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Revisiting the link between cereal diversity and production in Ethiopia

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Abstract

Recently, a number studies suggest that, at the micro level, cereal diversity positively affects mean yields and decreases the variability of yield. However, most analyses: 1) focus on very specific sub-regions, 2) use cross-sectional data; and 3) leave unexplained what drives the positive relationship. We attempt to answer these questions using data from the Ethiopian Rural Household Survey . To this end, we use a mix of parametric and semi-parametric regression techniques.

For the full sample, we find a positive and significant effect of greater cereal diversity on cereal production. However, this positive effect seems to be driven by specific agro-ecological zones and by households who cultivate one crop in particular (teff), with these results being consistent using both parametric and semi-parametric methods. Overall, these findings indicate that 1) the scope cereal diversity to drive increases in output may be limited, and 2) differences in potential yields from cereals in the crop mix seem to be part of the explanation. As a result, alternative conservation solutions may be needed.

JEL classification: Q16, Q57

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1 Introduction

The effect of crop diversity on agricultural production remains somewhat of a conundrum in the Agricultural Economics literature, with recent micro-evidence at odds with historical trends in agricultural development. However, the importance of understanding this link remains important, as it speaks directly to the productivity of agricultural systems and their resilience to climate and weather. This implies that crop diversity may have an important role to play in terms of food security. However, whether increases in crop diversity represent a viable development strategy capable of delivering sustained productivity gains remains an open question.

Recently, a number of microeconomic studies seem to suggest a "win-win-win" situation in the form of increased productivity, reduced volatility of output and greater in situ conservation (Di Falco and Perrings 2003, Di Falco and Chavas 2006 and Di Falco et al. 2007). These findings, however, contrast sharply with historical trends in agricultural development, which appear to be driven by increasingly mechanized, specialized and input-intensive agriculture. This trend has been epitomized, at different periods in history, by cases such as the United States, Europe, and more recently, by China and India (Borlaug 2000, Evenson and Gollin 2003).

As such, a "micro-macro" paradox seems to have emerged. Studies at the farmer level seem to suggest that crop diversity positively affects agricultural productivity. At the macro level, however, increases in productivity in the most recent success stories seem to have been driven by less diverse systems. This current state of affairs is likely to be puzzling for policy-makers and is particularly important in the African context. According to Collier and Dercon 2014, the current African experience is unlikely to lead to the radical transformation of the Agricultural sector, which could spur broad-based economic development. This implies alternatives to the current model have to be sought.

Consequently, this paper looks at cereal diversity and seeks to understand whether an increase in cereal diversity represents a viable alternative leading to sustained productivity gains. Specifically, we focus on two questions. First, we test whether increases in crop diversity lead to productivity increases. Second, whether these effects can be explain by regional patterns and/or by a specific crop, indicating a composition effect.

In order to address these questions, we use data from the Ethiopian Rural Household Survey (ERHS) and use a mix of parametric and semi-parametric methods. Addressing this question in the context of Ethiopia using panel data is relevant since 1) agriculture has been selected to be an engine of socio-economic transformation (World Bank (2007a), Di Falco and Bezabih (2012)); 2) much of the previous literature on crop diversity has focused on Ethiopia (Di Falco and Chavas 2009 and Di Falco et al. 2007 and Di Falco and Chavas 2012a); and 3) the use of panel data is likely to mitigate concerns surrounding results from previous work.

Overall, two main findings emerge from this paper. First, consistent with previous literature, we find a sizeable average positive effect of crop diversity using both parametric and non-parametric methods. However, unlike previous studies we notice that this overall positive effect seems to be driven by one crop and a restricted set of agro-ecological zones. Second, because of this, we test whether this relationship could be driven by differences in the potential yield of the cereals in the crop mix. One of the cereals, teff, is notoriously low-productivity crop (Vandercasteelen et al. 2013) and it could be driving the crop diversity results. Our results show that, when teff producers are excluded, the effects of crop diversity on production become noticeably smaller and insignificant in all parametric results. A similar conclusion is drawn from the semi-parametric results.

Overall, these results suggest that the positive diversity-productivity link is a lot more tenuous than what has previously been suggested in the literature. Consequently, the scope for production gains from higher levels of crop diversity may be lower than previously though t. Furthermore, our results also indicate that a compositional effect, rather than the traditional complementarity and facilitation effects found in the ecological literature, could partly explain the positive relationship found in previous studies. Taken together, this questions the potential of increasing cereal diversity as a means to increase cereal productivity.

The rest of this paper is structured as follows. The next section provides a brief overview of the literature on-farm biodiversity. Section three discusses the channels through which crop diversity may impact agricultural productivity. Section four discusses our measurement of crop diversity. Section five describes the data and the methodology used. Section six presents the results and section seven concludes.

2 Agriculture in Africa and Ethiopia

The current African experience promoting smallholder agriculture has not yet led to the productivity increases that will change African Agriculture beyond recognition (Collier and Dercon 2014). According to the authors, a radical transformation of the agricultural sector is deemed crucial for successful economic development. However, this transformation will have to occur in a very challenging environment defined by rapid demographic pressures as well as the looming threat of climate change. According to the UN world population prospects 2015, over half of the global population increase will occur in Africa. This, allied to potentially large losses arising from climate change (Schlenker and Lobbel 2010) will make for a very challenging setting in which increases in productivity will need to happen.

In Ethiopia the importance of the Agricultural sector for its economic development is well recognized. As explained by Dercon and Zetlin (2009), since the early 1990s, the Ethiopian Governments growth strategy made the Agricultural sector a pillar of its national development strategy, under the agricultural development-led industrialization (ADLI). This policy focused primarily on smallholders and, according to Rahmato 2008, sought to increase crop production through the provision and distribution of a number of modern inputs (including seeds and fertilizer) and training.

As a result, our sample period (1994-2009), was characterized by a rapid expansion in cereal area cultivated (World Bank 2015) and a strong growth in terms of agricultural output. However, the growth in cereal yields was more modest (World Bank 2007a and World Bank 2007b) and this was partly attributable to both land degradation and weather variability, which were found to have non-negligible effects. Since 2008, however, national-level data shows a significant increase in cereal yields from 1.45 tonnes/ha in 2008 to 2.33 tonnes/ha in 2014.

Recently, while the importance of Agriculture in the economy has decreased, it remains a vital sector. In 2013 agriculture still accounted for about three quarters of total employment (73%) and 41% of GDP (World Bank 2015). Looking forward, one key debate relates to whether production systems should be geared towards the traditional patter of input-intensification or whether systems that are more diverse should be promoted (higher Agro-intensification). This debate hinges directly on the link between increased crop diversity and production.

3 Crop diversity and productivity

In recent years there has been an increase in the number of studies that have looked at the link between various forms of biodiversity, including cereal diversity, and agricultural outcomes. In general, there are a number of channels for why increased crop diversity may be beneficial for agriculture and development.

From an ecological perspective, higher levels of on-farm crop diversity potentially represent an effective way of preserving plant genetic resources (Di Falco 2012). However, there are also a number of channels through which it may directly affect crop production directly. The first such channel is through a sampling effect. In essence, a sampling effect implies that, the higher the species richness (i.e. higher number of species), the larger the probability that the key species with the highest effects on the performance are present in the ecosystem (Tilman et al. 2005, Di Falco 2012).

A second channel, as explained in Hooper et al. 2005 relates to a potential complementarity between crops. Different species use different resources at different times. Therefore, combining species which have different resource patterns may allow for such a complementarity effect, which is likely to result in a more efficient use of resources over time. As a result, in cases where resources are a limiting factor to growth and productivity, increasing the richness of the ecosystem could lead to greater productivity.

A third channel relates to a facilitation effect. This effect refers to positive interactions between species. An example of this effect can be found if, for example, one species is capable of providing a critical resource for other species or alleviate harsh environmental conditions (Hooper et al. 2005, Di Falco 2012). According to Hooper et al. 2005 the complementarity and facilitation effects are two of the main reasons leading to overyielding (i.e. yields from a mixture of crops exceeding those of monoculture).

From an economic perspective, there are also a number of reasons why higher levels of agro-biodiversity may be desirable. As argued by Baumgärtner 2007, biodiversity has the potential to act as a natural insurance for risk-averse farmers, thus potentially being a substitute for financial insurance (Baumgärtner 2007, Baumgärtner and Quaas 2008, Quaas and Baumgärtner 2008). Moreover, as argued by Di Falco 2012, it allows farmers to produce and market their crops multiple times a year. This has the potential to hedge farmers against crop price volatility, as well as provide a smoother inflow of income.

Empirically, the majority of the evidence supporting increased crop diversity as a key source of productivity comes from studies in ecology performed in an experimental setting. Consequently, the experimental results need not translate to non-experimental settings where conditions are likely to differ substantially. This has led to the productive importance of biodiversity in agriculture being increasingly studied in non-experimental settings. The overarching results of this literature, however, seem to broadly corroborate the overall findings from the agroecology literature. The vast majority of studies focusing at the household level tend to find non-negligible economic gains from more diverse systems, both in the form of increased mean yields and reduced output volatility.

Evidence from Asia (Smale et al. 1998, Smale 2008) as well as Europe (Di Falco and Chavas 2006, Di Falco and Perrings 2003, Di Falco and Perrings 2005) all seem to suggest that higher levels of crop diversity are generally correlated with higher yields and lower variance in yields and/or reduced probability of crop failure. An additional study by Omer et al. 2007, which uses a stochastic frontier model approach, finds that higher levels of biodiversity are associated with a higher frontier and reduced inefficiency in the case of the UK.

In Africa, Ethiopia has probably been the most studied country and most of the research has focused on the Highlands of Ethiopia. In Tigray, Di Falco and Chavas 2009, Di Falco et al. 2007 and Di Falco and Chavas 2012a all find that, on average, higher levels of crop diversity have a net positive effect on productivity. However, Di Falco and Chavas 2012a highlight that there may be different sources of value for diversity. In particular, they find a positive complementarity effect (positive synergies between crops) and a negative convexity effect (scale effect). The latter provides an incentive to specialize. However, overall, the authors still find a positive value of crop diversity. In the Amhara region, Di Falco et al. 2010, Di Falco and Chavas 2012b and BangwayoSkeete et al. 2012 all find a positive effect of crop diversity on mean yield. In addition to this, Di Falco et al. 2010 also finds that this effect tends to be stronger when rainfall is lower.

In sum, most studies seem to suggest a positive effect of greater crop diversity on production, productivity and reduced variability. Moreover, the estimated effects also tend to be large, with and Chavas 2012b, for example, finding an estimated effect of crop diversification amounting to approximately 17% of revenue for an average farm.

However, despite recent empirical evidence, a number of gaps remain in this literature. First, the majority of the literature focusing on Ethiopia has focused on the Ethiopian Highlands. As a result, findings may not be transposable to other areas of Ethiopia. Since the Ethiopian Highlands tend to be quite moisture-strained, it may be the case that this reduces the effectiveness of other inputs[1] , thus favouring increasing crop diversity as an alternative. As a result, whether crop diversity yields similar gains across agro-ecological settings is still an open question. Secondly, previous research studying the cereal diversity-productivity link in Agricultural Economics does not convincingly answer why a positive relationship exists. Beyond the marginal effects, authors have not questioned which underlying was likely to explain this link. This is not a trivial question since, policy implications will differ depending on whether the result is driven by one specific crop (a "sampling" effect) or whether it is driven by interactions between cereals ("complementarity" and "facilitation effects"). Previous research does not even address the possibility that results could be driven by the inclusion particular high- or low- performing crop/subspecies of a crop. We believe that our empirical specification, explained in section five, partly addresses some of these concerns.

4 Defining cereal diversity

Quantifying diversity is complicated and, so far, no universal definition has been agreed-upon. A number of different definitions have been proposed (Baumgärtner 2006) but different definitions are used in different contexts, not least because different professions value biodiversity for different reasons (see Baumgärtner 2006 for a review of the debate). For our purpose, the most common indices used include a simple count measure (as used in Di Falco et al. 2010), the Simpson index and the Shannon Index (used by Di Falco and Chavas 2008). In this paper, we opt for the use of the Shannon Index of cereal diversity for three reasons.

First, as argued by Di Falco and Chavas 2008, it is possible that a simple index of species richness, which fails to control for evenness, will lead to a "sampling effect". As a result, the diversity index may capture the performance of a single species (crops in our case) rather than the effect of diversity. However, since the Shannon index controls for both richness and evenness this problem becomes less severe.

[1]Gebregziabher et al. 2012 find that in the Tigray region, the yield response to chemical fertilizer is poor under rain-fed conditions since it is a moisture-strained environment.

Secondly, the Shannon index is likely to be more suitable than the Simpson index in this context, as it has been found in the literature that the Simpson index could be biased towards the dominant species (Magurran 1988, Di Falco and Chavas 2008).

Finally, it is important to mention that other measures could have been used to construct an index of cereal diversity. For instance, the index proposed by Weitzman 1992, which is a measure of genetic distance, would probably be suitable in our context. However, the data required for the construction of such an index is simply not available in this dataset.

There are three limitations of the Shannon index in this application. First, while we observe different cereals, we do not observe different sub-species of the same crop[2]. This was shown to be important in Di Falco and Chavas 2008 and it is an issue we are not able to address given our data. A second limitation is that our Shannon index is built at the household level. As a result, it is possible that, in some cases, a non-negative Shannon index captures two monocultures in separate plots[3]. Finally, a third limitation is that we look at the Shannon index for cereals only. This has certainly been the most common type of crop diversity explored in the agricultural economics literature. However, measuring other types of crop diversity could lead to different effects on crop production.

As in Di Falco and Chavas 2008, we calculate the cereal Shannon index as follows:

$$SI = -\sum_i p_i * log(p_i) \tag{1}$$

Where p_i represents the proportion (of cereal area) allocated to cereal crop i. Given that we include six cereals in the analysis, the Shannon index in our has a theoretical range between 0-1.8[4].

[2] With the exception of teff, where we observe both white and black teff.

[3] However, in our data we do not have information about the location of different plots. As such, while it could be that the two monocultures are in plots very far away from each other, it could also be that they are located in plots adjacent to each other. As such, it is not clear whether building the Shannon index at the plot level would be preferable.

[4] A household cultivating two cereals in equal proportions will have a Shannon index of 0.69. If three cereals are cultivated in equal proportions, the Shannon index will take a value of approximately 1.1.

5 Data and methodology

5.1 Data

The dataset used is the Ethiopian Rural Household Survey (ERHS 2011)[5] and all waves since 1994 are used. The 1994 wave is composed of 1,470 households from 18 different peasant associations (15 different villages), spread over four regions. The location, characteristics and the Agro-ecological zone breakdown of these peasant associations can be found in figures A1 and A2 and Table A1, respectively (Appendix A)[6]. However, it is important to mention that this sample is not nationally representative (Dercon and Hoddinott 2004).

As mentioned in Dercon and Hoddinnot 2004, attrition between 1994-2004 is estimated at 13%. In addition, only observations that cultivate cereals in at least two consecutive periods were used in our sample. This choice was driven by the needs of the semi-parametric model. As a result, the sample in this paper consists of 1280 individuals (5806 observations), for which a table of summary statistics (Table 1) is presented below.

TABLE **??** HERE

Table **??** highlights stark differences in terms of the use of inputs across different agro-ecological zones. Overall, farmers in the Central Highlands and in the Arusi/Bale ("Other") agro-ecological zones allocate higher proportions of land to cereals, use more fertilizer, have higher average levels of cereal diversity and display the highest yields compared to the average household in the Northern Highlands or in the Enset agro-ecological zones.

[5]These data have been made available by the Economics Department, Addis Ababa University, the Centre for the Study of African Economies, University of Oxford and the International Food Policy Research Institute. Funding for data collection was provided by the Economic and Social Research Council (ESRC), the Swedish International Development Agency (SIDA) and the United States Agency for International Development (US-AID); the preparation of the public release version of these data was supported, in part, by the World Bank. AAU, CSAE, IFPRI, ESRC, SIDA, USAID and the World Bank are not responsible for any errors in these data or for their use or interpretation.

[6]The agro-ecological zone breakdown was adapted from Hoddinott et al. 2011. Dercon and Hoddinott 2004 is the source for the map and site characteristics

In terms of the variables used in this paper, the dependent variable in this study is the total production of cereals, which sums the production (in kilograms) of each cultivated cereal. The explanatory variables included consist of cereal area (measured in ha), number of oxen, household size (to proxy for labour), the quantity of fertilizer[7], the number of hoes and ploughs. In addition to this, the crop diversity variable, the cereal Shannon Index, will be included. A detailed explanation of how these variables were constructed is available in Appendix B.

5.2 Methodology

5.2.1 Fixed Effects model

Our analysis of the productive effects of crop diversity is concerned with agricultural productivity and the role of crop diversity.

Concerning the functional form, we opt for a translog functional form, which includes the natural logarithm of land, labour, fertilizer, oxen, hoes, their squares and their interactions. In order to capture local level trends in output as well as aspects such as weather shocks which are common to households in a given peasant association, we also include a dummy variable for each peasant association-year[8]. We prefer to include peasant-association-year dummy variables rather than a time trend since we do not want to impose a specific time trend at the peasant association level.

We estimate a fixed effects modes as it accounts for unobserved heterogeneity at the household level. The estimated regression can be algebraically expressed as follows:

$$ln\, y_{it} = \alpha_i + \sum_{n=1}^{n=N} \beta_k ln(x_{nit}) 0.5 \sum_{n=1}^{n=N} \sum_{m=1}^{m=N} \beta_{nm}\, lnx_{nit} * lnx_{mit} + \sum_{t=1}^{t=T} \sum_{p=1}^{p=P} d_t * d_p + e_{it} \qquad (2)$$

[7]In the case of fertilizer, whenever there was data on the application of fertilizer directly on cereal, this data was used. When only the total amount of fertilizer was available, the total amount was apportioned to cereal area (i.e. we assumed the household uses fertilizer evenly in his land).

[8]i.e. For each peasant association we include a dummy for each year.

Equation ?? can be interpreted in four parts. First, $_i$ captures household-specific, time-invariant features. The second part refers to the inclusion of the natural logarithms of all the explanatory variables, their squares and their interactions. The third part of this equation refers to the year-peasant association dummy variables ($d_t * d_p$), which absorbs common shocks at the peasant association level for different years[9]. Finally, the last component is the error term, e_it. We note that a number of our variables (oxen, fertilizer) have a large proportion of 0 values. This has been shown to potentially lead to biased estimates of the marginal effects if not dealt with properly (Battese, 1997). In our case, however, the correction proposed by Battese (1997) would conflict with the fixed effects, as many of the input-use dummies are time-invariant. Nevertheless, we show (in Appendix A) that using the correction proposed by Battese (1997) does not alter the main conclusions of the paper, though the magnitudes become different. We also explain the correction proposed by Battese, its rationale and how it is implemented in practice in Appendix B.

5.3 Semiparametric regression estimator

In addition to the parametric results, since there is little theoretical guidance on the likely shape of the relationship between cereal diversity and production, we also conduct a series of semi-parametric regressions. This specification allows for greater flexibility in the relationship, since it makes it easier to investigate a possible non-linear effect of crop diversity on production. The basic cross section model proposed by Robinson (1988) can be summarized using the following equation:

$$ln\, y_{it} = \boldsymbol{\beta}_x \mathbf{X}_{it} + f(sh_{it}) + e_{it} \tag{3}$$

Where $\mathbf{X}$ is a set of explanatory variables which includes all inputs except the Shannon index. For the parametric component of the model, we use the two sets of variables detailed in the previous section, but exclude the Shannon index. The latter is captured in the component $f(sh_{it})$, which represents the non-parametric smooth function of the Shannon index, which we believe may be non-linear.

[9]This is likely to include aspects such as rainfall, temperature, as well as peasant-association specific trends in production over time.

This model has subsequently been extended to include fixed effects in a panel data setting (Baltagi and Li, 2002). The Baltagi and Li (2002) differs from the original model by taking the first differences of equation **??**. We implement this procedure using the *xtsemipar* command in STATA 14 (Libois and Verardi, 2012). For all sets of results, we use a kernel regression with the rule-of-thumb bandwidth. In all cases, we use a degree 4 local weighted polynomial fit using the Epanechnikov kernel[10].

5.4 Limitations of the empirical approach

The first and most important limitation of our approach, as with other papers in this literature, relates to the issue of the endogeneity. Given that the choice of the level of cereal diversity is likely to be endogenous and that we were unable to find a suitable instrument, we are not able to claim the estimation of a causal relationship between cereal diversity and production. However, our empirical specification is more stringent than the norm in similar studies, thereby potentially attenuating concerns related to endogeneity. Specifically, we take three steps that make for a more convincing approach to the estimation of this relationship than what has traditionally been the case in the literature. First, we use panel data and, as a result, this allows us to control for household fixed effects, which are likely to control for household-specific, time-invariant characteristics. Secondly, all of our specifications use peasant association-year fixed effects, which are likely to control for common, time-varying unobservable heterogeneity at the peasant-association level.

A second limitation relates to the narrow focus of our question as we focus solely on the effect of cereal diversity on cereal production. This has been the most common approach in agricultural economics. However, it is possible that other types of diversity (such as mixing a cereal with a legume, for instance) may have a very different effect on production.

Finally, we focus only on the productive implications of the diversity of systems of cereal production. We do not discuss the relationship between crop diversity and other production or environmental variables, such as volatility or erosion, which may be important and pertinent.

[10] We also test the sensitivity of our results to a degree one local polynomial fit.

6 Results

6.1 Parametric results

As can be seen, from Table ??, the estimated coefficients associated with the Shannon index differ substantially from one agro-ecological zone to another. Concerning the overall productive effect of cereal diversity on production, as has been the norm in the literature, we find a positive and statistically significant effect between cereal diversity and cereal production for the full sample (column 1, Table ??). However, running the regressions separately by agro-ecological zone reveals very stark differences. Although we find a positive elasticity in every agro-ecological zone (columns 2-5, Table ??), this elasticity is only large and statistically significant in the "Other agro-ecological zones (Arusi/Bale). An interesting aspect from these results is that the ordering of the magnitude mirrors closely the proportion of households who cultivate teff, known to be a lower productivity crop. In other words, the two agro-ecological zones displaying higher coefficients are also the agro-ecological zones where teff is most prevalent.

We thus test whether the effect we capture could be attributed to the cultivation of teff and break the sample into households that cultivate teff and those who do not. These results can be seen in Tables ??-??. Overall, the results in Table ??, which only include households who cultivate teff, seem to suggest a positive significant elasticity of cereal diversity in two out of four agro-ecological zones. However, once households that cultivate teff are removed, none of the elasticities are statistically significant, though in one case the coefficient increases. These results do not prove beyond doubt that the full effect is attributable to a compositional effect. For one, sample sizes decrease substantially in a number of agro-ecological zones, which makes it harder to ascertain statistical significance. Nevertheless, these results are indicative that, perhaps, a compositional effect, whereby crops (or subspecies of specific crops) with different productive potential are mixed, could be part of the explanation behind the result found in the crop diversity literature. Perhaps, what is being captured in these results is that, as cereal diversity increases, the relative contribution of the low productivity cereal gradually fades, thereby leading to higher levels of production and productivity.

Whether, if it exists, this compositional effect can still be reconciled with the traditional channels through which crop diversity can lead to over yielding is difficult to answer. On the one hand, the existence of such a compositional effect would probably be at odds with the "complementarity" and the "facilitation" effects since cereals are likely to be quite similar and may not differ a lot in the timing of resources. However, at a stretch, it could be argued that it could represent a conscious "sampling" effect since the household may well select the crop that performs the best (most productive), given the environment. However, if the composition of cereals is driving the result, this questions the extent to which promoting cereal diversity could lead to improved agricultural production and thereby development. The reason being that, if a compositional effect is driving the result, this implies that increases in diversity only lead to increases in productivity in one direction, when diversity increases by adding a high productivity crop to a low productivity crop. Increases in diversity in the other direction would not yield increases in productivity. From a policy perspective, therefore, if this effect is the main driver of productivity increases, the policy implication is that systems should promote more productive crops.

We also carry out three sets of robustness checks, which are available in Appendix A. Tables **??**- **??** summarize the results when the regression is estimated by OLS and the Battese (1997) correction is applied. Tables **??**-**??** show the results when we only consider households for which there is no imputed data for fertilizer, ploughs and hoes. Finally, Tables **??**-**??** summarize the results when only the households for which we have six observations are considered (i.e. a balanced panel)[11] . Though magnitudes certainly differ, the overarching conclusions remain the same in all three robustness checks.

[11] Balanced sub-sample refers to the sub-sample of households for which we have observations for each period. However, the teff only and no teff regression are not necessarily balanced since some households switch in and out of teff during the sample period. Also, as can be seen in Tables B21-B26, using the balanced sample leads to a sharp decrease in sample size. This is very severe in the Enset area for the no-teff subsample, where there are very few observations with a Shannon index above 0. As a result, for this subsample, we do not have a high degree of confidence in the results presented.

6.2 Semi-parametric results

Given that there is no proven underlying theory informing the expected shape and magnitude of the production-diversity relationship, the statistically insignificant results displayed in the previous section may be masking existing non-linearities. In other words, it is possible that the insignificant result in parametric models are a result of not taking into account non-linearities in an appropriate way. Alternatively, it could be that there may be a positive effect of crop diversity, but that this effect is confined to a subset of diversity values. Additionally, it is possible that, while a stark relationship exists in a number of subsamples, the statistically significance may be hampered by the small sample sizes of the sub-samples. It is for these reasons that we also run a set of semi-parametric regressions, which allow for a more flexible characterization of the relationship between crop diversity and production and tend to be less sensitive to sample size.

The parametric part of the results are summarized in Tables **??**-**??** and the smooth functions of the crop diversity result on the partialled-out residuals are available in Figures **??**-**??**[12]. The same local polynomial including the scatter plots are also available in the Appendix (figures **??**-**??**). For each figure corresponding to a given geographical region, we have three subfigures. Subfigure (a) summarizes the results when all the households in a given region are included, subfigure (b) summarizes the results when teff producers are excluded and subfigure (c) shows the results when only teff producers are included.

