demanded by consumers around the world, mostly in developed countries. This demand translates into the emergence of certification systems and standards, which have become more or less mandatory and regulate access to international high-value chains. Increasing incomes and the formation of a broader middle class in many developing countries and transition economies fuel these trends. So far there is still no clear and undisputed answer as to whether small farmers benefit from this trend. Empirical evidence suggests a positive impact on the economic and household well-being of small farmers - but the impact is not the same for all the farmers. We contribute to the discussion about the heterogeneity of standards' impacts by considering financial skills in measuring the economic impact of a food safety and quality standard, GlobalGAP.

In this paper, we analyzed the impact of GlobalGAP adoption on the economic situation of small pea farmers in the Guatemalan highlands. By using matching techniques we showed the positive impact of GlobalGAP on revenue from pea production, total agricultural revenue and the total household income of pea farmers in Guatemala. Certified farmers benefit from beneficial price schemes and a more secure marketing situation with binding agreements. The impact of GlobalGAP is heterogeneous depending on the financial literacy level of the farmers: GlobalGAP has a strong and significant positive effect on revenue from pea production for farmers with higher financial literacy skills; for farmers with lower financial literacy skills, the impact disappears. We do not detect any significant impact of GlobalGAP on total household income when we stratify our sample into two groups based on financial literacy (high and low). To check the sensitivity of our results towards hidden bias, we calculated Rosenbaum bounds. The use of three different matching estimators confirms the robustness of our results. Financial literacy seems to enable farmers to better translate GlobalGAP adoption into economic benefits. Our results confirm our initial assumption that the impact of food safety standards might be heterogeneous for differently skilled farmers.

Our results hold important managerial and policy implications. Exporters are interested in the continuous and reliable standard compliance of farmers. This allows exporters to constantly deliver high quality, safe products to their buyers, who are mainly in Europe or the US. Clear benefits from standard adoption are a strong incentive for farmers to adhere to the standard. By improving farmers' financial and other business-related skills via extension services and trainings, benefits from organizational innovations such as GlobalGAP could become more visible to those farmers. In this sense, this study of the role of financial literacy has revealed an important starting point for increasing the attractiveness of certification and farmers' willingness to comply with standards.

Integration into high value chains is seen as a means to alleviate poverty and foster rural development (FAO 2014). Public institutions and non-governmental organizations are, therefore, increasingly interested in the implementation of public and private food safety and quality standards in order to improve market integration of small farmers in developing countries. Training farmers in financial and business-related skills could help them benefit more from new technologies and decrease their vulnerability in the competitive environment of global value chains. Standards might have positive impulses for farm household well-being and rural development—as long as farmers have the necessary skills to use new technologies for their own benefit. Thus, the study also provides a starting point for political decisions and administrative actions aiming at rural development and poverty alleviation.

Similar to most studies on the impact of the adoption of organizational innovations in food supply chains, there are also some shortcomings. One important shortcoming of the results is the potential endogeneity of GlobalGAP adoption. We control for this in our analysis by matching on the area of common support, testing the balancing property and calculating Rosenbaum bounds of hidden bias. This reduces bias in the results, but does not completely eliminate it. Future research should take this problem into account.

Nevertheless we come to interesting results by exploring the role of financial literacy in innovation adoption. It is important to consider farmers' financial and other business-related skills in order to better understand how new technologies like food safety and quality standards impact farm level. Future research should deepen the understanding of how cognitive skills influence the economic impact of new technologies. The ongoing modernization and transformation of the global food system increasingly requires the ability of farmers and other supply chain actors to adapt to a new business environment. Ensuring the ability of farmers to make use of the opportunities provided to them by this development is vital in creating benefits and improving resilience.

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9. Appendix

A1 Numeracy and financial literacy test

If there is a possibility of 10% of getting ill, how many persons out of 100 would get ill?

Five persons have bought the winning number in a lottery. The prize is 2,000 quetzals. How much will each winner receive?

Imagine you had 1,000 quetzals in a savings account. The annual interest rate is 2% (20 quetzals in the first year). After five years, how much will you have in the saving account if you do not touch the money?

- More than 1020 quetzals
- Exactly 1020 quetzals
- Less than 1020 quetzals

Imagine that your income will double next year. The prices of all the products that you consume will also double. With your income, how much will you be able to buy next year?