FIGURE **??** HERE

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FIGURE **??** HERE

[12]Figures which include the scatter plots are available in the Appendix Tables **??**-**??**. Both sets of figures (**??**-**??** and **??**-**??**) use a degree 4 polynomial (the default) and the rule-of-thumb bandwidth. The rule-of-thumb bandwidth is summarized in the Appendix in Table **??**

The semi-parametric results, to a certain extent, confirm the findings of the parametric results. We find a clear positive correlation between the Shannon index for panel (a) of the full sample (Figure ??) and in the Arusi/Bale/Hararghe agro-ecological zones (Figure ??), with the Northern Highlands (Figure ??) also displaying a positive, but somewhat noisy relationship. Also similar to our findings from the parametric models, these results appear to be largely driven by the inclusion of teff producers, with none of the panels (b) displaying a large, clear and positive relationship, though panel (b) of Figure ?? seems to suggest a somewhat positive relationship[13]. Conversely, most panels (c), with the exception of panel (c) in Figure ?? suggest a positive relationship, suggesting that the inclusion of teff producers seems to drive our results. This provides some support for the existence of a potential compositional effect.

However, the semiparametric also shed some light on additional aspects of this relationship. First, when we find a clear positive relationship, we tend to also find a large, statistically significant negative intercept. For the Arusi/Bale/Hararghe "Other") agro-ecological zones, this can be explained by the fact that the vast majority of farmers who cultivate one crop cultivate teff. As a result, an increase in the crop diversity index could indicate a shift away from a low productivity cereal. A similar mechanism may be at play in the Northern Highlands for the case of Barley, which is the second lowest productivity crop in our sample . Second, the semi-parametric results also highlight aspects related to the shape of the relationship. Partly as a result of the negative intercept, in some cases (Figure ??, ?? and ??), the strongest positive relationship occurs between low to medium values of the Shannon index. We also find a sharp (but very noisy) decrease in the relationship at large levels of cereal diversity in three out of four agro-ecological zones (Figure ?? being the exception). Taken together, these results suggest rather limited benefits of pursuing very diverse systems in terms of cereal production.

7 Conclusion

This paper revisited the link between cereal diversity and cereal production using a panel representative of a larger geographical area in Ethiopia than what has typically been the case. Doing this allows us to understand whether in situ conservation may yet deliver a promising solution in terms of conservation of plant genetic material alongside sustained productivity gains.

[13] Panel (b) in Figure ?? is not particularly informative as there are very few observations of non-teff producer with a non-0 Shannon index (less than 5% of the values). This is made more clear in Table ??.

In some cases, our results corroborate a number of previous results in the literature. For instance, we find large positive gains of cereal diversity on cereal production for the full sample. However, unlike previous studies, we find that these effects are very heterogeneous across agro-ecological zones. Specifically, specific agro-ecological zones (Arusi/Bale/Hararghe) and one crop (teff) seem to be driving these results in both parametric and semi-parametric specifications. This suggests that, at least in our case, the "biodiversity" effect seems to be capturing a decreasing share of a low productivity crop in the crop-mix.

Whether this can be reconciled with the typical channels used to explain the crop diversity ("biodiversity")-productivity link is arguable. The fact that this result seems to be driven by teff suggests that this result is at odds with the "complementarity" and the "facilitation" effect. However, in a way this could be considered a deliberate "sampling" effect.

These results highlight the importance for practitioners in the literature to attempt to understand what is driving the results between diversity and productivity. It is important to at least consider the possibility that this effect could partly reflect different potential yields for cereals in the crop mix. As a result, increases in the diversity index could be capturing a move away or towards a particularly high- or low-performing cereal. In our case, given that we do not have data on subspecies, the results seem to be partly driven by one crop (teff). However, a similar mechanism could be at play with particular high- or low-performing subspecies of a given crop.

From a policy perspective, however, the results highlight two main points. Firstly, while diversity, in itself, may be desirable for a number of reasons, its positive productive implications are not clear once farmers who cultivate low-yield crops are removed from the sample. As a result, it seems that increases in diversity only seem to have a positive effect in one direction (from high proportion of low-yield crop to diverse mix of low- and high-yield crops). Secondly, the shape revealed in the semi-parametric method suggest that these effects are not linear and that, beyond a certain point, the associated gains of increased diversity seem tenuous, at best.

Taken together, these results suggest that cereal diversity is unlikely to be a panacea for cereal productivity. Lack of clear production gains from increasing cereal diversity allied to the development of alternative sources of insurance and the modernization of agriculture, which tends to lead to a reduction of cereal diversity, highlights the need to focus on alternative means of conserving crop genetic diversity.

In addition to this, our paper highlights a number of possible directions for future research. First, this paper focuses on a very narrow type of crop diversity (cereal diversity) and these results are not necessarily transposable to other types of crop diversity, for which the relationship may be very different. Second, while we believe our empirical specification improves on previous literature focusing on this question, endogeneity remains a concern. Consequently, our results do not settle this debate and we cannot and do not claim a perfect causal relationship. Further research regarding potential instruments or alternative research designs (e.g. field experiments) would be useful. A third aspect that was absent from this analysis relates to the relationship between land degradation-crop diversity. As argued by Taddese 2001, land degradation is a serious issue in Ethiopia and crop diversity may well have an important effect on land quality, which we do not capture or investigate in this paper. Finally, our analysis leaves aside the links between cereal diversity and income, nutrition as well as production and income volatility, all of which could be valid reasons to pursue a diversification strategy, despite limited gains in output. In our specific case, while teff typically displays lower yields, it has a very high market value compared to other cereals. As a result, it could still make economic sense to cultivate teff, despite its productive implications.

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8 Figures and Tables

Table 1: Summary Statistics

	All		**N. Highlands**		**C. Highlands**		**Other**		**Enset**	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Cereal Production (kgs)	810.12	988.32	343.69	414.28	1073.79	946.29	1260.72	1300.63	256.18	385.94
Cereal Yield (kg/ha)	806.22	753.13	518.14	518.58	922.89	766.19	972.23	799.23	714.35	795.18
Cereal Area (ha)	1.20	1.09	0.87	0.95	1.43	1.01	1.64	1.25	0.53	0.65
Shannon index	0.49	0.41	0.45	0.43	0.50	0.34	0.77	0.37	0.13	0.26
Number of oxen	0.87	1.10	0.64	0.83	1.20	1.13	0.95	1.28	0.41	0.84
Household Size	6.02	2.72	5.21	2.39	5.84	2.65	6.30	2.58	7.04	3.04
Quantity Fertilizer (kgs)	51.12	86.78	2.90	10.99	76.32	84.90	82.94	120.68	18.88	31.88
Number of ploughs (units)	1.78	2.98	1.76	3.05	2.31	3.32	1.66	2.99	0.94	1.69
Number of hoes (units)	1.12	1.59	0.82	1.40	1.41	1.80	1.07	1.56	1.00	1.30
Tigray	0.13	0.33	0.56	0.50	0.00	0.00	0.00	0.00	0.00	0.00
Amhara	0.37	0.48	0.44	0.50	0.78	0.42	0.00	0.00	0.00	0.00
Oromia	0.33	0.47	0.00	0.00	0.22	0.42	1.00	0.00	0.00	0.00
SSN	0.18	0.38	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Northern Highlands	0.23	0.42	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Central Highlands	0.34	0.48	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Other	0.25	0.43	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Enset	0.18	0.38	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Number of observations	5806		1324		2003		1456		1023	

Table 2: **Main results : Parametric translog**

	All	N. Highlands	C. Highlands	Other	Enset
Shannon index	0.047	0.03	0.024	0.122	0.021
	(0.029)	(0.054)	(0.046)	(0.077)	(0.066)
Shannon index (square)	0.006	0.005	0.003	0.015	0
	(0.004)	(0.007)	(0.006)	(0.010)	(0.008)
Area*Shannon index	-0.006**	-0.008	-0.005	0.008	-0.015**
	(0.003)	(0.005)	(0.004)	(0.008)	(0.007)
Household size*Shannon index	0.003	0.007	0.001	-0.007	-0.008
	(0.004)	(0.007)	(0.006)	(0.011)	(0.011)
Oxen*Shannon index	0.000	0.000	0.000	-0.001	0.000
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Fertilizer*Shannon index	0.000	0.000	0.000	0.001	-0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Hoes*Shannon index	0.000	0.001***	0.000	0.000	-0.002**
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Ploughs*Shannon index	0.000	-0.001*	0.000	-0.001	0.002***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	6.335***	4.991***	6.449***	5.929***	5.577***
	(0.110)	(0.355)	(0.167)	(0.234)	(0.404)
Elasticity of Shannon index	0.022**	0.012	0.013	0.098*	0.022
p-value	0.013	0.159	0.566	0.075	0.500
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Linear variables	✓	✓	✓	✓	✓
Squares	✓	✓	✓	✓	✓
Interactions	✓	✓	✓	✓	✓
Number of households	1281	289	429	299	264
Number of observations	5804	1323	2003	1456	1023
Average obs. per household	4.531	4.578	4.669	4.87	3.875
R-squared a	0.546	0.658	0.556	0.509	0.453
R-squared w	0.555	0.671	0.571	0.526	0.481

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. The specification in the regression is a translog specification and the full list of coefficients can be seen in Table **??** in the Appendix. As explained in the methodology section, this specification does not include the adjustment proposed by Battese since many of these dummies are time-invariant which would be incompatible with the fixed effects. Instead 0 values are assigned the value of 0.000001.

Table 3: **Main results : Parametric translog (teff only)**

	All	N. Highlands	C. Highlands	Other	Enset
Shannon index	0.184***	0.129	0.061	0.303***	0.215*
	(0.047)	(0.086)	(0.067)	(0.076)	(0.128)
Shannon index (square)	0.023***	0.029**	0.006	0.036***	0.015
	(0.006)	(0.012)	(0.009)	(0.010)	(0.017)
Area*Shannon index	-0.019***	-0.035***	-0.018**	-0.006	-0.021**
	(0.005)	(0.012)	(0.009)	(0.017)	(0.009)
Household size*Shannon index	-0.001	0.028	-0.005	-0.018	-0.043***
	(0.006)	(0.018)	(0.011)	(0.015)	(0.016)
Oxen*Shannon index	0.000	-0.001	0.000	0.001	0.001
	(0.000)	(0.002)	(0.001)	(0.001)	(0.001)
Fertilizer*Shannon index	0.000	-0.002	0.000	0.000	-0.001
	(0.000)	(0.002)	(0.001)	(0.001)	(0.001)
Hoes*Shannon index	0.001	0.002	0.002**	0.002*	-0.002
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Ploughs*Shannon index	0.001**	-0.002	0.001	-0.003**	0.004***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Constant	6.347***	5.472***	6.791***	5.747***	5.801***
	(0.146)	(0.558)	(0.338)	(0.230)	(0.575)
Elasticity of Shannon index	0.105***	0.154**	0.024	0.235***	0.001
p-value	0.000	0.019	0.607	0.000	0.981
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Linear variables	✓	✓	✓	✓	✓
Squares	✓	✓	✓	✓	✓
Interactions	✓	✓	✓	✓	✓
Number of households	782	152	217	211	202
Number of observations	2799	544	679	960	616
Average obs. per household	3.579	3.579	3.129	4.55	3.05
R-squared a	0.511	0.358	0.557	0.597	0.535
R-squared w	0.526	0.412	0.59	0.616	0.573

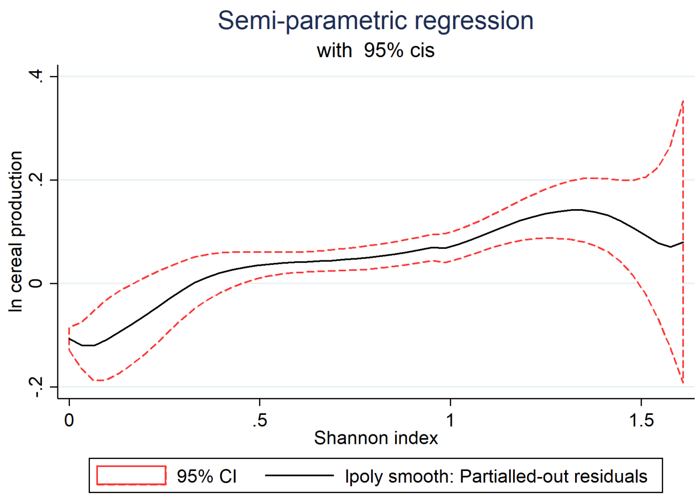
Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. The specification in the regression is a translog specification and the full list of coefficients can be seen in Table **??** in the Appendix. As explained in the methodology section, this specification does not include the adjustment proposed by Battese since many of these dummies are time-invariant which would be incompatible with the fixed effects. Instead 0 values are assigned the value of 0.000001.

Table 4: Main results : Parametric translog (no teff)

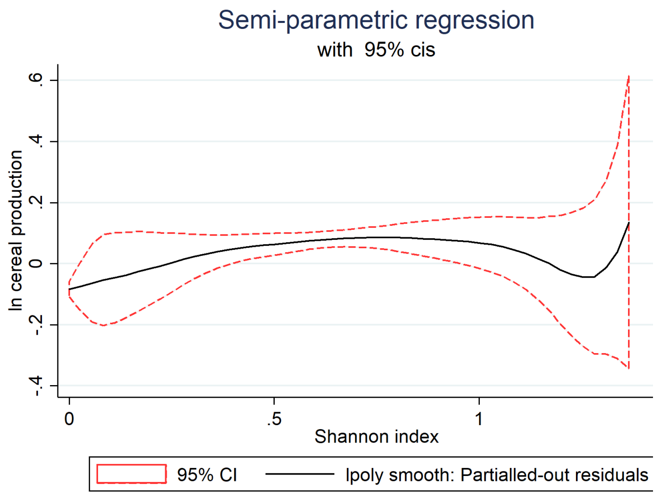
	All	N. Highlands	C. Highlands	Other	Enset
Shannon index	-0.004	-0.088	0.098	-0.079	0.04
	(0.051)	(0.070)	(0.080)	(0.148)	(0.129)
Shannon index (square)	-0.002	-0.013	0.012	-0.022	-0.003
	(0.007)	(0.009)	(0.011)	(0.021)	(0.015)
Area*Shannon index	-0.002	0.004	-0.001	0.014	-0.013
	(0.004)	(0.009)	(0.005)	(0.010)	(0.016)
Household size*Shannon index	-0.001	0.004	-0.004	-0.035**	-0.023
	(0.005)	(0.009)	(0.008)	(0.016)	(0.036)
Oxen*Shannon index	0.000	0.000	0.000	-0.001	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Fertilizer*Shannon index	0.000	0.000	-0.001	0.001	0.002
	(0.000)	(0.001)	(0.000)	(0.001)	(0.002)
Hoes*Shannon index	0.000	0.001	-0.001	0.000	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Ploughs*Shannon index	0.000	0.000	0.000	0.000	0.003
	(0.000)	(0.001)	(0.001)	(0.001)	(0.003)
Constant	6.324***	5.039***	6.357***	6.300***	6.501***
	(0.174)	(0.541)	(0.214)	(0.698)	(1.303)
Elasticity of Shannon index	0.007*	0.0354*	0.038	-0.0689	0.011
p-value	0.090	0.066	0.229	0.369	0.897
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Linear variables	✓	✓	✓	✓	✓
Squares	✓	✓	✓	✓	✓
Interactions	✓	✓	✓	✓	✓
Number of households	894	211	345	128	210
Number of observations	3006	779	1324	496	407
Average obs. per household	3.362	3.692	3.838	3.875	1.938
R-squared a	0.593	0.752	0.564	0.332	0.486
R-squared w	0.607	0.768	0.584	0.394	0.548

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. The specification in the regression is a translog specification and the full list of coefficients can be seen in Table **??** in the Appendix. As explained in the methodology section, this specification does not include the adjustment proposed by Battese since many of these dummies are time-invariant which would be incompatible with the fixed effects. Instead 0 values are assigned the value of 0.000001.

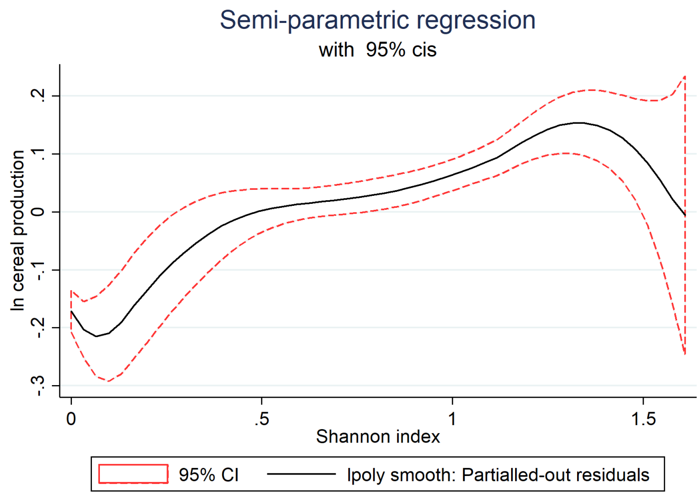
Figure 1: Effect of Shannon index Semi parametric Full sample



(a) Full sample

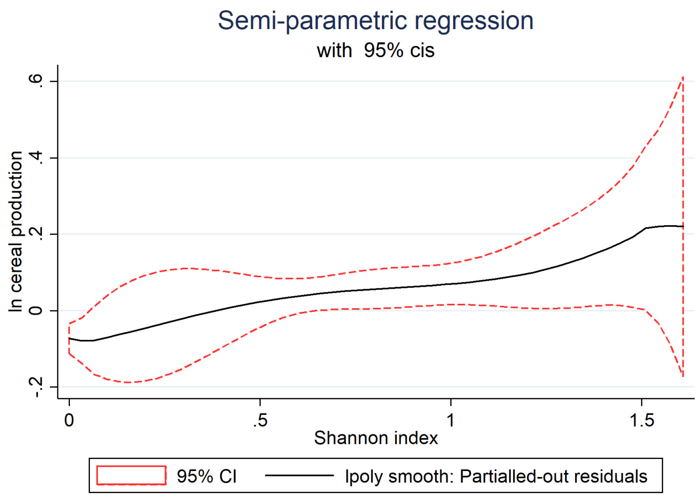


(b) Non teff-producing households

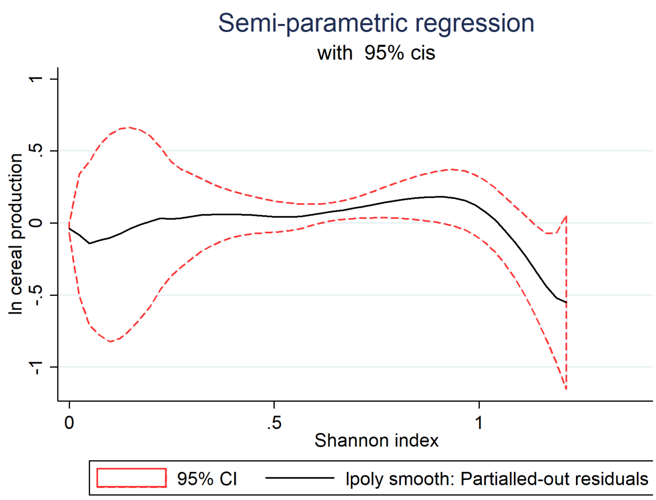


(c) Teff-producing households

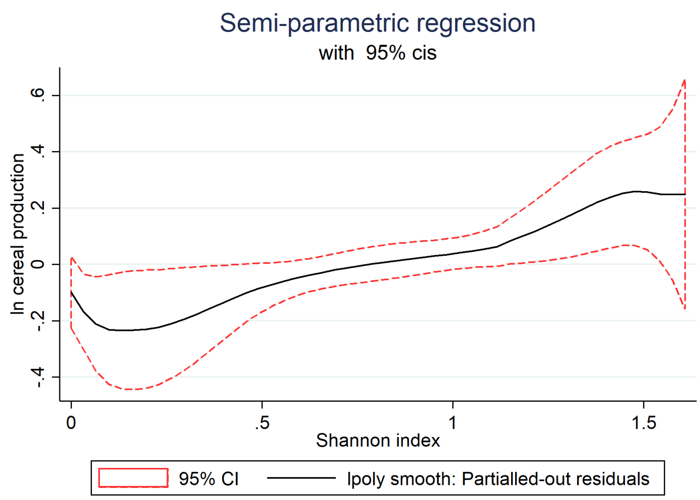
Figure 2: Effect of Shannon index Semi parametric Northern Highlands



(a) **Full sample**

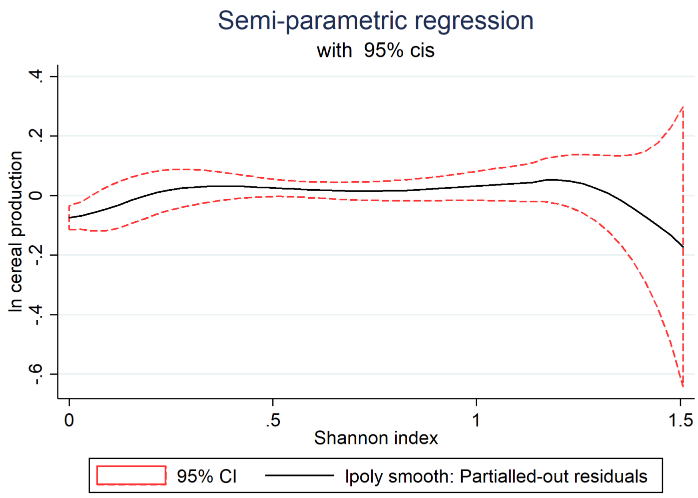


(b) **Non teff-producing households**

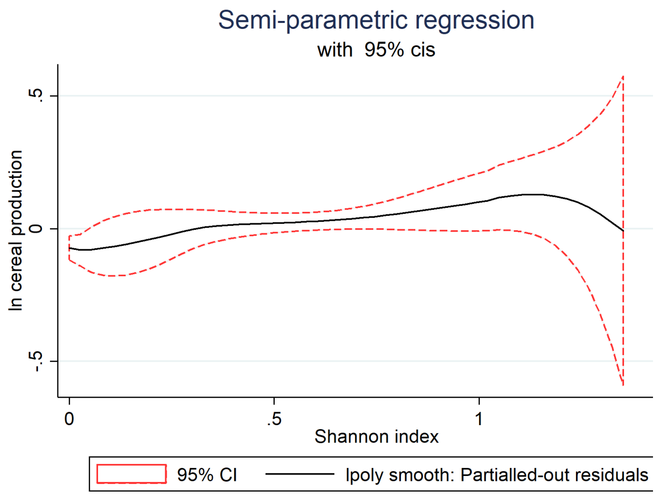


(c) **Teff-producing households**

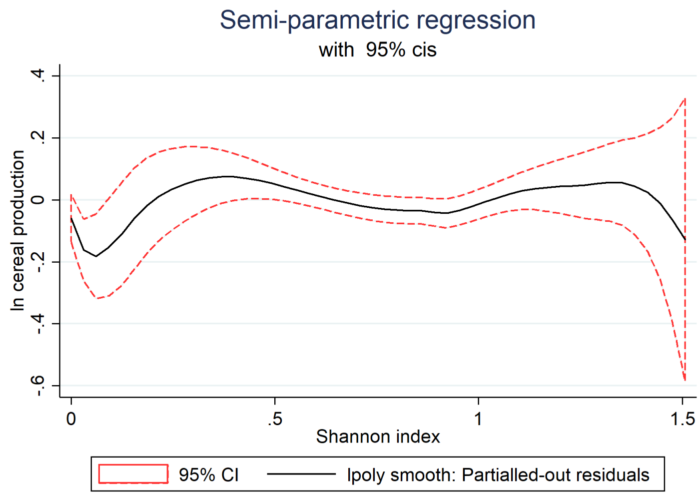
Figure 3: Effect of Shannon index Semi parametric Central Highlands



(a) **Full sample**

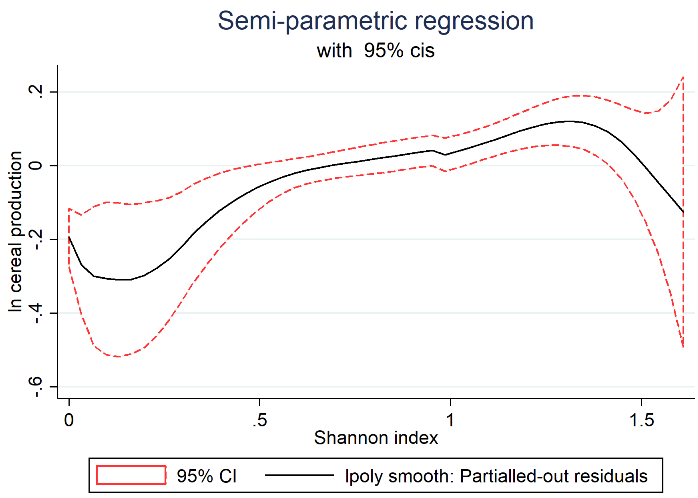


(b) **Non teff-producing households**

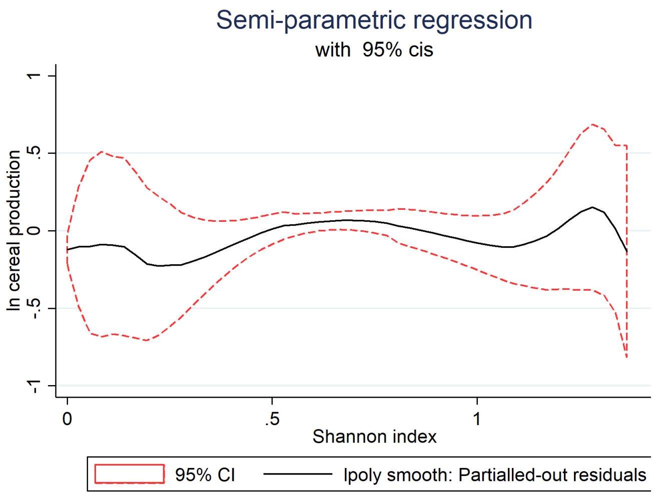


(c) **Teff-producing households**

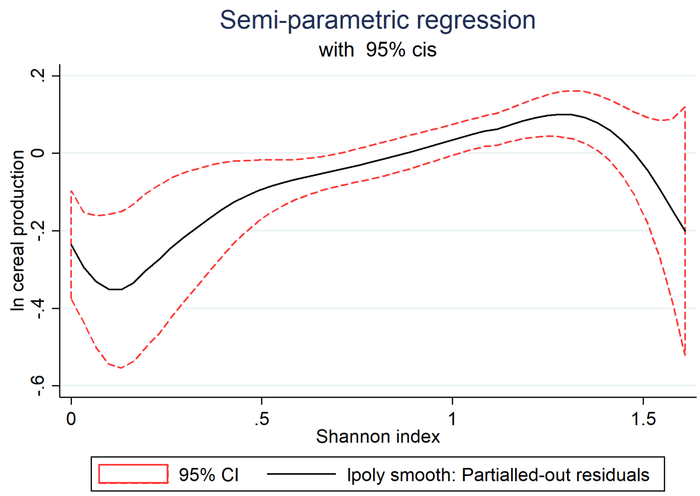
Figure 4: Effect of Shannon index Semi parametric Arussi/Bale



(a) **Full sample**

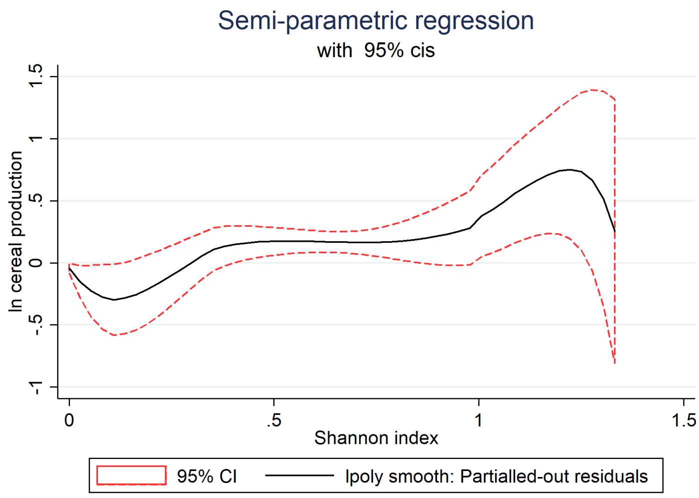


(b) **Non teff-producing households**

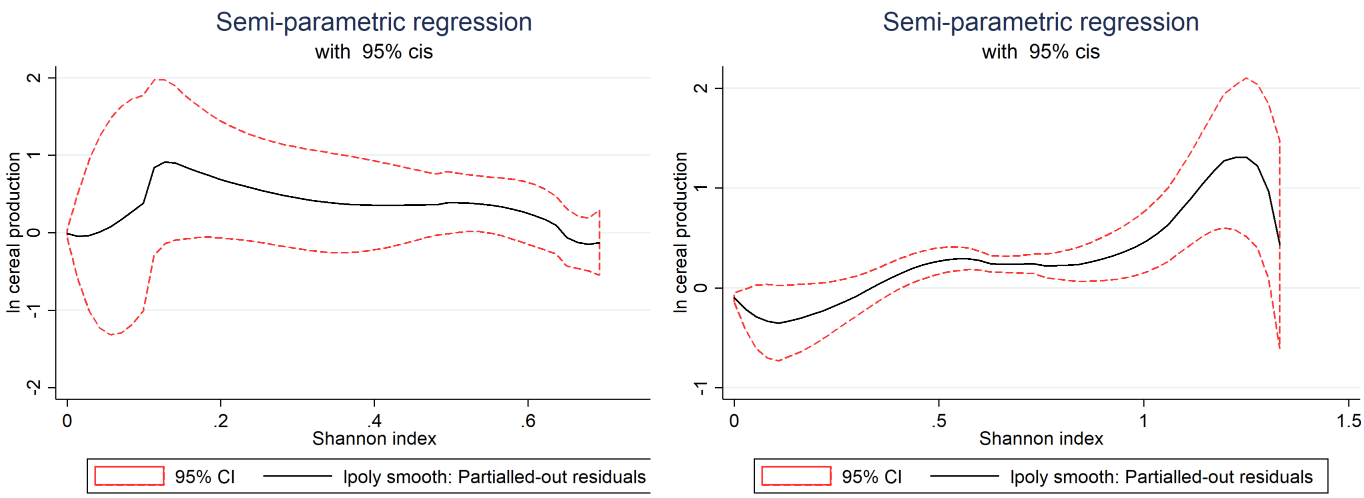


(c) **Teff-producing households**

Figure 5: Effect of Shannon index Semi parametric Enset



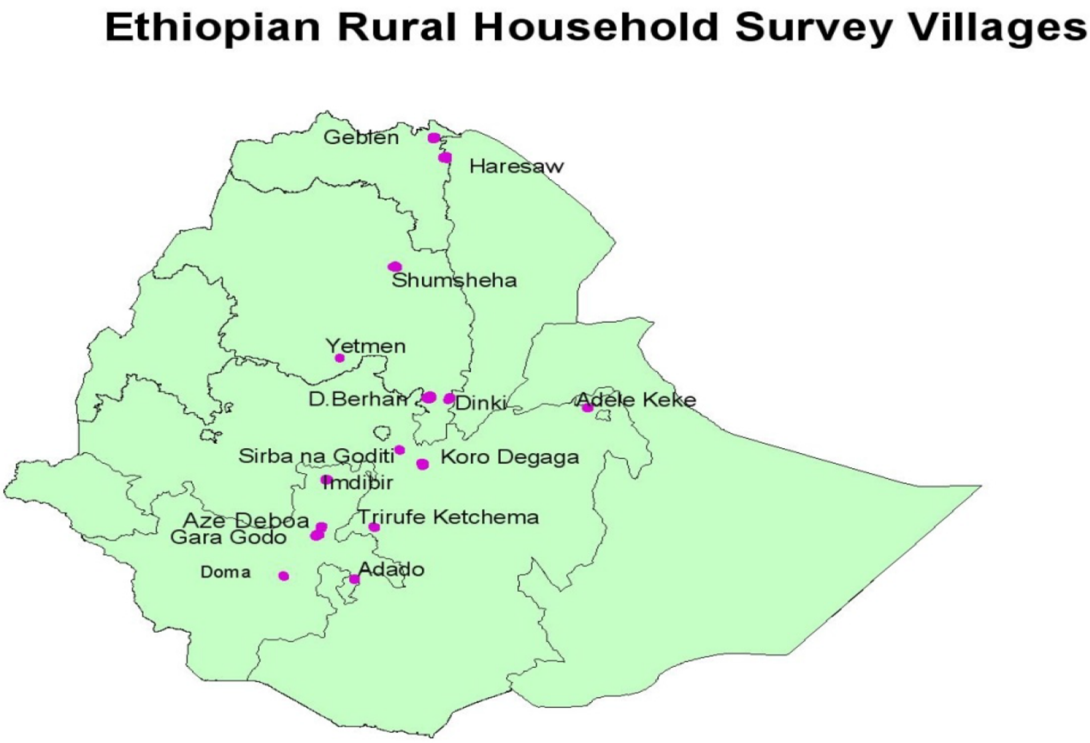
(a) **Full sample**



(b) **Non teff-producing households** (c) **Teff-producing households**

9 Appendix A - Additional figures and tables

Figure A1: Map of Villages in the ERHS (up to 2004)



Source: Dercon and Hoddinott 2004

Figure A2: Background information of Villages in the ERHS (up to 2004)

Survey site	Location	Background	Main crops	Perennial crops?	Mean Rainfall mm
Haresaw	Tigray	Poor and vulnerable area.	Cereals	no	558
Geblen	Tigray	Poor and vulnerable area; used to be quite wealthy.	Cereals	no	504
Dinki	N. Shoa	Badly affected in famine in 84/85; not easily accessible even though near Debre Berhan.	Millet, teff	no	1664
Debre Berhan	N.Shoa	Highland site. Near town.	Teff, barley, beans	no	919
Yetmen	Gojjam	Near Bichena. Ox-plough cereal farming system of highlands.	Teff, wheat and beans	no	1241
Shumsha	S.Wollo	Poor area in neighbourhood of airport near Lalibela.	Cereals	no	654
Sirbana Godeti	Shoa	Near Debre Zeit. Rich area. Much targeted by agricultural policy. Cereal, ox-plough system.	Teff	no	672
Adele Keke	Hararghe	Highland site. Drought in 85/86	Millet, maize, coffee, chat	yes, no food	748
Korodegaga	Arssi	Poor cropping area in neighbourhood of rich valley.	Cereals	no	874
Turfe Kechemane	S.Shoa	Near Shashemene. Ox-plough, rich cereal area. Highlands.	Wheat, barley, teff, potatoes	yes, some	812
Imdibir	Shoa (Gurage)	Densely populated enset area.	Enset, chat, coffee, maize	yes, including food	2205
Aze Deboa	Shoa (Kembata)	Densely populated. Long tradition of substantial seasonal and temporary migration.	Enset, coffee, maize, teff, sorghum	yes, including food	1509
Addado	Sidamo (Dilla)	Rich coffee producing area; densely populated.	Coffee, enset	yes, including food	1417
Gara Godo	Sidamo (Wolayta)	Densely packed enset-farming area. Famine in 83/84. Malaria in mid-88.	Barley, enset	yes, including food	1245
Doma	Gama Gofa	Resettlement Area (1985); Semi-arid; droughts in 85, 88,89,90; remote.	Enset, maize	yes, some	1150

Source: Dercon and Hoddinott 2004

Table A1: List of Peasant Associations by AEZ

Agro-Ecological Zone	Peasant Association
Northern Highlands	Haresaw
	Geblen
	Shumsheha
Central Highlands	Dinki
	Debre Berhan Milki
	Debre Berhan Kormargefia
	Debre Berhan Karafino
	Debre Berhan Bokafia
	Yetmen
	Turufe Ketchema
Enset	Imdibir
	Aze-Deboa
	Adado
	Gara-Godo
	Do'oma
Other	Sirbana Godeti
	Korodegaga
	Adele Keke

Source: Adapted and changed slightly from Nisrane et al 2011

Table A2: Parametric translog full

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.596***	0.550***	0.510***	0.353**	0.262
	(0.058)	(0.129)	(0.087)	(0.146)	(0.181)
Household size	0.006	0.261	-0.25	0.354	0.019
	(0.108)	(0.281)	(0.169)	(0.237)	(0.320)
Oxen	0.128***	0.127*	0.093**	0.146***	0.273**
	(0.029)	(0.069)	(0.044)	(0.053)	(0.112)
Fertilizer	0.024***	-0.067*	0.018	0.029*	0.03
	(0.009)	(0.039)	(0.012)	(0.016)	(0.031)
Hoes	0.029	-0.005	0.04	0.098**	-0.058
	(0.021)	(0.053)	(0.030)	(0.043)	(0.072)
Ploughs	0.015	0.031	0.038*	0.046	-0.064
	(0.014)	(0.033)	(0.023)	(0.029)	(0.057)
Shannon index	0.047	0.03	0.024	0.122	0.021
	(0.029)	(0.054)	(0.046)	(0.077)	(0.066)
Area (square)	0.036	0.03	-0.141***	0.047	0.072
	(0.026)	(0.053)	(0.041)	(0.071)	(0.052)
Household size (square)	0.038	0.012	0.238**	-0.328**	-0.004
	(0.066)	(0.142)	(0.102)	(0.151)	(0.162)
Oxen (square)	0.018***	0.018*	0.014**	0.019**	0.038**
	(0.004)	(0.010)	(0.006)	(0.008)	(0.015)
Fertilizer (square)	0.003**	-0.009	0.002	0.005**	0.001
	(0.002)	(0.007)	(0.002)	(0.002)	(0.004)
Hoes (square)	0.004	-0.002	0.005	0.011*	-0.002
	(0.003)	(0.008)	(0.004)	(0.006)	(0.010)
Ploughs (square)	0.001	0.004	0.004	0.005	-0.011
	(0.002)	(0.004)	(0.003)	(0.004)	(0.009)
Shannon index (square)	0.006	0.005	0.003	0.015	0
	(0.004)	(0.007)	(0.006)	(0.010)	(0.008)
Area*Household size	-0.055*	-0.037	0.029	0.091	-0.015
	(0.029)	(0.055)	(0.046)	(0.071)	(0.081)
Area*Oxen	-0.001	-0.001	-0.001	0	-0.002
	(0.002)	(0.005)	(0.003)	(0.005)	(0.005)
Area*Fertilizer	0	0	0.002	-0.009**	-0.001
	(0.002)	(0.006)	(0.003)	(0.004)	(0.004)
Area*Hoes	0.002	-0.003	0.002	0.003	0.001
	(0.002)	(0.004)	(0.004)	(0.004)	(0.005)
Area*Ploughs	0	0.007*	-0.005	0.006	-0.009
	(0.002)	(0.004)	(0.004)	(0.005)	(0.006)
Area*Shannon index	-0.006**	-0.008	-0.005	0.008	-0.015**
	(0.003)	(0.005)	(0.004)	(0.008)	(0.007)
Household size*Oxen	0.000	0.000	0.005	-0.008	-0.005
	(0.003)	(0.008)	(0.005)	(0.006)	(0.011)
Household size*Fertilizer	-0.001	0.013	0.000	0.006	-0.015*
	(0.003)	(0.009)	(0.005)	(0.006)	(0.009)
Household size*Hoes	0.001	0.008	0.001	-0.007	0.015*
	(0.003)	(0.006)	(0.006)	(0.006)	(0.009)
Household size*Ploughs	-0.004	-0.015*	-0.007	-0.001	-0.009
	(0.003)	(0.008)	(0.006)	(0.008)	(0.008)
Household size*Shannon index	0.003	0.007	0.001	-0.007	-0.008
	(0.004)	(0.007)	(0.006)	(0.011)	(0.011)
Oxen*Fertilizer	0.000	-0.001	0.000	0.001	0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Oxen*Hoes	0.000	0	0.001**	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Oxen*Ploughs	0.000	0.000	0.000	0.000	-0.001**
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Oxen*Shannon index	0.000	0.000	0.000	-0.001	0.000
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Fertilizer*Hoes	0.000**	0.001**	0.000	0.000	0.001
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Fertilizer*Ploughs	0.000	-0.001	0.000	0.000	0.001
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Fertilizer*Shannon index	0.000	0.000	0.000	0.001	-0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Hoes*Ploughs	0.000	0.000	-0.001**	0.001	0.000
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Hoes*Shannon index	0.000	0.001***	0.000	0.000	-0.002**
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Ploughs*Shannon index	0.000	-0.001*	0.000	-0.001	0.002***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	6.335***	4.991***	6.449***	5.929***	5.577***
	(0.110)	(0.355)	(0.167)	(0.234)	(0.404)
Elasticity of Shannon index	0.022**	0.012	0.013	0.098*	0.022
p-value	0.013	0.159	0.566	0.075	0.500
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	1281	289	429	299	264
Number of observations	5804	1323	2003	1456	1023
Average obs. per household	4.531	4.578	4.669	4.87	3.875
R-squared a	0.546	0.658	0.556	0.509	0.453
R-squared w	0.555	0.671	0.571	0.526	0.481

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese since many of these dummies are time-invariant which would be incompatible with the fixed effects. Instead 0 values are assigned the value of 0.000001.

Table A3: Parametric translog full (teff only)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.571***	0.572**	0.527***	0.541**	-0.07
	(0.096)	(0.258)	(0.168)	(0.216)	(0.268)
Household size	0.149	0.04	-0.197	0.488**	-0.189
	(0.147)	(0.506)	(0.338)	(0.244)	(0.400)
Oxen	0.163***	0.157*	0.076	0.157***	0.252*
	(0.038)	(0.095)	(0.073)	(0.056)	(0.146)
Fertilizer	0.038***	-0.069	0.031	0.032*	0.025
	(0.013)	(0.046)	(0.023)	(0.018)	(0.044)
Hoes	0.033	-0.067	-0.023	0.092**	0.046
	(0.028)	(0.062)	(0.053)	(0.045)	(0.092)
Ploughs	-0.017	0.086	-0.037	-0.001	-0.147*
	(0.021)	(0.061)	(0.038)	(0.034)	(0.077)
Shannon index	0.184***	0.129	0.061	0.303***	0.215*
	(0.047)	(0.086)	(0.067)	(0.076)	(0.128)
Area (square)	0.153***	0.182*	-0.001	-0.185	0.131*
	(0.043)	(0.108)	(0.096)	(0.127)	(0.073)
Household size (square)	-0.082	0.201	0.204	-0.474***	0.038
	(0.095)	(0.297)	(0.194)	(0.176)	(0.205)
Oxen (square)	0.021***	0.014	0.009	0.021***	0.028
	(0.005)	(0.013)	(0.011)	(0.008)	(0.020)
Fertilizer (square)	0.005**	-0.007	0.005	0.004	0.000
	(0.002)	(0.007)	(0.004)	(0.003)	(0.005)
Hoes (square)	0.003	-0.011	-0.002	0.008	0.015
	(0.004)	(0.009)	(0.007)	(0.007)	(0.013)
Ploughs (square)	-0.002	0.017**	-0.007	0.001	-0.020*
	(0.003)	(0.007)	(0.005)	(0.004)	(0.011)
Shannon index (square)	0.023***	0.029**	0.006	0.036***	0.015
	(0.006)	(0.012)	(0.009)	(0.010)	(0.017)
Area*Household size	-0.100**	-0.18	-0.014	0.143	0.19
	(0.048)	(0.143)	(0.088)	(0.129)	(0.115)
Area*Oxen	0.000	-0.003	-0.002	0.012	0.004
	(0.003)	(0.007)	(0.006)	(0.007)	(0.007)
Area*Fertilizer	-0.002	0.000	0.000	-0.028***	-0.005
	(0.003)	(0.008)	(0.006)	(0.008)	(0.009)
Area*Hoes	0.003	-0.013*	0.005	0.005	0.009
	(0.003)	(0.007)	(0.006)	(0.006)	(0.007)
Area*Ploughs	-0.005	0.012	-0.020**	0.006	-0.021***
	(0.004)	(0.009)	(0.009)	(0.008)	(0.008)
Area*Shannon index	-0.019***	-0.035***	-0.018**	-0.006	-0.021**
	(0.005)	(0.012)	(0.009)	(0.017)	(0.009)
Household size*Oxen	-0.007	-0.016	-0.003	-0.013	-0.025*
	(0.005)	(0.011)	(0.009)	(0.008)	(0.013)
Household size*Fertilizer	-0.003	0.019	0.004	0.01	-0.014
	(0.005)	(0.017)	(0.008)	(0.009)	(0.014)
Household size*Hoes	-0.003	0.008	0.009	-0.016*	0.024*
	(0.005)	(0.011)	(0.007)	(0.008)	(0.014)
Household size*Ploughs	0.007	-0.014	-0.004	0.005	0.004
	(0.005)	(0.014)	(0.011)	(0.011)	(0.011)
Household size*Shannon index	-0.001	0.028	-0.005	-0.018	-0.043***
	(0.006)	(0.018)	(0.011)	(0.015)	(0.016)
Oxen*Fertilizer	0.000	0.002	0.000	0.001	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Oxen*Hoes	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)
Oxen*Ploughs	0.000	0.002**	0.000	0.000	-0.002*
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Oxen*Shannon index	0.000	-0.001	0.000	0.001	0.001
	(0.000)	(0.002)	(0.001)	(0.001)	(0.001)
Fertilizer*Hoes	0.000*	0.001	0.001	0.000	0.001
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Fertilizer*Ploughs	0.001	-0.003**	0.001	0.000	0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Fertilizer*Shannon index	0.000	-0.002	0.000	0.000	-0.001
	(0.000)	(0.002)	(0.001)	(0.001)	(0.001)
Hoes*Ploughs	0.000	-0.001	-0.002**	0.000	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Hoes*Shannon index	0.001	0.002	0.002**	0.002*	-0.002
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Ploughs*Shannon index	0.001**	-0.002	0.001	-0.003**	0.004***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Constant	6.347***	5.472***	6.791***	5.747***	5.801***
	(0.146)	(0.558)	(0.338)	(0.230)	(0.575)
Elasticity of Shannon index	0.105***	0.154**	0.024	0.235***	0.001
p-value	0.000	0.019	0.607	0.000	0.981
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	782	152	217	211	202
Number of observations	2799	544	679	960	616
Average obs. per household	3.579	3.579	3.129	4.55	3.05
R-squared a	0.511	0.358	0.557	0.597	0.535
R-squared w	0.526	0.412	0.59	0.616	0.573

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese since many of these dummies are time-invariant which would be incompatible with the fixed effects. Instead 0 values are assigned the value of 0.000001.

Table A4: Parametric translog full (no teff)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.562***	0.752***	0.483***	0.128	0.307
	(0.078)	(0.258)	(0.110)	(0.211)	(0.363)
Household size	-0.157	0.165	-0.309	-0.01	-0.076
	(0.166)	(0.374)	(0.210)	(0.551)	(0.910)
Oxen	0.102**	0.076	0.099*	-0.06	0.281
	(0.047)	(0.117)	(0.057)	(0.208)	(0.239)
Fertilizer	0.021	-0.082	0.027	0.015	0.068
	(0.014)	(0.062)	(0.017)	(0.032)	(0.066)
Hoes	0.033	0.143	0.099**	0.047	-0.241**
	(0.035)	(0.116)	(0.040)	(0.119)	(0.118)
Ploughs	0.054**	0.029	0.063**	0.228***	0.075
	(0.023)	(0.048)	(0.031)	(0.081)	(0.144)
Shannon index	-0.004	-0.088	0.098	-0.079	0.04
	(0.051)	(0.070)	(0.080)	(0.148)	(0.129)
Area (square)	-0.041	-0.156	-0.179***	0.064	0.049
	(0.037)	(0.129)	(0.051)	(0.118)	(0.091)
Household size (square)	0.149	0.043	0.249*	-0.038	-0.096
	(0.096)	(0.173)	(0.127)	(0.296)	(0.418)
Oxen (square)	0.016**	0.015	0.015*	-0.01	0.044
	(0.007)	(0.017)	(0.008)	(0.030)	(0.032)
Fertilizer (square)	0.003	-0.013	0.005*	0.004	0.002
	(0.002)	(0.011)	(0.003)	(0.005)	(0.009)
Hoes (square)	0.005	0.021	0.012**	0.006	-0.039**
	(0.005)	(0.017)	(0.006)	(0.017)	(0.016)
Ploughs (square)	0.005	0.001	0.008*	0.029***	0.003
	(0.003)	(0.007)	(0.004)	(0.011)	(0.018)
Shannon index (square)	-0.002	-0.013	0.012	-0.022	-0.003
	(0.007)	(0.009)	(0.011)	(0.021)	(0.015)
Area*Household size	-0.014	-0.096	0.077	0.211**	-0.016
	(0.039)	(0.089)	(0.057)	(0.101)	(0.133)
Area*Oxen	-0.004	-0.002	-0.003	-0.002	-0.018**
	(0.003)	(0.009)	(0.005)	(0.008)	(0.009)
Area*Fertilizer	0.004	0.01	-0.002	-0.013**	0.007
	(0.003)	(0.010)	(0.004)	(0.006)	(0.007)
Area*Hoes	0.002	0.001	0.001	0.008	0
	(0.003)	(0.007)	(0.005)	(0.008)	(0.008)
Area*Ploughs	0.005	0.015**	0.002	0.014	0.006
	(0.003)	(0.008)	(0.006)	(0.009)	(0.009)
Area*Shannon index	-0.002	0.004	-0.001	0.014	-0.013
	(0.004)	(0.009)	(0.005)	(0.010)	(0.016)
Household size*Oxen	0.004	0.006	0.01	-0.002	0.002
	(0.005)	(0.013)	(0.007)	(0.015)	(0.022)
Household size*Fertilizer	0.001	0.012	-0.003	0.008	-0.006
	(0.004)	(0.011)	(0.006)	(0.010)	(0.019)
Household size*Hoes	0.002	0.009	-0.003	0.005	-0.002
	(0.004)	(0.008)	(0.007)	(0.010)	(0.018)
Household size*Ploughs	-0.012**	-0.020*	-0.006	-0.013	-0.019
	(0.005)	(0.011)	(0.009)	(0.014)	(0.019)
Household size*Shannon index	-0.001	0.004	-0.004	-0.035**	-0.023
	(0.005)	(0.009)	(0.008)	(0.016)	(0.036)
Oxen*Fertilizer	-0.000*	-0.001	-0.001	0.001	-0.002*
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Oxen*Hoes	0.000	-0.001	0.001***	0.000	0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Oxen*Ploughs	-0.001**	-0.001	-0.001	-0.001	-0.003
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Oxen*Shannon index	0.000	0.000	0.000	-0.001	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Fertilizer*Hoes	0.000	0.002**	0.000	0.000	0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Fertilizer*Ploughs	0.000	-0.001	0.000	0.000	0.003**
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Fertilizer*Shannon index	0.000	0.000	-0.001	0.001	0.002
	(0.000)	(0.001)	(0.000)	(0.001)	(0.002)
Hoes*Ploughs	0.000	0.000	-0.001	0.000	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Hoes*Shannon index	0.000	0.001	-0.001	0.000	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Ploughs*Shannon index	0.000	0.000	0.000	0.000	0.003
	(0.000)	(0.001)	(0.001)	(0.001)	(0.003)
Constant	6.324***	5.039***	6.357***	6.300***	6.501***
	(0.174)	(0.541)	(0.214)	(0.698)	(1.303)
Elasticity of Shannon index	0.007*	0.0354*	0.038	-0.0689	0.011
p-value	0.090	0.066	0.229	0.369	0.897
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	894	211	345	128	210
Number of observations	3006	779	1324	496	407
Average obs. per household	3.362	3.692	3.838	3.875	1.938
R-squared a	0.593	0.752	0.564	0.332	0.486
R-squared w	0.607	0.768	0.584	0.394	0.548

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese since many of these dummies are time-invariant which would be incompatible with the fixed effects. Instead 0 values are assigned the value of 0.000001.