- More than this year
- The same as this year
- Less that this year

The bank has leant you 3,000 quetzals; the interest rate is 1% every month. If you pay 30 quetzals every month, when will you have paid back the loan?

- In less than five years
- In less than ten years
- Never

Imagine you get a loan of 1,000 quetzals from the bank. Which option is better for you?

- To pay 5% interest every month
- To pay 24% interest a year

A2-1 Principal component analysis for the financial literacy index

Table A-1 Principal components for financial literacy

Principal components/correlation
Number of obs. = 277
Rotation: (unrotated = principal)
Rho = 1.0000

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	4.10547	3.30873	0.6842	0.6842
Comp2	0.796745	0.373399	0.1328	0.8170
Comp3	0.423346	0.15087	0.0706	0.8876
Comp4	0.272477	0.0172805	0.0454	0.9330
Comp5	0.255196	0.108431	0.0425	0.9755
Comp6	0.146765	0.	0.0245	1.0000

Table A-2 Factor loadings for component 1

Principal components (eigenvectors)

Variable	Comp1
Probability skills	0.3610
Division skills	0.3033
Interest	0.4553
Inflation	0.4363
Credit repayment	0.4187
Interest2	0.4524

Table A-3 Kaiser-Meyer-Olkin measure of sampling adequacy

Variable	KMO
Probability skills	0.8972
Division skills	0.8668
Interest	0.8617
Inflation	0.9122
Credit repayment	0.9283
Interest2	0.8698
Overall	0.8888

Table A-4 Bartlett's test of sphericity

Chi-square	1163.503
Degrees of freedom	15
p-value	0.000

A2-2 Principal component analysis for asset index

Table A-5 Principal components for the asset index

Principal components/correlation
Number of obs. = 277
Rotation: (unrotated = principal)
Rho = 1.0000

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.84616	0.429529	0.1420	0.1420
Comp2	1.41664	0.139036	0.1090	0.2510
Comp3	1.2776	0.0526699	0.0983	0.3493
Comp4	1.22493	0.16598	0.0942	0.4435
Comp5	1.05895	0.0197427	0.0815	0.5249
Comp6	1.03921	0.140667	0.0799	0.6049
Comp7	0.89854	0.0263536	0.0691	0.6740
Comp8	0.872187	0.0525365	0.0671	0.7411
Comp9	0.81965	0.105628	0.0671	0.7411
Comp10	0.714022	0.015416	0.0549	0.8591
Comp11	0.698606	0.0892119	0.0537	0.9128
Comp12	0.609394	0.0852783	0.0469	0.9597
Comp13	0.524116		0.0403	1.0000

Table A-6 Factor loadings for component 1

Principal component 1 (eigenvectors)

Variable	Comp1
Car	0.1752
Pickup	0.3797
Motorbike	0.1257
Bike	0.0525
Truck	0.3073
Knapsack sprayer	0.2996
Knapsack manual	0.1785
Irrigation	0.3449
Reservoir	0.3278
Storage silo	0.1088
TV	0.3500
Radio	0.2796
Mobile	0.3895

Table A-7 Bartlett's test and KMO

Bartlett's test of sphericity	
Chi-square	1163.503
Degrees of freedom	15
p-value	0.000
KMO	0.560

A3 Analysis

Table A-8 Variables used in the propensity score model

Age	Age of the household head in years
Age2	Age of household head in years squared
Education	Years of formal education
Education2	Years of formal education squared
MembersOnFarm	Family members working on-farm
Ha owned before 2009	Hectares of land owned before 2009
Land title	Dummy 1= land title, 0 otherwise
Irrigation	Dummy 1= using irrigation, 0 otherwise
BuyerFFV	Dummy 1 = Buyer for fresh products in the village, 0 otherwise
LocalMarket	Dummy 1 = Local market in the village, 0 otherwise
FarmX	Farm asset index
Livestock_NR	Number of livestock owned
Mother tongue	Dummy 1 = Spanish 0 = Indigenous language
Exporter before 2009	Dummy 1 = delivered to exporter already before 2009, 0 otherwise
Formal credit access	Dummy 1 = Access to formal credit, 0 otherwise
Experience pea production	Years of experience in pea production
Specialization	Percentage of land dedicated to pea production
T_costs	Transportation costs dollar per kg per km transported good
FLX	Financial literacy index
Treatment variable	1 = GlobalGAP 0 otherwise