Table A5: Semi-parametric model: Parametric component (Full sample)

	All	Teff	No teff
Area	0.637***	0.689***	0.594***
	(0.066)	(0.102)	(0.086)
Household size	-0.151	-0.031	-0.146
	(0.136)	(0.154)	(0.235)
Oxen	0.103***	0.110**	0.100*
	(0.036)	(0.046)	(0.060)
Fertilizer	0.019*	0.026*	0.014
	(0.011)	(0.014)	(0.016)
Hoes	0.032	0.033	0.046
	(0.025)	(0.034)	(0.038)
Ploughs	0.024	0.009	0.059**
	(0.018)	(0.026)	(0.027)
Area (square)	0.006	0.017	-0.009
	(0.012)	(0.019)	(0.017)
Household size (square)	0.070*	0.022	0.081
	(0.042)	(0.050)	(0.071)
Oxen (square)	0.007***	0.007**	0.008*
	(0.003)	(0.003)	(0.004)
Fertilizer (square)	0.002*	0.002*	0.001
	(0.001)	(0.001)	(0.001)
Hoes (square)	0.002	0.002	0.003
	(0.002)	(0.002)	(0.003)
Ploughs (square)	0.001	0.001	0.003
	(0.001)	(0.002)	(0.002)
Area*Household size	-0.066**	-0.107**	-0.029
	(0.033)	(0.050)	(0.043)
Area*Oxen	-0.001	0.001	-0.003
	(0.002)	(0.003)	(0.003)
Area*Fertilizer	-0.001	-0.005	0.002
	(0.002)	(0.003)	(0.003)
Area*Hoes	0.006**	0.007**	0.004
	(0.002)	(0.003)	(0.003)
Area*Ploughs	0.000	-0.004	0.007**
	(0.002)	(0.003)	(0.003)
Household size*Oxen	0.001	-0.002	0.006
	(0.004)	(0.006)	(0.007)
Household size*Fertilizer	0.002	0	0.004
	(0.003)	(0.005)	(0.005)
Household size*Hoes	0.000	-0.004	0.002
	(0.004)	(0.005)	(0.005)
Household size*Ploughs	-0.006	0	-0.014**
	(0.004)	(0.005)	(0.006)
Oxen*Fertilizer	0.000	0	-0.001*
	(0.000)	(0.000)	(0.000)
Oxen*Hoes	0.000	0	0
	(0.000)	(0.000)	(0.000)
Oxen*Ploughs	0.000	0	-0.001
	(0.000)	(0.000)	(0.000)
Fertilizer*Hoes	0.000	0	0.001
	(0.000)	(0.000)	(0.000)
Fertilizer*Ploughs	0.000*	0.001	0
	(0.000)	(0.000)	(0.000)
Hoes*Ploughs	0.000	-0.001	0
	(0.000)	(0.000)	(0.000)
Village-year fixed effects	✓	✓	✓
Number of observations	4289	2149	2140
Number of households	1280	782	893
R-squared a	0.485	0.484	0.5

Table A6: Semi-parametric model: Parametric component (Northern Highlands)

	All	Teff	No teff
Area	0.695***	0.460*	1.021***
	(0.143)	(0.254)	(0.250)
Household size	0.079	-0.395	0.222
	(0.399)	(0.480)	(0.530)
Oxen	0.09	0.125	0.059
	(0.088)	(0.104)	(0.145)
Fertilizer	-0.038	-0.046	-0.074
	(0.042)	(0.043)	(0.069)
Hoes	-0.057	-0.082	0.07
	(0.059)	(0.069)	(0.136)
Ploughs	0.045	0.024	0.066
	(0.045)	(0.069)	(0.073)
Area (square)	0.02	0.02	0.005
	(0.028)	(0.047)	(0.052)
Household size (square)	-0.02	0.138	-0.098
	(0.111)	(0.138)	(0.151)
Oxen (square)	0.007	0.005	0.006
	(0.006)	(0.007)	(0.011)
Fertilizer (square)	-0.003	-0.003	-0.008
	(0.004)	(0.003)	(0.006)
Hoes (square)	-0.004	-0.005	0.005
	(0.004)	(0.005)	(0.010)
Ploughs (square)	0.004	0.004	0.004
	(0.003)	(0.004)	(0.005)
Area*Household size	-0.057	-0.006	-0.115
	(0.068)	(0.136)	(0.091)
Area*Oxen	0.003	0.001	0.011
	(0.005)	(0.007)	(0.010)
Area*Fertilizer	0.000	-0.004	0.011
	(0.006)	(0.007)	(0.011)
Area*Hoes	0.006	-0.007	0.006
	(0.004)	(0.007)	(0.007)
Area*Ploughs	0.004	0.003	0.015*
	(0.005)	(0.008)	(0.008)
Household size*Oxen	0.001	-0.02	0.01
	(0.012)	(0.015)	(0.016)
Household size*Fertilizer	0.001	0.005	-0.001
	(0.009)	(0.016)	(0.012)
Household size*Hoes	0.009	0.013	0.01
	(0.008)	(0.014)	(0.010)
Household size*Ploughs	-0.014	-0.009	-0.018
	(0.010)	(0.014)	(0.012)
Oxen*Fertilizer	-0.001	0.001	-0.003**
	(0.001)	(0.001)	(0.001)
Oxen*Hoes	0.000	-0.001	0
	(0.001)	(0.001)	(0.001)
Oxen*Ploughs	0.000	0.002	-0.002*
	(0.001)	(0.001)	(0.001)
Fertilizer*Hoes	0.002**	0.001	0.002**
	(0.001)	(0.001)	(0.001)
Fertilizer*Ploughs	-0.001	-0.003*	-0.001
	(0.001)	(0.002)	(0.001)
Hoes*Ploughs	0.000	-0.001	0
	(0.001)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	977	428	549
Number of households	289	152	211
R-squared a	0.596	0.305	0.695

Table A7: Semi-parametric model: Parametric component (Central Highlands)

	All	Teff	No teff
Area	0.629***	0.593***	0.639***
	(0.108)	(0.176)	(0.126)
Household size	-0.364*	-0.337	-0.417
	(0.203)	(0.296)	(0.262)
Oxen	0.058	0.031	0.064
	(0.059)	(0.084)	(0.075)
Fertilizer	0.023	0.071***	0.014
	(0.015)	(0.025)	(0.020)
Hoes	0.069**	0.034	0.097**
	(0.032)	(0.051)	(0.041)
Ploughs	0.022	-0.027	0.060*
	(0.025)	(0.044)	(0.033)
Area (square)	-0.074***	-0.084*	-0.076***
	(0.022)	(0.045)	(0.024)
Household size (square)	0.169***	0.139	0.196**
	(0.063)	(0.086)	(0.082)
Oxen (square)	0.004	0.002	0.005
	(0.004)	(0.006)	(0.006)
Fertilizer (square)	0.002	0.005**	0.002
	(0.001)	(0.002)	(0.002)
Hoes (square)	0.004**	0.002	0.006**
	(0.002)	(0.003)	(0.003)
Ploughs (square)	0.000	-0.001	0.003
	(0.002)	(0.003)	(0.002)
Area*Household size	-0.049	-0.031	-0.043
	(0.059)	(0.091)	(0.070)
Area*Oxen	0.000	0.011	-0.004
	(0.005)	(0.007)	(0.006)
Area*Fertilizer	-0.001	0	-0.005
	(0.004)	(0.006)	(0.005)
Area*Hoes	0.001	0.009	-0.001
	(0.005)	(0.006)	(0.006)
Area*Ploughs	-0.001	-0.016*	0.005
	(0.005)	(0.009)	(0.006)
Household size*Oxen	0.005	0.004	0.006
	(0.006)	(0.011)	(0.008)
Household size*Fertilizer	0.003	-0.009	0.006
	(0.006)	(0.009)	(0.007)
Household size*Hoes	0.000	-0.006	0.002
	(0.006)	(0.010)	(0.008)
Household size*Ploughs	-0.011	0.002	-0.016*
	(0.007)	(0.011)	(0.009)
Oxen*Fertilizer	0.000	0	0
	(0.000)	(0.001)	(0.001)
Oxen*Hoes	0.000	0	0.001*
	(0.000)	(0.001)	(0.001)
Oxen*Ploughs	0.000	0.001	-0.001*
	(0.000)	(0.001)	(0.001)
Fertilizer*Hoes	0.000	0	0
	(0.000)	(0.000)	(0.001)
Fertilizer*Ploughs	0.000	0	0
	(0.000)	(0.001)	(0.001)
Hoes*Ploughs	-0.001	-0.002**	-0.001
	(0.001)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	1490	507	983
Number of households	428	217	344
R-squared a	0.398	0.393	0.413

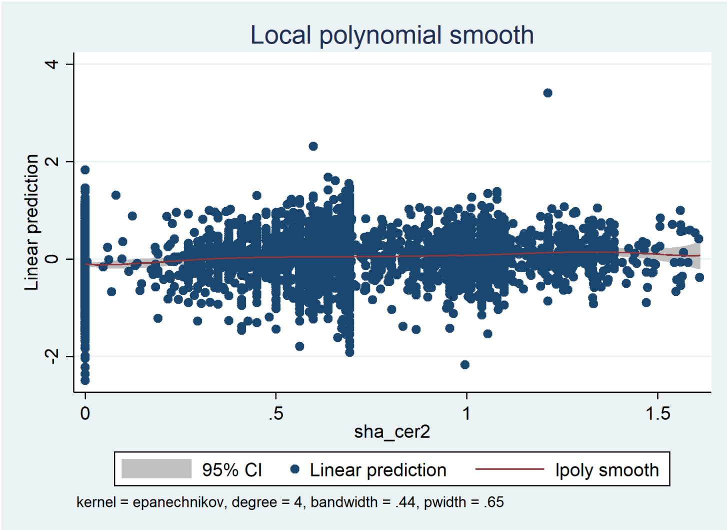
Table A8: Semi-parametric model: Parametric component (Arusi/Bale (Other))

	All	Teff	No teff
Area	0.415**	0.740***	0.408
	(0.162)	(0.278)	(0.248)
Household size	0.206	0.614**	-0.601
	(0.233)	(0.248)	(0.466)
Oxen	0.125*	0.116	0.107
	(0.065)	(0.071)	(0.211)
Fertilizer	0.003	0.009	0.026
	(0.017)	(0.019)	(0.039)
Hoes	0.095*	0.107*	0.071
	(0.050)	(0.058)	(0.103)
Ploughs	0.011	-0.008	0.127
	(0.037)	(0.041)	(0.087)
Area (square)	0.041	-0.062	0.121*
	(0.037)	(0.070)	(0.068)
Household size (square)	-0.098	-0.199**	0.116
	(0.078)	(0.097)	(0.135)
Oxen (square)	0.008*	0.009*	0.007
	(0.005)	(0.005)	(0.015)
Fertilizer (square)	0.001	0.001	0.004
	(0.001)	(0.001)	(0.003)
Hoes (square)	0.005	0.006	0.004
	(0.004)	(0.004)	(0.008)
Ploughs (square)	0.002	0.001	0.007
	(0.002)	(0.003)	(0.006)
Area*Household size	0.022	-0.051	0.047
	(0.077)	(0.162)	(0.111)
Area*Oxen	-0.006	0.005	-0.011
	(0.005)	(0.008)	(0.009)
Area*Fertilizer	-0.003	-0.014**	-0.007
	(0.004)	(0.006)	(0.007)
Area*Hoes	0.005	0.004	0.011
	(0.005)	(0.007)	(0.009)
Area*Ploughs	0.002	-0.001	0.012
	(0.005)	(0.008)	(0.008)
Household size*Oxen	-0.005	0	-0.007
	(0.007)	(0.010)	(0.012)
Household size*Fertilizer	0.008	0.006	0.011
	(0.006)	(0.008)	(0.010)
Household size*Hoes	-0.009	-0.015*	-0.006
	(0.007)	(0.009)	(0.012)
Household size*Ploughs	0.004	0.008	-0.011
	(0.007)	(0.009)	(0.013)
Oxen*Fertilizer	0.000	0	0.001
	(0.000)	(0.000)	(0.001)
Oxen*Hoes	0.000	0	0
	(0.000)	(0.001)	(0.001)
Oxen*Ploughs	0.000	-0.001	0
	(0.000)	(0.001)	(0.001)
Fertilizer*Hoes	0.000	0	0
	(0.000)	(0.001)	(0.001)
Fertilizer*Ploughs	0.000	0	0
	(0.000)	(0.001)	(0.001)
Hoes*Ploughs	0.000	0	0
	(0.001)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	1125	735	390
Number of households	299	211	128
R-squared a	0.47	0.567	0.317

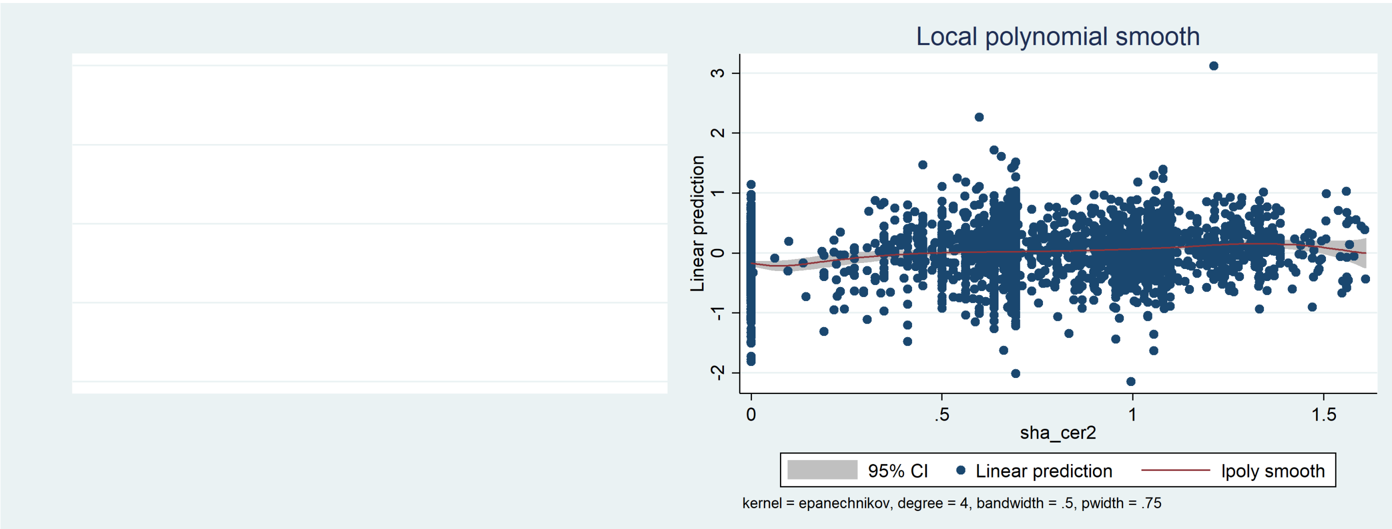
Table A9: Semi-parametric model: Parametric component (Enset)

	All	Teff	No teff
Area	0.441**	0.543*	0.214
	(0.192)	(0.300)	(0.254)
Household size	-0.365	-0.398	0.433
	(0.391)	(0.507)	(0.849)
Oxen	0.165	0.142	0.284
	(0.160)	(0.206)	(0.310)
Fertilizer	0.002	0.01	-0.02
	(0.032)	(0.041)	(0.070)
Hoes	-0.051	0.124	-0.237
	(0.084)	(0.113)	(0.157)
Ploughs	0.082	0.073	0.056
	(0.093)	(0.111)	(0.148)
Area (square)	0.01	-0.003	0.028
	(0.026)	(0.039)	(0.039)
Household size (square)	0.190*	0.175	0.068
	(0.108)	(0.125)	(0.240)
Oxen (square)	0.013	0.01	0.024
	(0.011)	(0.014)	(0.022)
Fertilizer (square)	-0.001	-0.001	-0.002
	(0.003)	(0.003)	(0.004)
Hoes (square)	0.000	0.014*	-0.016
	(0.006)	(0.008)	(0.012)
Ploughs (square)	0.006	0.006	0.002
	(0.007)	(0.008)	(0.011)
Area*Household size	-0.044	-0.096	0.11
	(0.088)	(0.131)	(0.115)
Area*Oxen	-0.002	0	-0.005
	(0.006)	(0.008)	(0.009)
Area*Fertilizer	-0.008	-0.015*	-0.001
	(0.005)	(0.008)	(0.007)
Area*Hoes	0.000	0	-0.003
	(0.006)	(0.007)	(0.008)
Area*Ploughs	-0.004	0.003	-0.003
	(0.006)	(0.008)	(0.008)
Household size*Oxen	0.003	-0.002	0.015
	(0.013)	(0.015)	(0.023)
Household size*Fertilizer	-0.003	-0.001	0.005
	(0.009)	(0.013)	(0.027)
Household size*Hoes	0.020*	0.019	0.017
	(0.011)	(0.013)	(0.020)
Household size*Ploughs	-0.016	-0.01	-0.022
	(0.010)	(0.012)	(0.019)
Oxen*Fertilizer	0.000	0.001	-0.001
	(0.001)	(0.001)	(0.001)
Oxen*Hoes	0.000	0	0.001
	(0.001)	(0.001)	(0.002)
Oxen*Ploughs	-0.002**	-0.002*	-0.002
	(0.001)	(0.001)	(0.002)
Fertilizer*Hoes	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)
Fertilizer*Ploughs	0.001	0.001	0.002
	(0.001)	(0.001)	(0.001)
Hoes*Ploughs	-0.001	-0.002*	0
	(0.001)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	697	479	218
Number of households	264	202	210
R-squared a	0.477	0.548	0.309

Figure A3: Effect of Shannon index Semi parametric Full sample



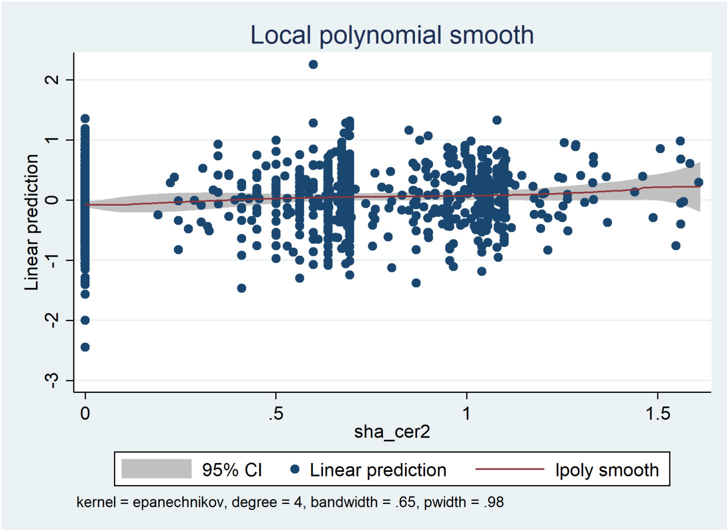
(a) **Full sample**



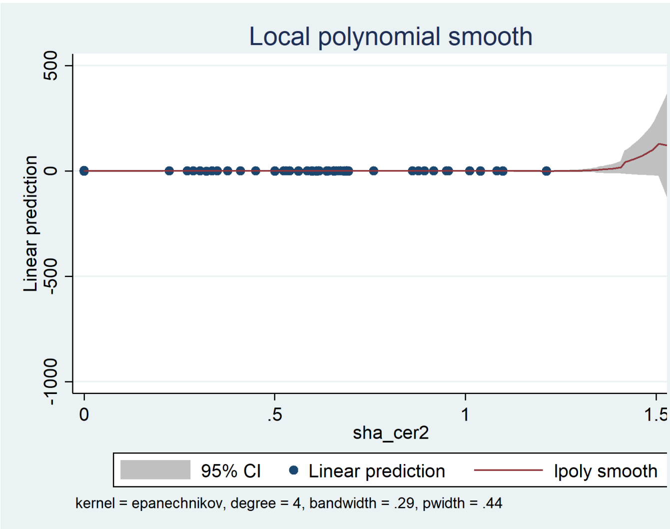
(b) **Non teff-producing households**

(c) **Teff-producing households**

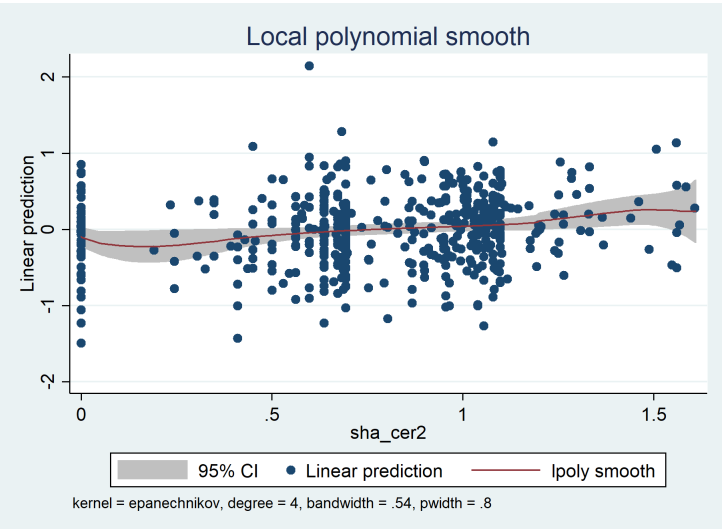
Figure A4: Effect of Shannon index Semi parametric Northern Highlands



(a) **Full sample**

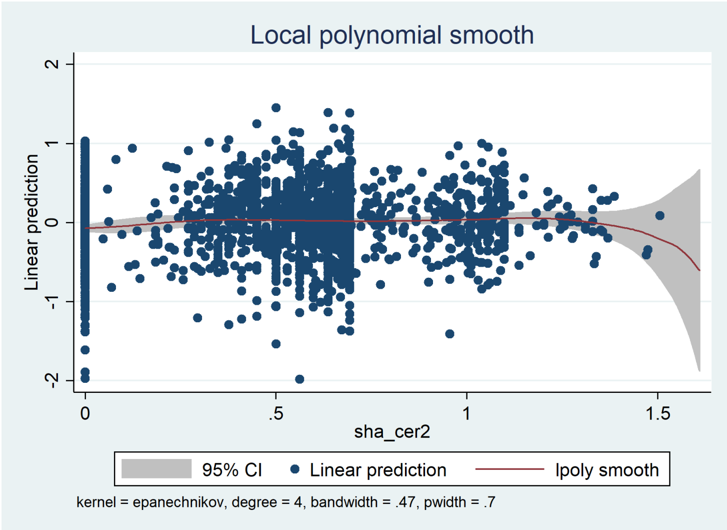


(b) **Non teff-producing households**

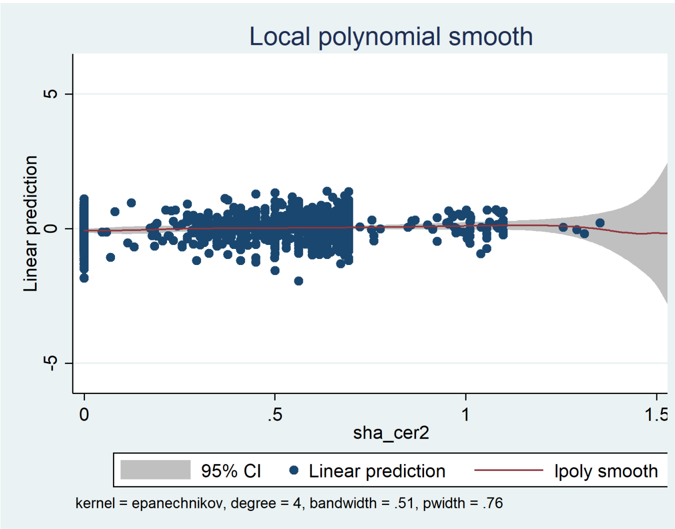


(c) **Teff-producing households**

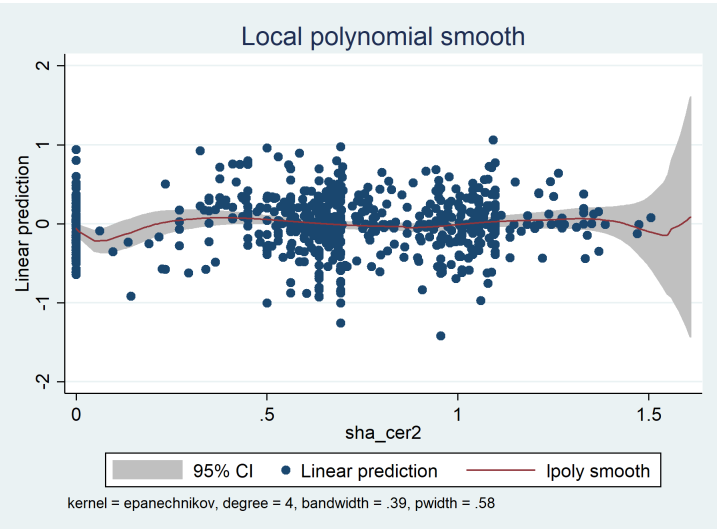
Figure A5: Effect of Shannon index Semi parametric Central Highlands



(a) **Full sample**

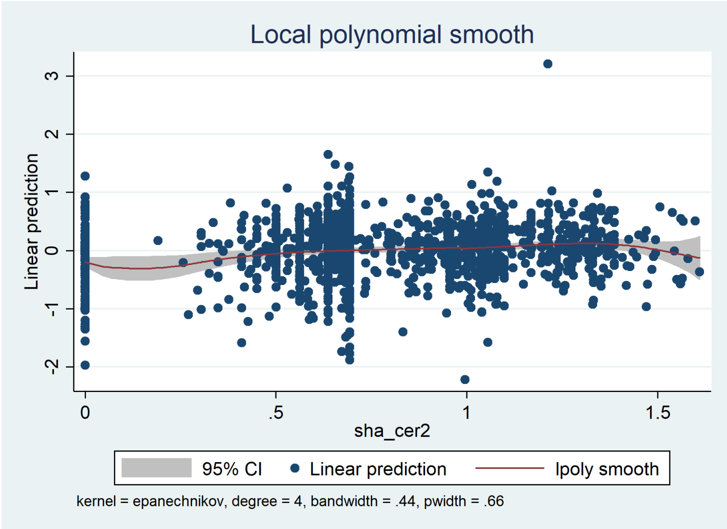


(b) **Non teff-producing households**

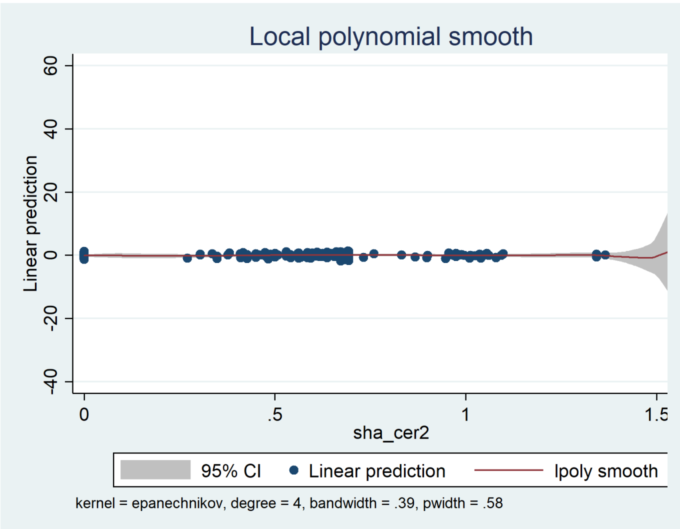


(c) **Teff-producing households**

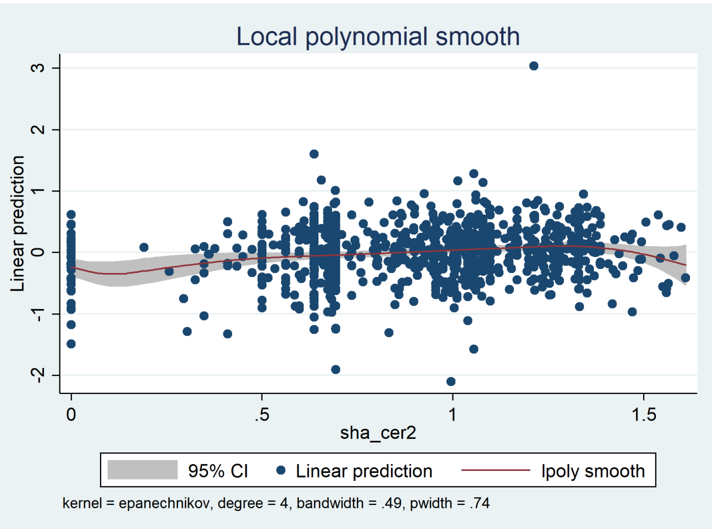
Figure A6: Effect of Shannon index Semi parametric Arussi/Bale



(a) **Full sample**

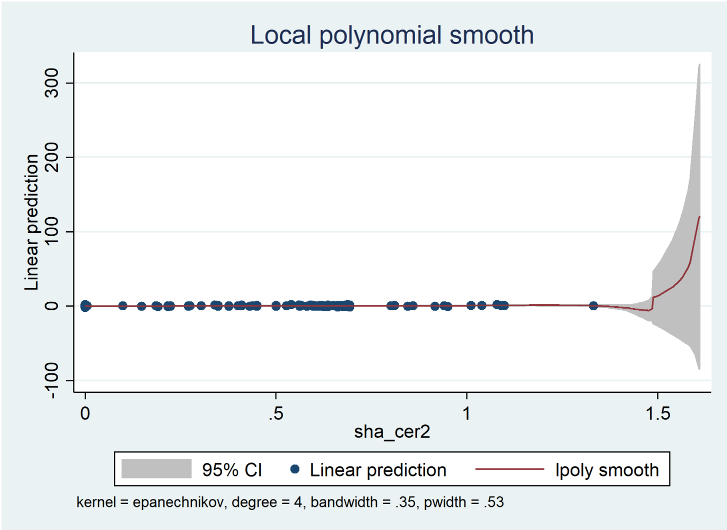


(b) **Non teff-producing households**

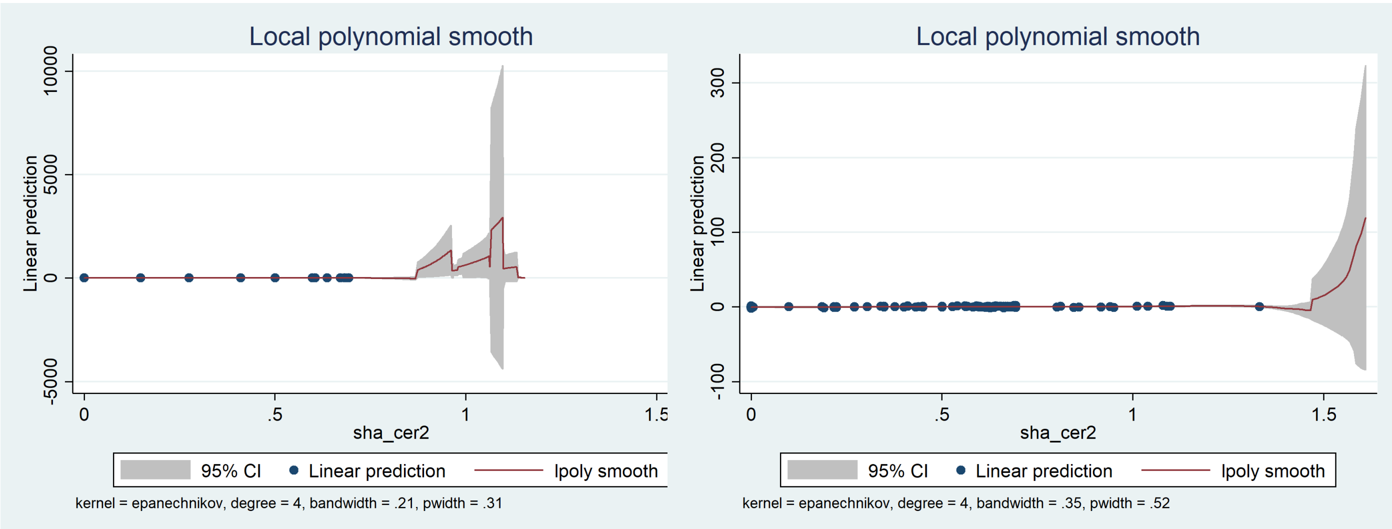


(c) **Teff-producing households**

Figure A7: Effect of Shannon index Semi parametric Enset



(a) **Full sample**



(b) **Non teff-producing households**

(c) **Teff-producing households**

Table A10: Bandwidth choice

	All	N. Highlands	C. Highlands	Other	Enset
Main	0.43	0.67	0.51	0.43	0.44
No teff	0.35	0.29	0.46	0.36	0.22
Teff	0.5	0.51	0.4	0.49	0.33

10 Appendix B - Robustness Checks

10.1 Battese Correction Main Sample

Table B1: Main results : Parametric translog (Battese adjustment)

	All	N. Highlands	C. Highlands	Other	Enset
Dummy Shannon index	-0.174***	-0.131**	-0.113***	-0.141**	-0.217**
	(0.026)	(0.053)	(0.042)	(0.067)	(0.091)
Shannon index	0.090**	-0.076	0.073	0.227	0.132
	(0.043)	(0.148)	(0.136)	(0.183)	(0.131)
Shannon index (square)	0.007*	-0.005	0.004	-0.016	0.011
	(0.004)	(0.015)	(0.010)	(0.018)	(0.015)
Area*Shannon index	0.016**	0.058	-0.01	0.177***	0.012
	(0.007)	(0.071)	(0.055)	(0.066)	(0.011)
Household size*Shannon index	0.011	0.074	-0.069	-0.046	0.002
	(0.016)	(0.076)	(0.072)	(0.096)	(0.028)
Oxen*Shannon index	-0.029	0.12	0.019	-0.115*	-0.104
	(0.031)	(0.105)	(0.085)	(0.062)	(0.484)
Fertilizer*Shannon index	-0.001	-0.022	0.032*	0.02	0.005
	(0.006)	(0.053)	(0.019)	(0.026)	(0.014)
Hoes*Shannon index	0.01	0.071	-0.003	-0.282**	0.023
	(0.020)	(0.068)	(0.062)	(0.110)	(0.028)
Ploughs*Shannon index	-0.015	0.003	-0.067	-0.142*	0.007
	(0.014)	(0.026)	(0.045)	(0.084)	(0.029)
Constant	6.931***	5.839***	6.297***	5.670***	5.746***
	(0.153)	(0.227)	(0.150)	(0.200)	(0.262)
Elasticity of Shannon index	0.091***	0.027	0.027	0.096	0.127
p-value	0.002	0.731	0.552	0.109	0.322
Household fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Dummies	✓	✓	✓	✓	✓
Linear variables	✓	✓	✓	✓	✓
Squares	✓	✓	✓	✓	✓
Interactions	✓	✓	✓	✓	✓
Number of households	1281	289	429	299	264
Number of observations	5804	1323	2002	1456	1023
R-squared a	0.787	0.752	0.687	0.624	0.55

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. The specification in the regression is a translog specification and the full list of coefficients can be seen in Table **??**

Table B2: Main results : Parametric translog - Teff only (Battese adjustment)

	All	N. Highlands	C. Highlands	Other	Enset
Dummy Shannon index	-0.350***	-0.274**	-0.096	-0.299***	-0.509***
	(0.043)	(0.112)	(0.084)	(0.094)	(0.109)
Shannon index	0.093	0.255	-0.219	0.473**	0.099
	(0.069)	(0.307)	(0.200)	(0.235)	(0.170)
Shannon index (square)	0.014*	0.187***	-0.02	0.004	0
	(0.007)	(0.054)	(0.018)	(0.241)	(0.021)
Area*Shannon index	0.016	-0.155	-0.242**	0.129	0.261**
	(0.027)	(0.121)	(0.116)	(0.105)	(0.128)
Household size*Shannon index	0.056	0.024	0.086	0.015	0.254**
	(0.035)	(0.206)	(0.112)	(0.119)	(0.108)
Oxen*Shannon index	0.007	-0.067	0.153	0.004	-0.929
	(0.081)	(0.244)	(0.167)	(0.130)	(0.667)
Fertilizer*Shannon index	-0.002	-0.055	0.036	-0.057*	-0.036
	(0.014)	(0.091)	(0.029)	(0.031)	(0.051)
Hoes*Shannon index	0.008	0.073	0.042	-0.281**	0.36
	(0.050)	(0.083)	(0.110)	(0.114)	(0.244)
Ploughs*Shannon index	-0.038	0.134	-0.084	-0.1	-0.151**
	(0.023)	(0.091)	(0.081)	(0.089)	(0.073)
Constant	5.892***	5.851***	6.502***	5.254***	5.372***
	(0.575)	(0.314)	(0.281)	(0.234)	(0.439)
Elasticity of Shannon index	0.104***	0.154**	0.024	0.235***	0.001
p-value	0.000	0.019	0.607	0.000	0.981
Household fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Dummies	✓	✓	✓	✓	✓
Linear variables	✓	✓	✓	✓	✓
Squares	✓	✓	✓	✓	✓
Interactions	✓	✓	✓	✓	✓
Number of households	782	152	217	211	202
Number of observations	2799	544	679	960	616
R-squared a	0.783	0.517	0.73	0.699	0.521

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. The specification in the regression is a translog specification and the full list of coefficients can be seen in Table **??**

Table B3: Main results : Parametric translog - No teff (Battese adjustment)

	All	N. Highlands	C. Highlands	Other	Enset
Dummy Shannon index	-0.096**	-0.011	-0.135*	0.044	-0.109
	(0.041)	(0.083)	(0.070)	(0.119)	(0.341)
Shannon index	-0.027	-0.21	0.065	-0.717	0.213
	(0.078)	(0.308)	(0.245)	(0.471)	(0.494)
Shannon index (square)	-0.016*	-0.028	-0.076	-0.049	0.01
	(0.009)	(0.023)	(0.138)	(0.033)	(0.057)
Area*Shannon index	0.030***	0.04	0.041	-0.03	0.022*
	(0.009)	(0.113)	(0.066)	(0.154)	(0.013)
Household size*Shannon index	-0.024	0.016	-0.045	0.167	-0.04
	(0.021)	(0.128)	(0.104)	(0.240)	(0.042)
Oxen*Shannon index	-0.064*	0.07	-0.083	-0.225**	-0.39
	(0.039)	(0.189)	(0.109)	(0.093)	(1.553)
Fertilizer*Shannon index	0.022*	0.02	0.024	0.105	-0.023
	(0.012)	(0.071)	(0.026)	(0.065)	(0.028)
Hoes*Shannon index	0.025	-0.328	0.044	-0.332	0.026
	(0.023)	(0.280)	(0.084)	(0.400)	(0.030)
Ploughs*Shannon index	-0.004	0.011	-0.092	0.009	0.14
	(0.021)	(0.030)	(0.063)	(0.272)	(0.090)
Constant	6.869***	6.261***	6.313***	6.043***	5.595***
	(0.185)	(0.394)	(0.216)	(0.412)	(0.486)
Elasticity of Shannon index	-0.039	-0.228	0.042	-0.265	0.072
p-value	0.489	0.166	0.647	0.107	0.878
Household fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Dummies	✓	✓	✓	✓	✓
Linear variables	✓	✓	✓	✓	✓
Squares	✓	✓	✓	✓	✓
Interactions	✓	✓	✓	✓	✓
Number of households	893	211	344	128	210
Number of observations	3005	779	1323	496	407
R-squared a	0.789	0.751	0.668	0.447	0.62

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. The specification in the regression is a translog specification and the full list of coefficients can be seen in Table **??**

Table B4: Parametric translog full (Battese transformation)

	All	N. Highlands	C. Highlands	Other	Enset
Dummy fertilizer	-0.192***	-0.463**	-0.215**	-0.167	-0.151
	(0.056)	(0.190)	(0.099)	(0.127)	(0.110)
Dummy oxen	-0.073***	-0.099**	-0.091**	-0.154***	-0.064
	(0.022)	(0.046)	(0.038)	(0.045)	(0.059)
Dummy hoe	-0.021	0.031	-0.017	-0.109**	0.043
	(0.021)	(0.041)	(0.037)	(0.043)	(0.060)
Dummy plough	-0.083***	0.002	-0.104**	-0.065	-0.105*
	(0.024)	(0.049)	(0.042)	(0.050)	(0.054)
Dummy Shannon index	-0.174***	-0.131**	-0.113***	-0.141**	-0.217**
	(0.026)	(0.053)	(0.042)	(0.067)	(0.091)
Area	0.636***	0.561***	0.619***	0.624***	0.553***
	(0.036)	(0.074)	(0.070)	(0.099)	(0.103)
Household size	-0.071	0.126	-0.226**	0.18	-0.346*
	(0.060)	(0.121)	(0.104)	(0.144)	(0.200)
Oxen	0.388***	0.616*	0.231	0.278	1.590***
	(0.106)	(0.325)	(0.159)	(0.208)	(0.567)
Fertilizer	-0.117***	-0.348**	-0.111**	-0.091	-0.216**
	(0.034)	(0.172)	(0.056)	(0.072)	(0.094)
Hoes	0.004	-0.433**	0.276**	-0.062	0.066
	(0.081)	(0.217)	(0.123)	(0.163)	(0.270)
Ploughs	-0.01	0.107	-0.037	0.069	-0.125
	(0.062)	(0.132)	(0.093)	(0.127)	(0.360)
Shannon index	0.090**	-0.076	0.073	0.227	0.132
	(0.043)	(0.148)	(0.136)	(0.183)	(0.131)
Area (square)	-0.004	-0.01	-0.139***	0.049	0.028
	(0.015)	(0.035)	(0.031)	(0.044)	(0.035)
Household size (square)	0.095**	0.013	0.131*	-0.113	0.288**
	(0.040)	(0.086)	(0.069)	(0.093)	(0.121)
Oxen (square)	-0.031	-0.642	-0.122	0.237	0.023
	(0.109)	(0.508)	(0.162)	(0.197)	(0.484)
Fertilizer (square)	0.067***	0.084	0.058***	0.060***	0.088***
	(0.010)	(0.070)	(0.016)	(0.019)	(0.027)
Hoes (square)	0.032	-0.011	0.026	0.128	-0.305
	(0.057)	(0.151)	(0.076)	(0.124)	(0.225)
Ploughs (square)	0.002	0.022	0.04	0.058	-0.058
	(0.036)	(0.086)	(0.052)	(0.071)	(0.193)
Shannon index (square)	0.007*	-0.005	0.004	-0.016	0.011
	(0.004)	(0.015)	(0.010)	(0.018)	(0.015)
Area*Household size	-0.033*	0.007	0.027	-0.044	0.012
	(0.018)	(0.039)	(0.035)	(0.050)	(0.049)
Area*Oxen	0.035	-0.043	0.019	0.255***	-0.097
	(0.032)	(0.072)	(0.054)	(0.072)	(0.125)
Area*Fertilizer	-0.006	-0.005	-0.018	-0.026**	-0.032*
	(0.006)	(0.025)	(0.011)	(0.013)	(0.017)
Area*Hoes	0.019	-0.126**	0.102**	-0.095*	0.011
	(0.023)	(0.063)	(0.044)	(0.049)	(0.055)
Area*Ploughs	0.011	0.048	-0.053*	-0.036	-0.021
	(0.018)	(0.037)	(0.031)	(0.045)	(0.070)
Area*Shannon index	0.016**	0.058	-0.01	0.177***	0.012
	(0.007)	(0.071)	(0.055)	(0.066)	(0.011)
Household size*Oxen	-0.066	-0.074	0.047	-0.14	-0.697**
	(0.053)	(0.135)	(0.081)	(0.096)	(0.287)
Household size*Fertilizer	-0.01	0.047	0.006	0	-0.007
	(0.008)	(0.040)	(0.014)	(0.018)	(0.030)
Household size*Hoes	0.042	0.263**	-0.025	0.036	0.049
	(0.037)	(0.117)	(0.059)	(0.071)	(0.115)
Household size*Ploughs	0.024	-0.047	0.003	0.103*	0.066
	(0.029)	(0.062)	(0.046)	(0.062)	(0.133)
Household size*Shannon index	0.011	0.074	-0.069	-0.046	0.002
	(0.016)	(0.076)	(0.072)	(0.096)	(0.028)
Oxen*Fertilizer	-0.020*	-0.047	-0.016	-0.019	0.031
	(0.012)	(0.050)	(0.020)	(0.026)	(0.057)
Oxen*Hoes	-0.061	0.046	-0.077	0.009	-0.044
	(0.044)	(0.150)	(0.067)	(0.082)	(0.178)
Oxen*Ploughs	0.008	-0.06	0.088*	-0.138**	-0.077
	(0.034)	(0.094)	(0.049)	(0.068)	(0.208)
Oxen*Shannon index	-0.029	0.12	0.019	-0.115*	-0.104
	(0.031)	(0.105)	(0.085)	(0.062)	(0.484)
Fertilizer*Hoes	0.01	0.023	-0.009	0.009	0.055
	(0.010)	(0.049)	(0.016)	(0.023)	(0.035)
Fertilizer*Ploughs	0.002	-0.03	0.003	-0.030*	-0.013
	(0.007)	(0.028)	(0.011)	(0.017)	(0.042)
Fertilizer*Shannon index	-0.001	-0.022	0.032*	0.02	0.005
	(0.006)	(0.053)	(0.019)	(0.026)	(0.014)
Hoes*Ploughs	-0.039*	-0.009	-0.082***	0.001	0.06
	(0.022)	(0.056)	(0.032)	(0.049)	(0.094)
Hoes*Shannon index	0.01	0.071	-0.003	-0.282**	0.023
	(0.020)	(0.068)	(0.062)	(0.110)	(0.028)
Ploughs*Shannon index	-0.015	0.003	-0.067	-0.142*	0.007
	(0.014)	(0.026)	(0.045)	(0.084)	(0.029)
Constant	6.931***	5.839***	6.297***	5.670***	5.746***
	(0.153)	(0.227)	(0.150)	(0.200)	(0.262)
Elasticity of Shannon index	0.091***	0.027	0.027	0.096	0.127
p-value	0.002	0.731	0.552	0.109	0.322
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	1281	289	429	299	264
Number of observations	5804	1323	2002	1456	1023
R-squared a	0.787	0.752	0.687	0.623	0.549

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table B5: Parametric translog teff only (Battese transformation)

	All	N. Highlands	C. Highlands	Other	Enset
Dummy fertilizer	-0.105	-0.32	-0.196	-0.22	-0.026
	(0.079)	(0.249)	(0.140)	(0.146)	(0.174)
Dummy oxen	-0.074**	-0.1	-0.130**	-0.033	-0.042
	(0.032)	(0.082)	(0.065)	(0.054)	(0.070)
Dummy hoe	-0.021	-0.019	-0.041	-0.087*	0.1
	(0.030)	(0.071)	(0.057)	(0.047)	(0.079)
Dummy plough	-0.098***	0.058	-0.106	-0.053	-0.140**
	(0.035)	(0.088)	(0.073)	(0.064)	(0.067)
Dummy Shannon index	-0.350***	-0.274**	-0.096	-0.299***	-0.509***
	(0.043)	(0.112)	(0.084)	(0.094)	(0.109)
Area	0.649***	0.626***	0.697***	0.745***	0.407**
	(0.054)	(0.134)	(0.124)	(0.157)	(0.168)
Household size	0.019	-0.002	0.036	0.379**	-0.358
	(0.090)	(0.220)	(0.171)	(0.177)	(0.327)
Oxen	0.275*	0.244	-0.184	0.046	1.572*
	(0.141)	(0.432)	(0.305)	(0.200)	(0.899)
Fertilizer	-0.049	0.138	-0.079	-0.074	-0.199
	(0.047)	(0.302)	(0.079)	(0.077)	(0.149)
Hoes	-0.116	-0.499*	-0.072	0.015	0.334
	(0.101)	(0.290)	(0.194)	(0.161)	(0.372)
Ploughs	0.002	0.177	0.024	-0.05	-0.357
	(0.081)	(0.201)	(0.148)	(0.124)	(0.437)
Shannon index	0.093	0.255	-0.219	0.473**	0.099
	(0.069)	(0.307)	(0.200)	(0.235)	(0.170)
Area (square)	0.057**	0.016	-0.133*	-0.167**	0.106*
	(0.022)	(0.063)	(0.077)	(0.079)	(0.060)
Household size (square)	0.048	0.104	-0.088	-0.262**	0.364**
	(0.060)	(0.172)	(0.119)	(0.122)	(0.170)
Oxen (square)	-0.053	-1.172*	0.223	0.121	-0.402
	(0.139)	(0.628)	(0.380)	(0.177)	(0.757)
Fertilizer (square)	0.053***	-0.11	0.048**	0.039*	0.096**
	(0.014)	(0.130)	(0.023)	(0.020)	(0.041)
Hoes (square)	0.027	-0.043	0.11	0.06	-0.474
	(0.071)	(0.193)	(0.109)	(0.116)	(0.306)
Ploughs (square)	0.005	0.042	0.031	-0.026	0.099
	(0.047)	(0.114)	(0.085)	(0.068)	(0.233)
Shannon index (square)	0.014*	0.187***	-0.02	0.004	0
	(0.007)	(0.054)	(0.018)	(0.241)	(0.021)
Area*Household size	-0.063**	-0.08	-0.061	0.075	0.094
	(0.028)	(0.086)	(0.070)	(0.088)	(0.075)
Area*Oxen	0.098**	-0.051	0.086	0.258***	-0.09
	(0.048)	(0.111)	(0.118)	(0.074)	(0.236)
Area*Fertilizer	-0.007	-0.053	-0.007	-0.059***	-0.014
	(0.008)	(0.040)	(0.021)	(0.019)	(0.026)
Area*Hoes	0.03	-0.103	0.077	0.004	0.198**
	(0.031)	(0.108)	(0.077)	(0.064)	(0.083)
Area*Ploughs	0.016	0.061	-0.05	0.018	-0.072
	(0.024)	(0.067)	(0.056)	(0.058)	(0.081)
Area*Shannon index	0.016	-0.155	-0.242**	0.129	0.261**
	(0.027)	(0.121)	(0.116)	(0.105)	(0.128)
Household size*Oxen	-0.003	0.225	0.264*	-0.086	-0.629
	(0.070)	(0.212)	(0.149)	(0.091)	(0.479)
Household size*Fertilizer	-0.023**	-0.061	0.018	-0.003	-0.004
	(0.012)	(0.087)	(0.020)	(0.020)	(0.043)
Household size*Hoes	0.080*	0.297*	0.1	-0.026	0.103
	(0.048)	(0.172)	(0.099)	(0.072)	(0.154)
Household size*Ploughs	0	-0.12	-0.058	0.069	0.044
	(0.039)	(0.110)	(0.075)	(0.065)	(0.152)
Household size*Shannon index	0.056	0.024	0.086	0.015	0.254**
	(0.035)	(0.206)	(0.112)	(0.119)	(0.108)
Oxen*Fertilizer	-0.025	0.182*	-0.059*	0.017	0.016
	(0.016)	(0.094)	(0.031)	(0.025)	(0.093)
Oxen*Hoes	-0.069	-0.119	-0.207*	-0.066	-0.075
	(0.055)	(0.196)	(0.106)	(0.077)	(0.310)
Oxen*Ploughs	0.047	0.082	0.158*	-0.038	0.089
	(0.044)	(0.125)	(0.082)	(0.063)	(0.287)
Oxen*Shannon index	0.007	-0.067	0.153	0.004	-0.929
	(0.081)	(0.244)	(0.167)	(0.130)	(0.667)
Fertilizer*Hoes	0.014	0.101	0.004	0.02	0.034
	(0.012)	(0.077)	(0.021)	(0.023)	(0.050)
Fertilizer*Ploughs	-0.006	-0.143*	-0.007	0	-0.013
	(0.009)	(0.073)	(0.016)	(0.018)	(0.051)
Fertilizer*Shannon index	-0.002	-0.055	0.036	-0.057*	-0.036
	(0.014)	(0.091)	(0.029)	(0.031)	(0.051)
Hoes*Ploughs	-0.02	0.052	-0.092**	0.005	0.116
	(0.028)	(0.071)	(0.047)	(0.048)	(0.108)
Hoes*Shannon index	0.008	0.073	0.042	-0.281**	0.36
	(0.050)	(0.083)	(0.110)	(0.114)	(0.244)
Ploughs*Shannon index	-0.038	0.134	-0.084	-0.1	-0.151**
	(0.023)	(0.091)	(0.081)	(0.089)	(0.073)
Constant	5.892***	5.851***	6.502***	5.254***	5.372***
	(0.575)	(0.314)	(0.281)	(0.234)	(0.439)
Elasticity of Shannon index	0.104***	0.154**	0.024	0.235***	0.001
p-value	0.000	0.019	0.607	0.000	0.981
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	782	152	217	211	202
Number of observations	2799	544	679	960	616
R-squared a	0.783	0.517	0.73	0.699	0.521

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table B6: Parametric translog noteff (Battese transformation)

	All	N. Highlands	C. Highlands	Other	Enset
Dummy fertilizer	-0.188**	-0.995***	-0.201	0.001	-0.283*
	(0.081)	(0.340)	(0.139)	(0.236)	(0.155)
Dummy oxen	-0.077**	-0.056	-0.081*	-0.201***	-0.09
	(0.031)	(0.057)	(0.048)	(0.077)	(0.115)
Dummy hoe	-0.028	0.086*	-0.032	-0.154*	-0.098
	(0.030)	(0.050)	(0.049)	(0.085)	(0.093)
Dummy plough	-0.080**	-0.057	-0.106**	-0.115	-0.004
	(0.032)	(0.059)	(0.053)	(0.084)	(0.092)
Dummy Shannon index	-0.096**	-0.011	-0.135*	0.044	-0.109
	(0.041)	(0.083)	(0.070)	(0.119)	(0.341)
Area	0.592***	0.647***	0.606***	0.480**	0.583***
	(0.054)	(0.161)	(0.092)	(0.203)	(0.146)
Household size	-0.178**	0.095	-0.313**	-0.035	-0.24
	(0.083)	(0.166)	(0.135)	(0.291)	(0.299)
Oxen	0.506***	0.712	0.359*	0.457	1.154
	(0.161)	(0.659)	(0.196)	(1.033)	(0.839)
Fertilizer	-0.118**	-0.637**	-0.119	-0.106	0.006
	(0.052)	(0.277)	(0.077)	(0.165)	(0.166)
Hoes	0.212	0.097	0.449***	-0.412	0.831*
	(0.135)	(0.517)	(0.166)	(0.547)	(0.444)
Ploughs	0.002	0.124	-0.108	0.541	0.667
	(0.096)	(0.212)	(0.122)	(0.380)	(1.023)
Shannon index	-0.027	-0.21	0.065	-0.717	0.213
	(0.078)	(0.308)	(0.245)	(0.471)	(0.494)
Area (square)	-0.055**	0.025	-0.119***	0.034	-0.013
	(0.023)	(0.084)	(0.038)	(0.096)	(0.051)
Household size (square)	0.159***	0.001	0.232***	0.082	0.274
	(0.055)	(0.102)	(0.086)	(0.193)	(0.201)
Oxen (square)	0.013	-0.446	-0.265	3.039	-0.738
	(0.177)	(1.130)	(0.191)	(2.228)	(1.019)
Fertilizer (square)	0.060***	0.176*	0.065***	0.084*	0.034
	(0.015)	(0.103)	(0.021)	(0.047)	(0.042)
Hoes (square)	0.059	0.053	0.041	0.304	-0.286
	(0.095)	(0.288)	(0.112)	(0.448)	(0.349)
Ploughs (square)	-0.015	0.048	0.047	0.187	-0.596
	(0.057)	(0.146)	(0.066)	(0.249)	(0.521)
Shannon index (square)	-0.016*	-0.028	-0.076	-0.049	0.01
	(0.009)	(0.023)	(0.138)	(0.033)	(0.057)
Area*Household size	-0.021	-0.011	0.061	0.002	-0.007
	(0.026)	(0.062)	(0.045)	(0.097)	(0.072)
Area*Oxen	-0.038	-0.229	-0.042	0.07	-0.099
	(0.047)	(0.169)	(0.065)	(0.326)	(0.176)
Area*Fertilizer	0.001	0.055	-0.030**	-0.035	-0.023
	(0.009)	(0.048)	(0.014)	(0.027)	(0.029)
Area*Hoes	0.073**	0.086	0.193***	-0.052	0.003
	(0.037)	(0.139)	(0.060)	(0.134)	(0.082)
Area*Ploughs	0.023	0.051	-0.053	0.089	-0.103
	(0.029)	(0.068)	(0.041)	(0.120)	(0.197)
Area*Shannon index	0.030***	0.04	0.041	-0.03	0.022*
	(0.009)	(0.113)	(0.066)	(0.154)	(0.013)
Household size*Oxen	-0.171**	-0.208	-0.036	-0.675	-0.159
	(0.081)	(0.199)	(0.099)	(0.554)	(0.457)
Household size*Fertilizer	0.007	0.073	-0.006	0.011	-0.066
	(0.013)	(0.049)	(0.019)	(0.047)	(0.069)
Household size*Hoes	-0.025	0.101	-0.037	0.049	-0.362*
	(0.061)	(0.219)	(0.077)	(0.263)	(0.199)
Household size*Ploughs	0.045	-0.028	0.02	-0.047	-0.181
	(0.043)	(0.080)	(0.061)	(0.206)	(0.446)
Household size*Shannon index	-0.024	0.016	-0.045	0.167	-0.04
	(0.021)	(0.128)	(0.104)	(0.240)	(0.042)
Oxen*Fertilizer	-0.001	-0.149**	0.015	0.047	-0.138
	(0.019)	(0.068)	(0.026)	(0.112)	(0.128)
Oxen*Hoes	-0.082	-0.183	-0.051	0.053	-0.251
	(0.073)	(0.394)	(0.088)	(0.459)	(0.281)
Oxen*Ploughs	-0.042	-0.284	0.025	-1.419**	-0.641
	(0.056)	(0.202)	(0.066)	(0.606)	(0.477)
Oxen*Shannon index	-0.064*	0.07	-0.083	-0.225**	-0.39
	(0.039)	(0.189)	(0.109)	(0.093)	(1.553)
Fertilizer*Hoes	-0.001	-0.041	-0.045*	0.051	0.124*
	(0.017)	(0.088)	(0.024)	(0.066)	(0.069)
Fertilizer*Ploughs	0.008	-0.038	0.019	-0.06	0.086
	(0.013)	(0.034)	(0.017)	(0.043)	(0.102)
Fertilizer*Shannon index	0.022*	0.02	0.024	0.105	-0.023
	(0.012)	(0.071)	(0.026)	(0.065)	(0.028)
Hoes*Ploughs	-0.051	-0.14	-0.057	-0.129	0.201
	(0.036)	(0.118)	(0.045)	(0.147)	(0.300)
Hoes*Shannon index	0.025	-0.328	0.044	-0.332	0.026
	(0.023)	(0.280)	(0.084)	(0.400)	(0.030)
Ploughs*Shannon index	-0.004	0.011	-0.092	0.009	0.14
	(0.021)	(0.030)	(0.063)	(0.272)	(0.090)
Constant	6.869***	6.261***	6.313***	6.043***	5.595***
	(0.185)	(0.394)	(0.216)	(0.412)	(0.486)
Elasticity of Shannon index	-0.039	-0.228	0.042	-0.265	0.072
p-value	0.489	0.166	0.647	0.107	0.878
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	894	211	345	128	210
Number of observations	3006	779	1324	496	407
R-squared a	0.789	0.751	0.67	0.44	0.612

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

10.2 No imputed data

Table B7: Summary Statistics - no imputed values

	All		**N. Highlands**		**C. Highlands**		**Other**		**Enset**	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Cereal Production (kgs)	927.86	1074.11	420.71	443.24	1187.45	987.64	1319.30	1385.10	220.51	356.73
Cereal Yield (kg/ha)	848.51	774.19	510.64	488.47	950.24	786.24	1007.20	810.16	699.72	790.96
Cereal Area (ha)	1.31	1.11	1.12	1.01	1.54	1.05	1.62	1.23	0.46	0.54
Shannon index	0.54	0.41	0.59	0.43	0.51	0.33	0.80	0.35	0.14	0.27
Number of oxen	0.97	1.16	0.75	0.90	1.30	1.16	1.03	1.31	0.36	0.77
Household Size	6.27	2.72	5.36	2.30	6.06	2.63	6.43	2.61	7.37	3.07
Quantity Ferilizer (kgs)	64.66	93.54	2.64	10.64	89.95	86.08	93.81	124.24	22.51	35.20
Number of ploughs (units)	1.90	3.10	1.87	3.24	2.45	3.51	1.72	2.90	0.98	1.72
Number of hoes (units)	1.18	1.63	0.99	1.67	1.45	1.76	1.10	1.59	0.88	1.20
Tigray	0.05	0.22	0.31	0.46	0.00	0.00	0.00	0.00	0.00	0.00
Amhara	0.42	0.49	0.69	0.46	0.78	0.41	0.00	0.00	0.00	0.00
Oromia	0.36	0.48	0.00	0.00	0.22	0.41	1.00	0.00	0.00	0.00
SSN	0.17	0.38	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Northern Highlands	0.17	0.37	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Central Highlands	0.38	0.49	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Other	0.27	0.45	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Enset	0.17	0.38	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Number of observations	3928		664		1511		1078		675	

Table B8: Parametric translog full (No imputed data)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.544***	0.359*	0.532***	0.444**	0.332
	(0.082)	(0.200)	(0.112)	(0.191)	(0.256)
Household size	-0.108	-0.475	-0.286	0.123	-0.24
	(0.144)	(0.442)	(0.203)	(0.291)	(0.439)
Oxen	0.124***	0.138	0.101*	0.175***	0.372***
	(0.033)	(0.098)	(0.051)	(0.058)	(0.138)
Fertilizer	0.021**	-0.103*	0.008	0.029	0.008
	(0.010)	(0.060)	(0.014)	(0.019)	(0.033)
Shannon index	0.102***	0.169*	0.062	0.211***	0.034
	(0.037)	(0.086)	(0.052)	(0.075)	(0.090)
Area (square)	0.03	0.028	-0.184***	0.046	0.007
	(0.033)	(0.084)	(0.055)	(0.090)	(0.084)
Household size (square)	0.085	0.35	0.295**	-0.175	-0.078
	(0.090)	(0.248)	(0.126)	(0.184)	(0.204)
Oxen (square)	0.017***	0.011	0.016**	0.022***	0.046**
	(0.005)	(0.014)	(0.007)	(0.008)	(0.019)
Fertilizer (square)	0.003*	-0.016*	0.001	0.004	0.003
	(0.002)	(0.010)	(0.002)	(0.003)	(0.005)
Shannon index (square)	0.013**	0.026**	0.007	0.026**	-0.004
	(0.005)	(0.012)	(0.007)	(0.010)	(0.012)
Area*Household size	-0.049	-0.027	0.008	0.016	0.015
	(0.040)	(0.101)	(0.059)	(0.092)	(0.097)
Area*Oxen	0.001	-0.011*	0	0.005	0.009*
	(0.002)	(0.006)	(0.005)	(0.005)	(0.005)
Area*Fertilizer	0.002	0.003	0.004	-0.004	-0.004
	(0.002)	(0.007)	(0.005)	(0.004)	(0.006)
Area*Shannon index	-0.004	-0.008	0	0.015	-0.004
	(0.003)	(0.008)	(0.005)	(0.011)	(0.009)
Household size*Oxen	-0.003	-0.017*	0.006	-0.015**	-0.017
	(0.004)	(0.010)	(0.005)	(0.007)	(0.010)
Household size*Fertilizer	-0.002	0.006	0.001	0.002	-0.006
	(0.004)	(0.013)	(0.006)	(0.008)	(0.010)
Household size*Shannon index	-0.001	0.001	-0.006	-0.013	-0.015
	(0.005)	(0.013)	(0.007)	(0.012)	(0.013)
Oxen*Fertilizer	0	0.001	0	0.001	0.001
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Oxen*Shannon index	0	0.002**	0	-0.002	0.001*
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Fertilizer*Shannon index	0	-0.002*	0	0	-0.002**
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Constant	6.725***	6.247***	6.529***	6.244***	6.273***
	(0.137)	(0.529)	(0.191)	(0.275)	(0.601)
Elasticity of Shannon index	0.048	0.084	0.031	0.169	0.037
p-value	0.002	0.019	0.273	0.004	0.372
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	1056	213	376	271	196
Number of observations	3928	664	1511	1078	675
Average obs. per household	3.72	3.117	4.019	3.978	3.444
R-squared a	0.472	0.388	0.499	0.505	0.465
R-squared w	0.485	0.42	0.515	0.521	0.494

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese since many of these dummies are time-invariant which would be incompatible with the fixed effects. Instead 0 values are assigned the value of 0.000001.

Table B9: Parametric translog teff only (No imputed data)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.513***	0.367	0.900***	0.666***	-0.108
	(0.140)	(0.251)	(0.272)	(0.232)	(0.424)
Household size	-0.013	-0.188	-0.785*	0.287	-0.277
	(0.193)	(0.614)	(0.461)	(0.303)	(0.610)
Oxen	0.166***	0.185*	0.054	0.150**	0.581**
	(0.043)	(0.109)	(0.104)	(0.058)	(0.245)
Fertilizer	0.036**	-0.087	0.007	0.027	0.017
	(0.017)	(0.069)	(0.029)	(0.024)	(0.056)
Shannon index	0.197***	0.098	0.113	0.278***	0.143
	(0.056)	(0.101)	(0.080)	(0.074)	(0.165)
Area (square)	0.097*	0.111	-0.187	-0.144	0.004
	(0.053)	(0.158)	(0.158)	(0.135)	(0.118)
Household size (square)	-0.03	0.418	0.557**	-0.330*	-0.077
	(0.120)	(0.339)	(0.264)	(0.198)	(0.279)
Oxen (square)	0.021***	0.015	0.007	0.018**	0.071**
	(0.006)	(0.015)	(0.015)	(0.008)	(0.036)
Fertilizer (square)	0.004*	-0.007	0.004	0.003	0.001
	(0.002)	(0.010)	(0.004)	(0.003)	(0.006)
Shannon index (square)	0.025***	0.029**	0.012	0.034***	0.006
	(0.008)	(0.014)	(0.010)	(0.010)	(0.022)
Area*Household size	-0.065	-0.112	-0.179	0.054	0.201
	(0.069)	(0.138)	(0.150)	(0.137)	(0.171)
Area*Oxen	0	-0.006	-0.001	0.020***	0
	(0.004)	(0.007)	(0.009)	(0.007)	(0.010)
Area*Fertilizer	0.002	-0.002	0.013	-0.023***	-0.004
	(0.004)	(0.009)	(0.010)	(0.008)	(0.016)
Area*Shannon index	-0.013**	-0.024*	-0.005	0.017	-0.009
	(0.006)	(0.013)	(0.014)	(0.014)	(0.014)
Household size*Oxen	-0.009*	-0.021*	-0.001	-0.022**	-0.034***
	(0.005)	(0.011)	(0.011)	(0.009)	(0.013)
Household size*Fertilizer	-0.006	0.029	0.011	0.007	-0.013
	(0.007)	(0.024)	(0.013)	(0.012)	(0.020)
Household size*Shannon index	-0.002	0.053***	-0.013	-0.019	-0.029
	(0.008)	(0.020)	(0.016)	(0.014)	(0.020)
Oxen*Fertilizer	0	0.003**	0	0	0.002
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Oxen*Shannon index	0	-0.001	0.001	0.001	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Fertilizer*Shannon index	0	-0.002	0	-0.001	-0.002*
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Constant	6.621***	5.608***	7.255***	5.990***	6.223***
	(0.184)	(0.718)	(0.427)	(0.277)	(0.823)
Elasticity of Shannon index	0.117	0.179	0.061	0.229	0.019
p-value	0.000	0.032	0.249	0.000	0.744
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	632	121	166	186	159
Number of observations	2063	418	459	726	460
Average obs. per household	3.264	3.455	2.765	3.903	2.893
R-squared a	0.506	0.279	0.564	0.615	0.519
R-squared w	0.522	0.327	0.597	0.631	0.555

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese since many of these dummies are time-invariant which would be incompatible with the fixed effects. Instead 0 values are assigned the value of 0.000001.

Table B10: Parametric translog no teff (No imputed data)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.401***	0.697	0.368***	0.106	-0.446
	(0.101)	(0.617)	(0.132)	(0.310)	(0.920)
Household size	-0.361*	-1.374	-0.295	-0.778	2.356*
	(0.202)	(0.990)	(0.245)	(0.558)	(1.407)
Oxen	0.094*	0.044	0.086	0.085	0.414
	(0.055)	(0.304)	(0.063)	(0.209)	(0.318)
Fertilizer	0.008	-0.105	0.006	0.016	-0.115
	(0.015)	(0.148)	(0.018)	(0.035)	(0.100)
Shannon index	0.015	-0.488	0.056	0.031	-0.109
	(0.069)	(0.474)	(0.085)	(0.163)	(0.175)
Area (square)	-0.053	0.256	-0.207***	0.094	-0.35
	(0.042)	(0.268)	(0.064)	(0.146)	(0.225)
Household size (square)	0.291**	0.714	0.304**	0.392	-2.669***
	(0.126)	(0.505)	(0.154)	(0.299)	(0.670)
Oxen (square)	0.014*	-0.004	0.015	0.011	0.055
	(0.008)	(0.041)	(0.009)	(0.030)	(0.045)
Fertilizer (square)	0.001	-0.016	0.002	-0.001	-0.006
	(0.003)	(0.019)	(0.003)	(0.006)	(0.015)
Shannon index (square)	0	-0.067	0.005	-0.007	-0.034*
	(0.009)	(0.066)	(0.012)	(0.022)	(0.020)
Area*Household size	0.046	0.029	0.101	0.105	-0.101
	(0.052)	(0.211)	(0.072)	(0.150)	(0.266)
Area*Oxen	-0.002	-0.004	-0.003	-0.016	-0.005
	(0.004)	(0.019)	(0.006)	(0.011)	(0.008)
Area*Fertilizer	0.006*	0.006	0.004	0.003	-0.021
	(0.004)	(0.024)	(0.006)	(0.008)	(0.017)
Area*Shannon index	-0.003	0	0	0.011	-0.042
	(0.004)	(0.018)	(0.006)	(0.015)	(0.035)
Household size*Oxen	0.002	-0.03	0.014*	-0.007	-0.087***
	(0.005)	(0.024)	(0.007)	(0.020)	(0.031)
Household size*Fertilizer	0.001	-0.007	0.001	-0.001	0.089***
	(0.005)	(0.031)	(0.007)	(0.009)	(0.023)
Household size*Shannon index	-0.006	-0.004	-0.01	-0.039	-0.146***
	(0.007)	(0.022)	(0.009)	(0.026)	(0.048)
Oxen*Fertilizer	-0.001	-0.002	-0.001	0.001	-0.002
	(0.000)	(0.002)	(0.001)	(0.001)	(0.002)
Oxen*Shannon index	0	0.003	0	-0.001	-0.010***
	(0.000)	(0.002)	(0.001)	(0.001)	(0.003)
Fertilizer*Shannon index	0	-0.003	0	0.002	0.008*
	(0.000)	(0.002)	(0.001)	(0.001)	(0.004)
Constant	6.935***	6.937***	6.358***	7.243***	4.566***
	(0.204)	(1.429)	(0.231)	(0.772)	(1.304)
Elasticity of Shannon index	0.007	0.151	0.021	-0.027	0.184
p-value	0.68	0.289	0.585	0.789	0.117
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	666	140	282	108	136
Number of observations	1865	246	1052	352	215
Average obs. per household	2.8	1.757	3.73	3.259	1.581
R-squared a	0.468	0.604	0.488	0.248	0.672
R-squared w	0.491	0.661	0.509	0.306	0.724

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese since many of these dummies are time-invariant which would be incompatible with the fixed effects. Instead 0 values are assigned the value of 0.000001.

Table B11: Parametric translog full (Battese transformation, no imputed data)

	All	N. Highlands	C. Highlands	Other	Enset
Dummy fertilizer	-0.178***	-0.377*	-0.149	-0.265**	-0.108
	(0.069)	(0.217)	(0.127)	(0.135)	(0.148)
Dummy oxen	-0.085***	-0.140*	-0.064	-0.172***	-0.103
	(0.027)	(0.073)	(0.045)	(0.053)	(0.067)
Dummy Shannon index	-0.200***	-0.178**	-0.132***	-0.160*	-0.291***
	(0.032)	(0.081)	(0.048)	(0.086)	(0.110)
Area	0.616***	0.542***	0.600***	0.630***	0.496***
	(0.049)	(0.104)	(0.101)	(0.130)	(0.157)
Household size	-0.137*	-0.044	-0.237*	0.071	-0.611**
	(0.079)	(0.192)	(0.134)	(0.171)	(0.288)
Oxen	0.318***	0.259	0.302*	0.378*	1.816*
	(0.121)	(0.407)	(0.180)	(0.229)	(0.989)
Fertilizer	-0.113***	-0.202	-0.108	-0.118	-0.202*
	(0.041)	(0.214)	(0.068)	(0.077)	(0.120)
Shannon index	0.181***	0.379	0.189	0.228	0.216
	(0.056)	(0.268)	(0.167)	(0.248)	(0.189)
Area (square)	0.023	-0.021	-0.129***	0.029	0.06
	(0.019)	(0.049)	(0.045)	(0.059)	(0.050)
Household size (square)	0.164***	0.138	0.171**	-0.003	0.420***
	(0.050)	(0.137)	(0.081)	(0.107)	(0.155)
Oxen (square)	0.047	-0.57	-0.1	0.279	0.114
	(0.120)	(0.614)	(0.172)	(0.212)	(0.686)
Fertilizer (square)	0.071***	-0.039	0.066***	0.059***	0.101***
	(0.012)	(0.093)	(0.018)	(0.021)	(0.032)
Shannon index (square)	0.012***	0.05	0.012	0.008	0.021
	(0.005)	(0.031)	(0.010)	(0.025)	(0.019)
Area*Household size	-0.054**	-0.064	0.048	-0.093	-0.015
	(0.025)	(0.058)	(0.051)	(0.066)	(0.073)
Area*Oxen	0.044	-0.083	0.013	0.292***	-0.184
	(0.038)	(0.093)	(0.063)	(0.079)	(0.191)
Area*Fertilizer	0.001	-0.008	-0.023	-0.019	-0.001
	(0.007)	(0.032)	(0.016)	(0.016)	(0.023)
Area*Shannon index	0.009	0.067	0.057	0.218**	0.011
	(0.009)	(0.117)	(0.062)	(0.099)	(0.013)
Household size*Oxen	-0.023	0.117	0.028	-0.169*	-0.765
	(0.058)	(0.184)	(0.088)	(0.099)	(0.501)
Household size*Fertilizer	-0.012	0.081	-0.002	0.011	0.004
	(0.010)	(0.066)	(0.018)	(0.021)	(0.039)
Household size*Shannon index	-0.015	-0.087	-0.125	0.017	0.013
	(0.021)	(0.138)	(0.083)	(0.130)	(0.039)
Oxen*Fertilizer	-0.036**	0.023	-0.016	-0.054*	-0.048
	(0.014)	(0.072)	(0.024)	(0.029)	(0.084)
Oxen*Shannon index	-0.05	0.277*	-0.032	-0.157	-1.103
	(0.034)	(0.152)	(0.089)	(0.137)	(0.952)
Fertilizer*Shannon index	-0.005	-0.036	0.015	-0.025	0.002
	(0.007)	(0.072)	(0.024)	(0.033)	(0.015)
Constant	7.101***	6.000***	6.261***	5.813***	5.829***
	(0.168)	(0.280)	(0.194)	(0.233)	(0.364)
Elasticity of Shannon index	0.123	0.252	0.027	0.181	0.176
p-value	0	0.007	0.573	0.011	0.276
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	1056	213	376	271	196
Number of observations	3928	664	1511	1078	675
Average obs. per household	3.72	3.117	4.019	3.978	3.444
R-squared a	0.765	0.644	0.636	0.614	0.493

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table B12: Parametric translog teff only (Battese transformation, no imputed data)

	All	N. Highlands	C. Highlands	Other	Enset
Dummy fertilizer	-0.133	-0.123	-0.173	-0.231	-0.21
	(0.094)	(0.271)	(0.179)	(0.152)	(0.212)
Dummy oxen	-0.067*	-0.116	0.065	-0.032	-0.06
	(0.038)	(0.092)	(0.089)	(0.062)	(0.076)
Dummy Shannon index	-0.332***	-0.353**	0.07	-0.351***	-0.449***
	(0.054)	(0.151)	(0.106)	(0.116)	(0.129)
Area	0.569***	0.630***	0.397**	0.641***	0.548***
	(0.068)	(0.173)	(0.195)	(0.184)	(0.204)
Household size	0.02	-0.084	-0.17	0.336*	-0.574
	(0.109)	(0.261)	(0.261)	(0.195)	(0.389)
Oxen	0.184	0.048	0.041	0.11	3.130**
	(0.160)	(0.469)	(0.365)	(0.211)	(1.483)
Fertilizer	-0.06	-0.032	-0.103	-0.08	-0.402**
	(0.054)	(0.302)	(0.100)	(0.081)	(0.187)
Shannon index	0.162**	0.098	-0.059	0.540**	-0.004
	(0.081)	(0.325)	(0.242)	(0.262)	(0.403)
Area (square)	0.026	0.101	-0.255***	-0.127	0.09
	(0.027)	(0.088)	(0.097)	(0.090)	(0.079)
Household size (square)	0.087	0.255	0.038	-0.209	0.479**
	(0.069)	(0.196)	(0.145)	(0.130)	(0.198)
Oxen (square)	0.109	-0.709	0.236	0.209	-0.37
	(0.163)	(0.676)	(0.451)	(0.185)	(0.873)
Fertilizer (square)	0.063***	-0.106	0.054*	0.043**	0.151***
	(0.016)	(0.130)	(0.028)	(0.021)	(0.049)
Shannon index (square)	0.020***	0.158***	-0.016	0.069	-0.001
	(0.007)	(0.058)	(0.017)	(0.258)	(0.028)
Area*Household size	-0.053	-0.201*	0.114	0.085	0.062
	(0.035)	(0.109)	(0.101)	(0.099)	(0.097)
Area*Oxen	0.122**	-0.028	0.157	0.303***	0.281
	(0.055)	(0.141)	(0.134)	(0.076)	(0.437)
Area*Fertilizer	0.006	-0.032	-0.004	-0.045**	-0.036
	(0.010)	(0.050)	(0.028)	(0.022)	(0.035)
Area*Shannon index	-0.011	-0.187	-0.183	0.113	0.242
	(0.026)	(0.159)	(0.139)	(0.116)	(0.158)
Household size*Oxen	0.034	0.236	0.228	-0.134	-0.553
	(0.075)	(0.232)	(0.165)	(0.091)	(0.637)
Household size*Fertilizer	-0.031**	0.053	0.017	-0.004	0.014
	(0.014)	(0.113)	(0.030)	(0.023)	(0.052)
Household size*Shannon index	0.017	0.26	-0.01	0.026	0.266*
	(0.041)	(0.211)	(0.124)	(0.131)	(0.161)
Oxen*Fertilizer	-0.042**	0.144	-0.083**	-0.005	-0.443**
	(0.018)	(0.108)	(0.040)	(0.027)	(0.198)
Oxen*Shannon index	-0.01	0.017	0.115	-0.149	-3.174**
	(0.088)	(0.284)	(0.165)	(0.129)	(1.503)
Fertilizer*Shannon index	0.003	-0.113	0.014	-0.077**	-0.015
	(0.015)	(0.111)	(0.036)	(0.035)	(0.076)
Constant	6.048***	5.680***	6.617***	5.168***	5.653***
	(0.568)	(0.348)	(0.379)	(0.263)	(0.521)
Elasticity of Shannon index	0.117	0.179	0.061	0.229	0.019
p-value	0.000	0.032	0.249	0.000	0.744
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	632	121	166	186	159
Number of observations	2063	418	459	726	460
Average obs. per household	3.264	3.455	2.765	3.903	2.893
R-squared a	0.79	0.435	0.72	0.714	0.497

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table B13: Parametric translog no teff (Battese transformation, no imputed data)

	All	N. Highlands	C. Highlands	Other	Enset
Dummy fertilizer	-0.15	-0.764*	-0.16	-0.021	-0.024
	(0.105)	(0.395)	(0.175)	(0.248)	(0.222)
Dummy oxen	-0.117***	-0.124	-0.110**	-0.253***	-0.15
	(0.040)	(0.126)	(0.054)	(0.091)	(0.148)
Dummy Shannon index	-0.144***	-0.002	-0.192**	-0.015	-0.078
	(0.051)	(0.189)	(0.077)	(0.151)	(0.486)
Area	0.671***	1.317***	0.636***	0.477*	0.209
	(0.077)	(0.280)	(0.126)	(0.267)	(0.291)
Household size	-0.326***	-0.409	-0.308*	-0.381	-0.879*
	(0.114)	(0.330)	(0.160)	(0.364)	(0.488)
Oxen	0.455**	1.079	0.292	1.61	3.882**
	(0.187)	(1.029)	(0.216)	(1.342)	(1.744)
Fertilizer	-0.112*	-0.079	-0.115	-0.145	0.307
	(0.063)	(0.424)	(0.094)	(0.186)	(0.220)
Shannon index	0.11	1.428*	0.29	-1.009	-0.117
	(0.103)	(0.745)	(0.291)	(0.698)	(0.893)
Area (square)	0.001	0.277**	-0.100*	-0.052	0.033
	(0.030)	(0.140)	(0.053)	(0.129)	(0.082)
Household size (square)	0.249***	0.112	0.253**	0.302	0.606**
	(0.073)	(0.214)	(0.100)	(0.232)	(0.285)
Oxen (square)	-0.032	-0.186	-0.185	2.37	3.903*
	(0.185)	(1.800)	(0.197)	(1.848)	(2.111)
Fertilizer (square)	0.060***	0.013	0.068***	0.100*	0.005
	(0.018)	(0.155)	(0.025)	(0.051)	(0.046)
Shannon index (square)	-0.008	0.094	0.011	0.069	-0.024
	(0.011)	(0.090)	(0.142)	(0.077)	(0.103)
Area*Household size	-0.06	-0.270**	0.068	-0.078	0.044
	(0.038)	(0.111)	(0.063)	(0.127)	(0.129)
Area*Oxen	-0.033	0.148	-0.071	-0.082	-0.291
	(0.056)	(0.279)	(0.075)	(0.311)	(0.256)
Area*Fertilizer	0.001	0.161*	-0.03	-0.022	0.066*
	(0.012)	(0.089)	(0.020)	(0.032)	(0.039)
Area*Shannon index	0.025**	0.347	0.107	-0.136	0.006
	(0.011)	(0.321)	(0.074)	(0.238)	(0.014)
Household size*Oxen	-0.107	-0.273	-0.032	-0.881	-2.925***
	(0.092)	(0.341)	(0.106)	(0.651)	(1.065)
Household size*Fertilizer	0.015	0.019	-0.01	0.029	-0.067
	(0.017)	(0.097)	(0.023)	(0.056)	(0.086)
Household size*Shannon index	-0.057**	-0.810**	-0.132	0.267	-0.019
	(0.027)	(0.364)	(0.119)	(0.392)	(0.063)
Oxen*Fertilizer	-0.026	-0.016	0.016	-0.025	0.149
	(0.023)	(0.129)	(0.030)	(0.108)	(0.206)
Oxen*Shannon index	-0.095**	0.446	-0.136	1.288*	0
	(0.044)	(0.580)	(0.113)	(0.778)	.
Fertilizer*Shannon index	0.012	0.205	0.009	0.133	-0.015
	(0.015)	(0.132)	(0.034)	(0.090)	(0.021)
Constant	7.205***	6.866***	6.359***	6.627***	5.400***
	(0.214)	(0.548)	(0.260)	(0.474)	(0.755)
Elasticity of Shannon index	0.015	-0.112	0.06	-0.183	-0.167
p-value	0.809	0.794	0.533	0.368	0.837
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	666	140	282	108	136
Number of observations	1865	246	1052	352	215
Average obs. per household	2.8	1.757	3.73	3.259	1.581
R-squared a	0.743	0.643	0.596	0.395	0.556

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table B14: Semi-parametric model: Parametric component (Full sample), no imputed values

	All	Teff	No teff
Area	0.607***	0.630***	0.500***
	(0.090)	(0.144)	(0.113)
Household size	-0.278*	-0.123	-0.503**
	(0.163)	(0.207)	(0.255)
Oxen	0.131***	0.143***	0.134*
	(0.043)	(0.053)	(0.074)
Fertilizer	0.020*	0.028	0.016
	(0.012)	(0.017)	(0.018)
Area (square)	-0.005	0	-0.009
	(0.016)	(0.024)	(0.020)
Household size (square)	0.115**	0.032	0.216***
	(0.051)	(0.066)	(0.078)
Oxen (square)	0.008***	0.008**	0.009*
	(0.003)	(0.004)	(0.005)
Fertilizer (square)	0.001	0.001	0.002
	(0.001)	(0.001)	(0.002)
Area*Household size	-0.097**	-0.107	-0.051
	(0.045)	(0.073)	(0.055)
Area*Oxen	0	0.004	-0.007
	(0.003)	(0.004)	(0.005)
Area*Fertilizer	-0.001	-0.001	0.001
	(0.003)	(0.004)	(0.004)
Household size*Oxen	-0.009**	-0.012*	-0.006
	(0.005)	(0.006)	(0.007)
Household size*Fertilizer	-0.001	-0.005	0.003
	(0.005)	(0.007)	(0.006)
Oxen*Fertilizer	0	0	0
	(0.000)	(0.000)	(0.000)
Village-year fixed effects	✓	✓	✓
Number of observations	2765	1509	1256
R-squared a	0.413	0.459	0.362

Table B15: Semi-parametric model: Parametric component (Northern Highlands), no imputed value

	All	Teff	No teff
Area	0.395*	0.611**	0.401
	(0.236)	(0.287)	(0.537)
Household size	-1.195**	-1.102*	-1.211
	(0.484)	(0.622)	(0.966)
Oxen	0.117	0.13	0.095
	(0.115)	(0.129)	(0.361)
Fertilizer	-0.065	-0.054	-0.032
	(0.051)	(0.056)	(0.117)
Area (square)	0.013	0.011	0.055
	(0.043)	(0.063)	(0.085)
Household size (square)	0.315**	0.387**	0.293
	(0.142)	(0.187)	(0.280)
Oxen (square)	0.005	0.004	0.007
	(0.008)	(0.009)	(0.026)
Fertilizer (square)	-0.007*	-0.003	-0.008
	(0.004)	(0.004)	(0.009)
Area*Household size	-0.035	-0.201	0.084
	(0.123)	(0.153)	(0.247)
Area*Oxen	-0.006	-0.001	-0.008
	(0.007)	(0.009)	(0.014)
Area*Fertilizer	-0.003	-0.008	0.007
	(0.007)	(0.008)	(0.023)
Household size*Oxen	-0.028**	-0.035**	-0.017
	(0.014)	(0.016)	(0.030)
Household size*Fertilizer	-0.011	0.013	-0.032
	(0.012)	(0.021)	(0.024)
Oxen*Fertilizer	-0.001	0.001	-0.003
	(0.001)	(0.002)	(0.002)
Village-year fixed effects	✓	✓	✓
Number of observations	437	316	121
R-squared a	0.341	0.197	0.532

Table B16: Semi-parametric model: Parametric component (Central Highlands), no imputed values

	All	Teff	No teff
Area	0.644***	0.927***	0.560***
	(0.134)	(0.271)	(0.154)
Household size	-0.264	-0.141	-0.302
	(0.230)	(0.320)	(0.297)
Oxen	0.099	0.11	0.102
	(0.070)	(0.096)	(0.085)
Fertilizer	0.022	0.110***	0.013
	(0.018)	(0.041)	(0.022)
Area (square)	-0.086***	-0.048	-0.079***
	(0.028)	(0.069)	(0.030)
Household size (square)	0.165**	0.137	0.187*
	(0.072)	(0.085)	(0.096)
Oxen (square)	0.007	0.008	0.007
	(0.005)	(0.007)	(0.006)
Fertilizer (square)	0.002	0.004	0.002
	(0.001)	(0.003)	(0.002)
Area*Household size	-0.081	-0.222	-0.038
	(0.073)	(0.143)	(0.086)
Area*Oxen	-0.002	0.006	-0.006
	(0.006)	(0.009)	(0.007)
Area*Fertilizer	-0.002	0.01	-0.005
	(0.006)	(0.013)	(0.007)
Household size*Oxen	0.001	0.001	-0.003
	(0.007)	(0.012)	(0.009)
Household size*Fertilizer	0.001	-0.039*	0.005
	(0.008)	(0.022)	(0.009)
Oxen*Fertilizer	0	0	-0.001
	(0.001)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	1079	305	774
R-squared a	0.366	0.429	0.357

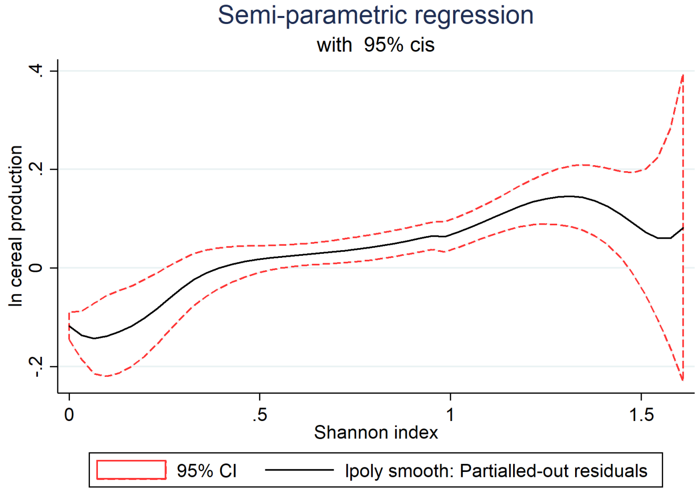
Table B17: Semi-parametric model: Parametric component (Arusi/Bale (Other)), no imputed values

	All	Teff	No teff
Area	0.484**	0.602*	0.277
	(0.204)	(0.324)	(0.315)
Household size	0.18	0.488	-0.839
	(0.308)	(0.373)	(0.568)
Oxen	0.173**	0.135*	0.354**
	(0.072)	(0.080)	(0.169)
Fertilizer	0.003	0.011	-0.02
	(0.020)	(0.026)	(0.037)
Area (square)	0.061	-0.025	0.114
	(0.053)	(0.082)	(0.075)
Household size (square)	-0.059	-0.162	0.251
	(0.098)	(0.131)	(0.166)
Oxen (square)	0.011**	0.008	0.027**
	(0.005)	(0.005)	(0.012)
Fertilizer (square)	0.001	0.001	-0.002
	(0.001)	(0.002)	(0.003)
Area*Household size	-0.062	-0.016	-0.062
	(0.103)	(0.183)	(0.152)
Area*Oxen	-0.002	0.012	-0.028**
	(0.006)	(0.009)	(0.013)
Area*Fertilizer	-0.001	-0.01	0.005
	(0.005)	(0.009)	(0.007)
Household size*Oxen	-0.01	-0.013	0.004
	(0.008)	(0.011)	(0.018)
Household size*Fertilizer	0.006	0.006	0.007
	(0.007)	(0.012)	(0.009)
Oxen*Fertilizer	0	0	0.001
	(0.000)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of observations	1004	692	312
Number of observations	788	534	254
R-squared a	0.443	0.537	0.268

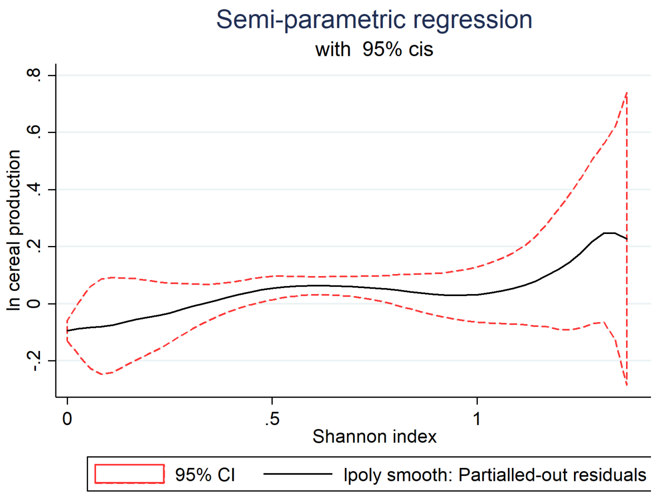
Table B18: Semi-parametric model: Parametric component (Enset), No imputed values

	All	Teff	No teff
Area	0.437*	0.361	0.51
	(0.251)	(0.345)	(0.512)
Household size	-0.142	-0.22	0.491
	(0.439)	(0.495)	(1.366)
Oxen	0.242	0.382*	0.24
	(0.173)	(0.215)	(0.295)
Fertilizer	0.024	-0.004	0.081
	(0.038)	(0.048)	(0.113)
Area (square)	-0.015	-0.042	0.02
	(0.040)	(0.059)	(0.066)
Household size (square)	0.047	0.029	-0.058
	(0.128)	(0.145)	(0.390)
Oxen (square)	0.014	0.024	0.009
	(0.013)	(0.016)	(0.021)
Fertilizer (square)	0.001	-0.001	0.008
	(0.003)	(0.003)	(0.007)
Area*Household size	-0.033	-0.019	-0.067
	(0.101)	(0.139)	(0.169)
Area*Oxen	0.008	0.008	-0.002
	(0.007)	(0.010)	(0.011)
Area*Fertilizer	-0.012*	-0.015	-0.013
	(0.007)	(0.011)	(0.015)
Household size*Oxen	-0.019*	-0.022	-0.055*
	(0.011)	(0.015)	(0.032)
Household size*Fertilizer	-0.009	-0.001	-0.005
	(0.012)	(0.013)	(0.050)
Oxen*Fertilizer	0.001	0.002	0
	(0.001)	(0.002)	(0.002)
Village-year fixed effects	✓	✓	✓
Number of observations	461	354	107
R-squared a	0.504	0.545	0.374

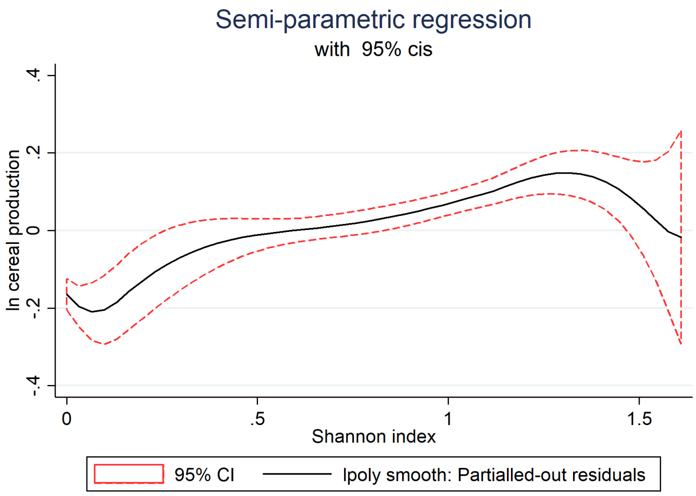
Figure B1: Effect of Shannon index Semi parametric Full sample (No imputed values)



(a) Full sample

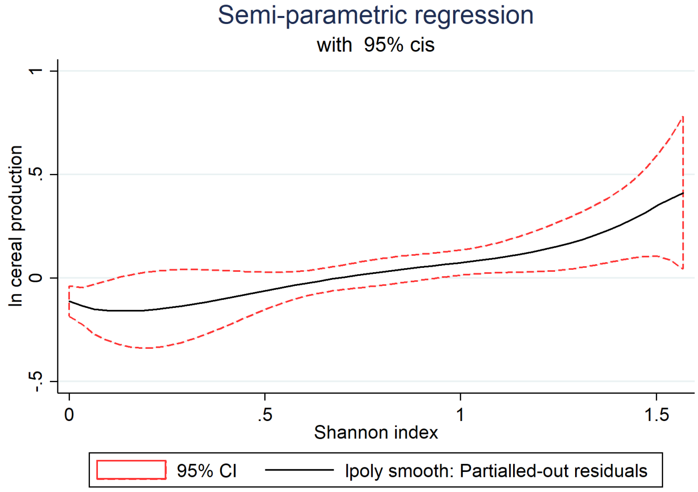


(b) Non teff-producing households

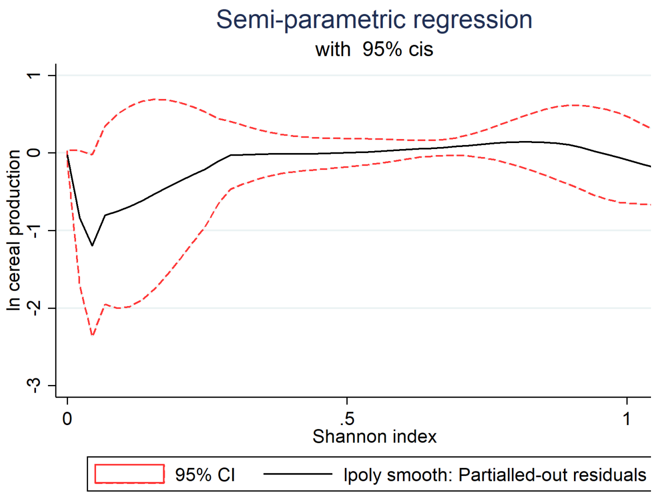


(c) Teff-producing households

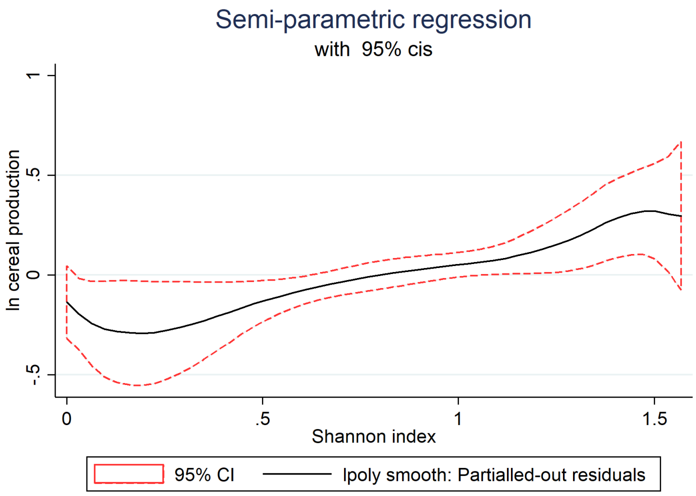
Figure B2: Effect of Shannon index Semi parametric Northern Highlands (No imputed values)



(a) **Full sample**

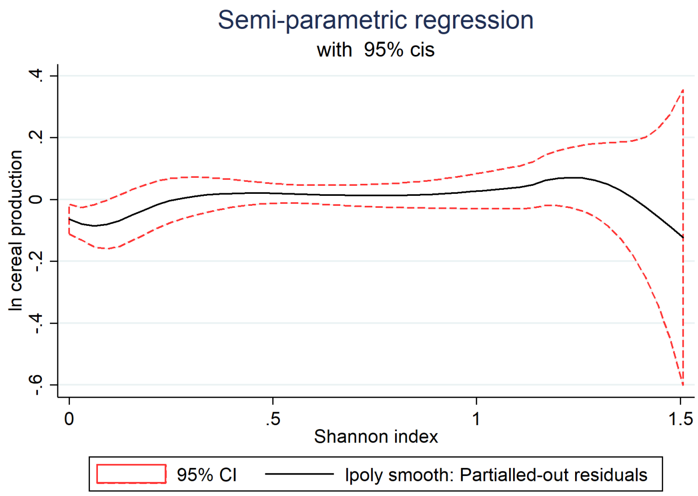


(b) **Non teff-producing households**

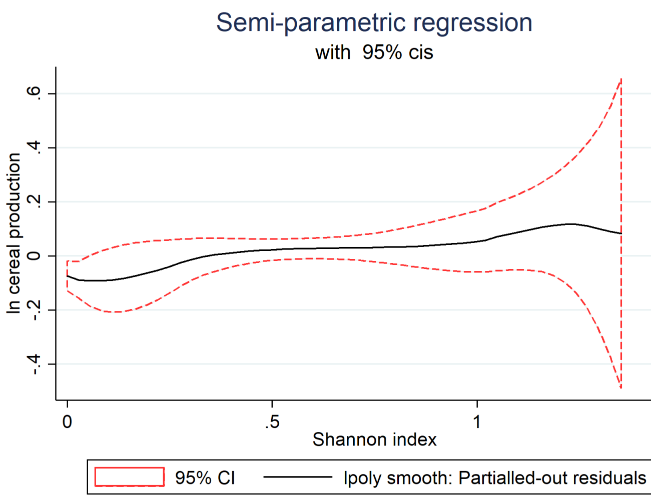


(c) **Teff-producing households**

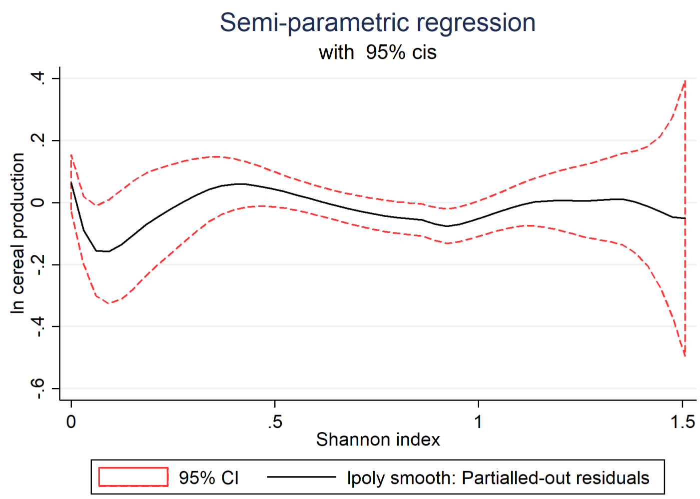
Figure B3: Effect of Shannon index Semi parametric Central Highlands (No imputed values)



(a) **Full sample**

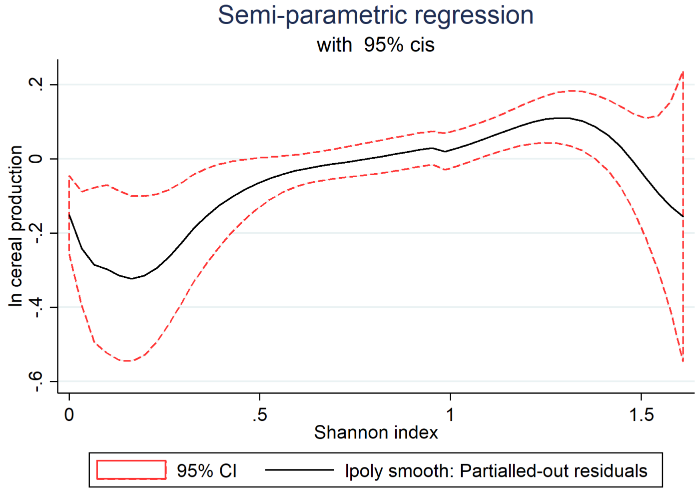


(b) **Non teff-producing households**

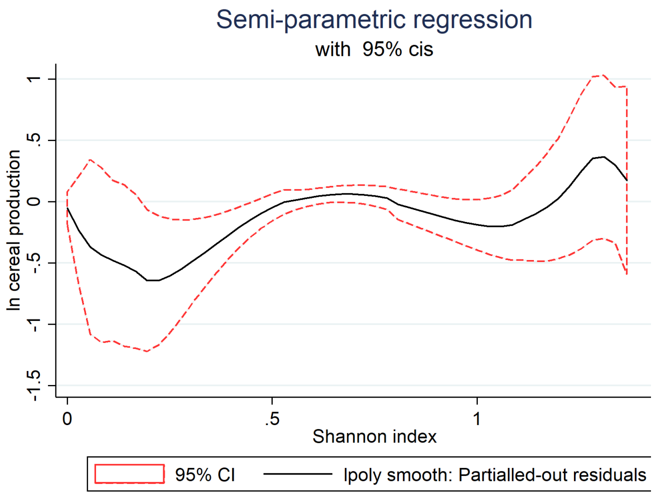


(c) **Teff-producing households**

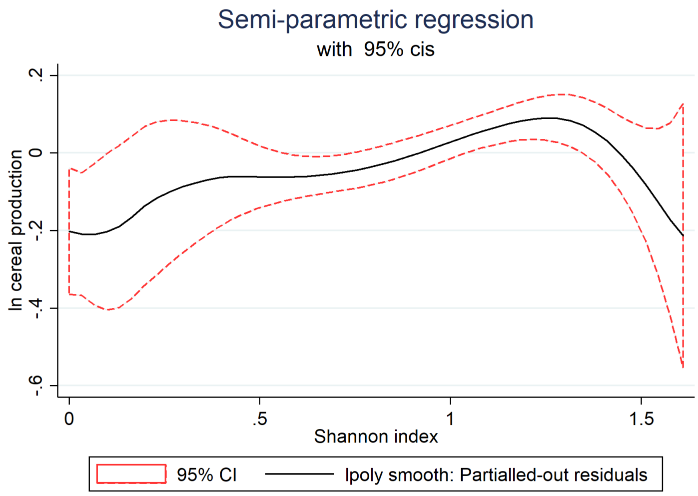
Figure B4: Effect of Shannon index Semi parametric Arussi/Bale (No imputed values)



(a) **Full sample**

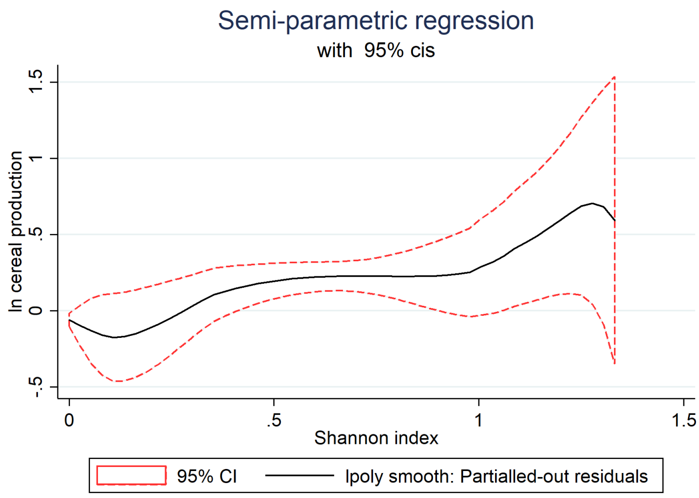


(b) **Non teff-producing households**

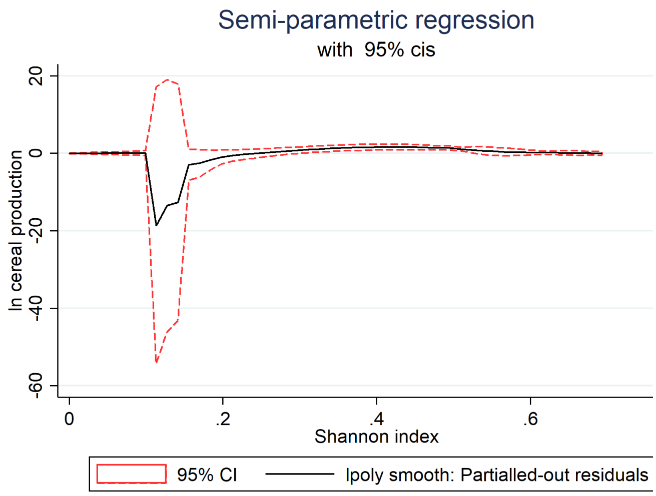


(c) **Teff-producing households**

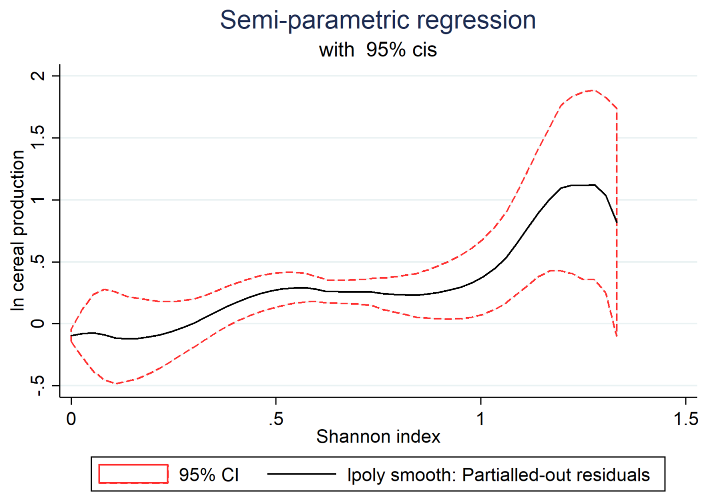
Figure B5: Effect of Shannon index Semi parametric Enset (No imputed values)



(a) **Full sample**

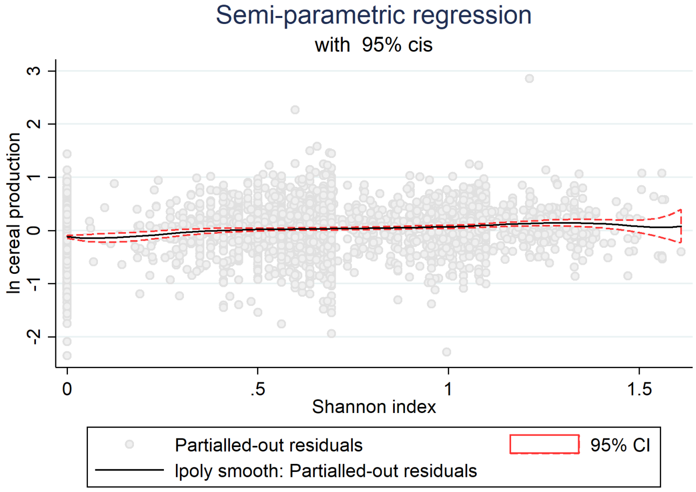


(b) **Non teff-producing households**

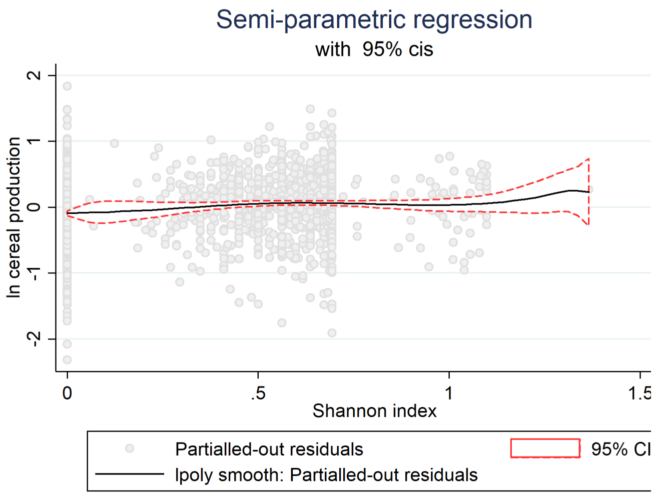


(c) **Teff-producing households**

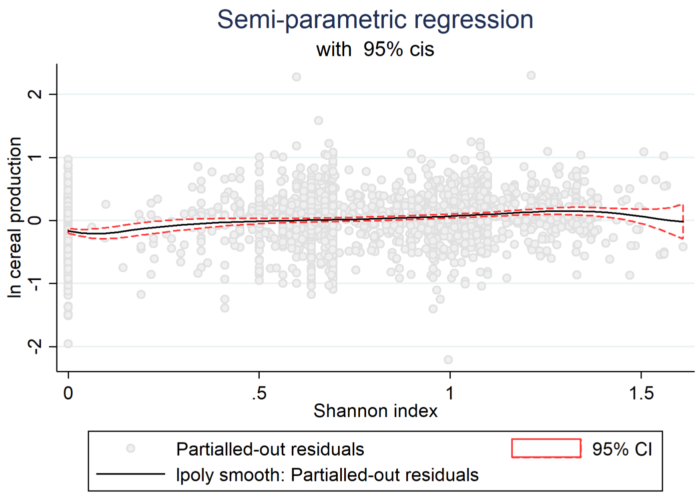
Figure B6: Effect of Shannon index Semi parametric Full sample (No imputed values, with scatter)



(a) **Full sample**

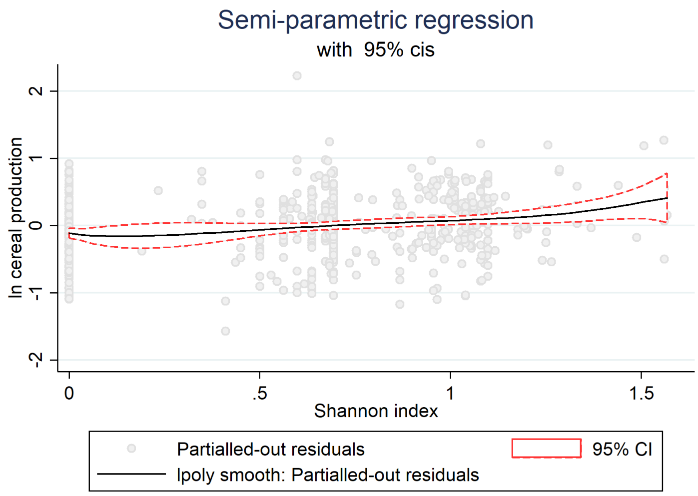


(b) **Non teff-producing households**

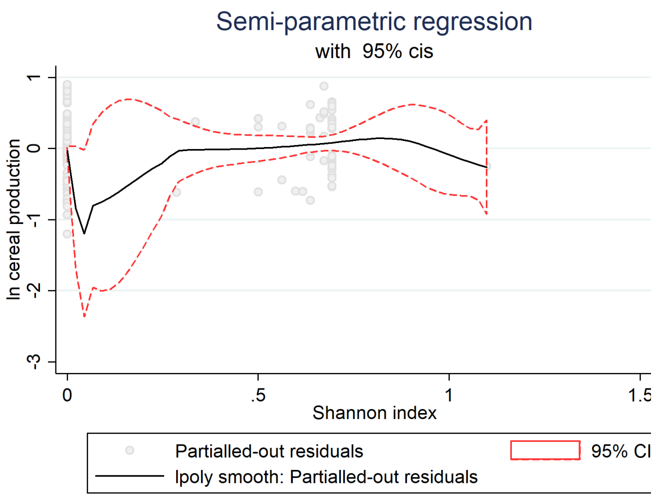


(c) **Teff-producing households**

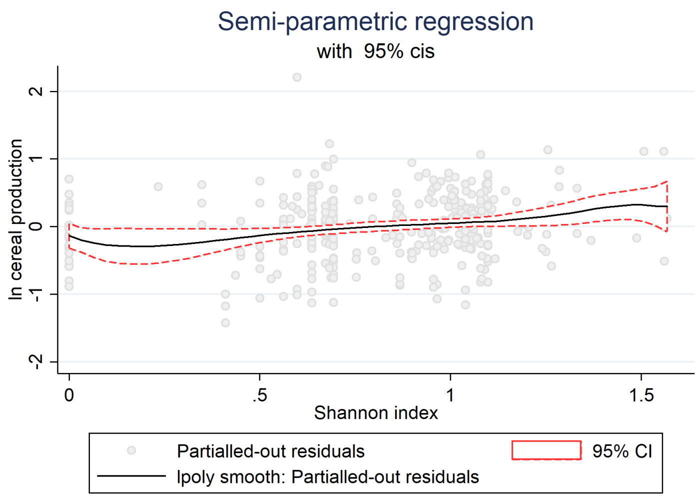
Figure B7: Effect of Shannon index Semi parametric Northern Highlands (No imputed values, with scatter)



(a) **Full sample**

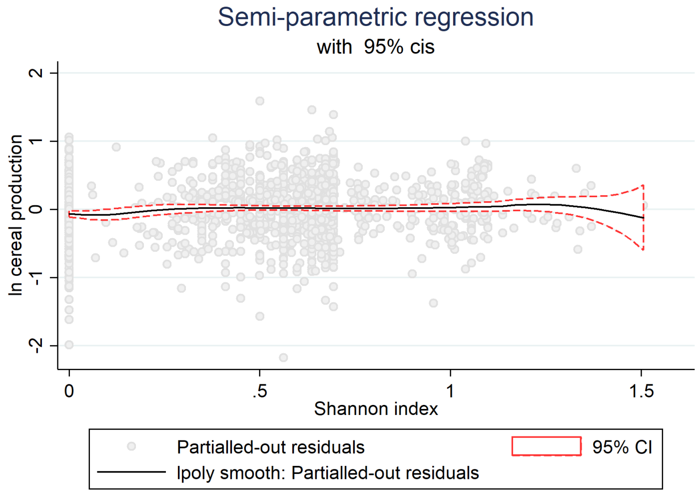


(b) **Non teff-producing households**

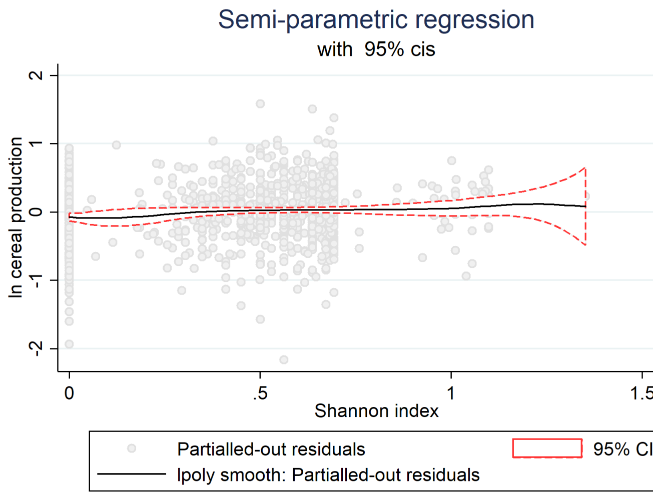


(c) **Teff-producing households**

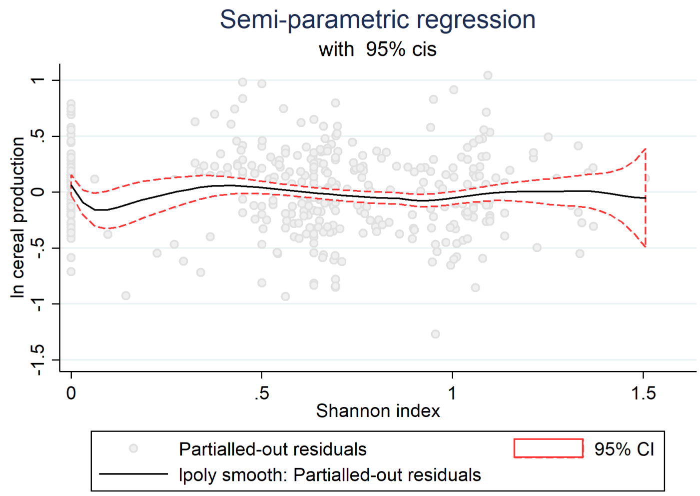
Figure B8: Effect of Shannon index Semi parametric Central Highlands (No imputed values, with scatter)



(a) **Full sample**

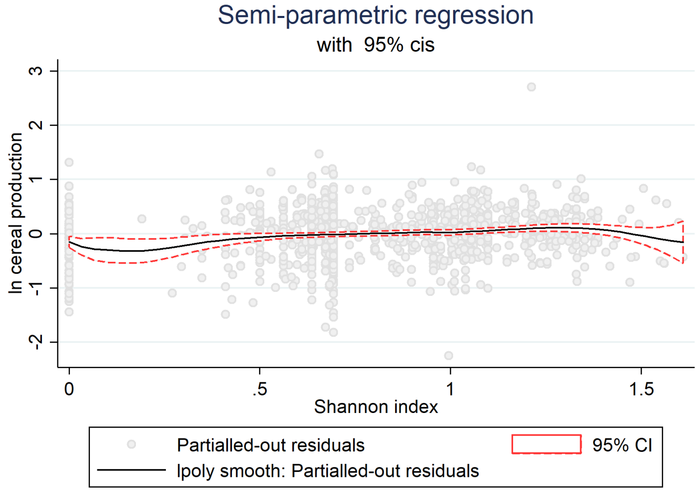


(b) **Non teff-producing households**

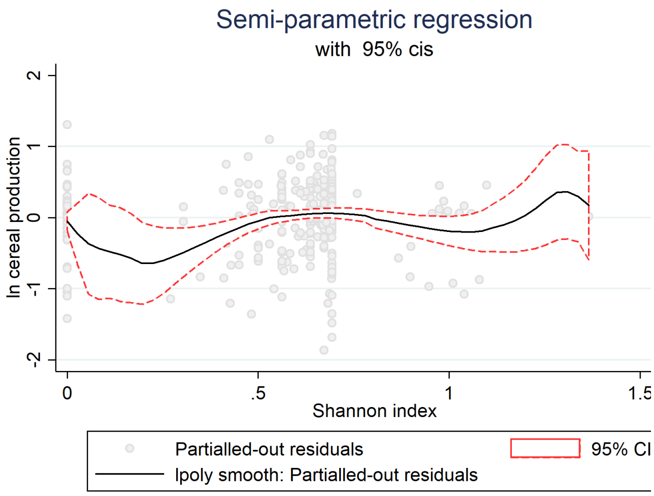


(c) **Teff-producing households**

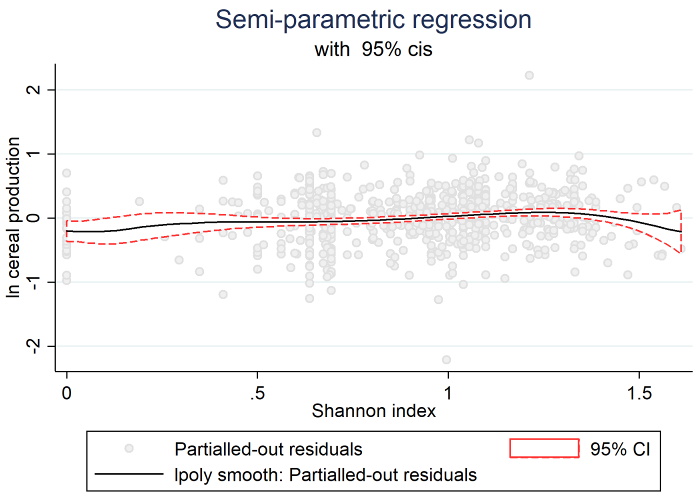
Figure B9: Effect of Shannon index Semi parametric Arussi/Bale (No imputed values, with scatter)



(a) **Full sample**

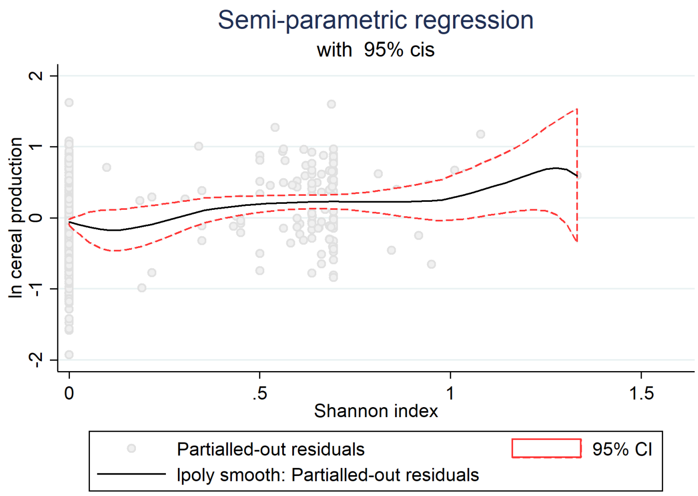


(b) **Non teff-producing households**

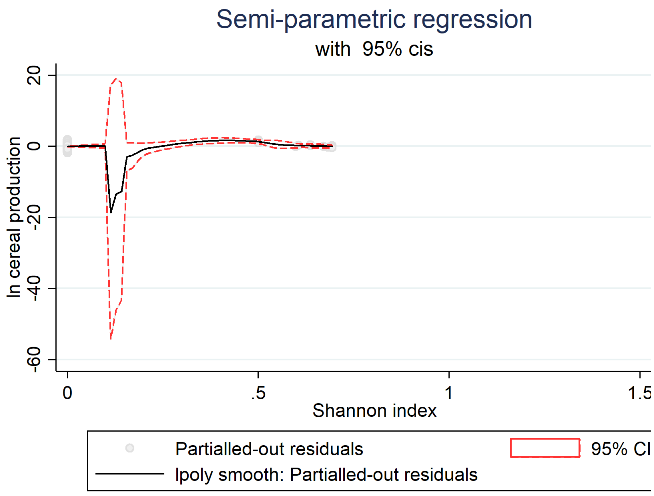


(c) **Teff-producing households**

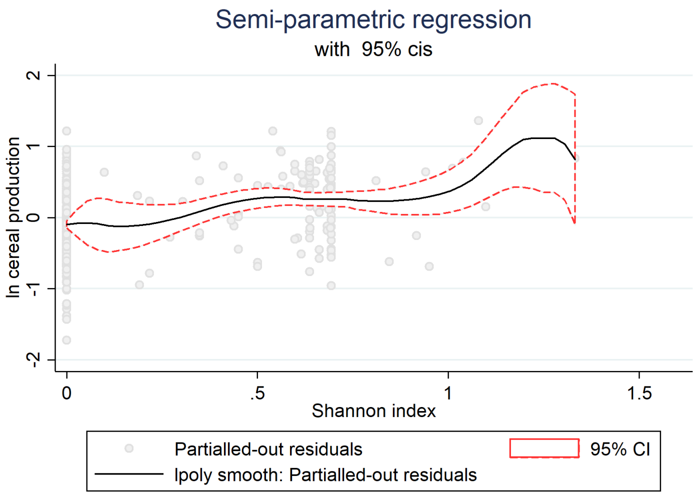
Figure B10: Effect of Shannon index Semi parametric Enset (No imputed values, with scatter)



(a) **Full sample**



(b) **Non teff-producing households**



(c) **Teff-producing households**

Table B19: Bandwidth choice

	All	N. Highlands	C. Highlands	Other	Enset
Main	0.43	0.67	0.51	0.43	0.44
No teff	0.35	0.29	0.46	0.36	0.22
Teff	0.5	0.51	0.4	0.49	0.33

10.3 Balanced Sample

Table B20: Summary Statistics - Balanced sample

	All		N. Highlands		C. Highlands		Other		Enset	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Cereal Production (kgs)	898.44	947.28	381.94	465.49	1142.46	946.49	1327.81	1105.42	261.95	275.03
Cereal Yield (kg/ha)	799.94	739.96	548.56	540.62	885.57	751.41	935.13	784.31	744.92	818.33
Cereal Area (ha)	1.35	1.16	0.92	1.03	1.57	1.05	1.82	1.28	0.54	0.62
Shannon index	0.54	0.41	0.49	0.44	0.53	0.33	0.82	0.37	0.15	0.28
Number of oxen	1.04	1.14	0.77	0.87	1.33	1.12	1.09	1.29	0.56	1.04
Household Size	6.15	2.56	5.59	2.42	6.02	2.45	6.39	2.45	7.12	3.03
Quantity Ferilizer (kgs)	59.37	88.28	3.34	12.19	86.02	88.41	89.66	113.05	23.18	29.68
Number of ploughs (units)	2.04	3.16	2.01	3.30	2.49	3.40	1.83	3.05	1.10	1.85
Number of hoes (units)	1.23	1.63	0.94	1.46	1.46	1.73	1.22	1.66	1.13	1.41
Tigray	0.14	0.34	0.57	0.50	0.00	0.00	0.00	0.00	0.00	0.00
Amhara	0.42	0.49	0.43	0.50	0.84	0.37	0.00	0.00	0.00	0.00
Oromia	0.32	0.46	0.00	0.00	0.16	0.37	1.00	0.00	0.00	0.00
SSN	0.12	0.33	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Northern Highlands	0.24	0.43	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Central Highlands	0.38	0.49	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Other	0.25	0.43	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Enset	0.12	0.33	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Number of observations	3702		888		1422		932		456	

Table B21: Parametric translog full (Balanced Panel)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.605***	0.502***	0.579***	0.371*	0.155
	(0.076)	(0.147)	(0.124)	(0.216)	(0.258)
Household size	0.004	0.032	-0.205	0.553*	-0.356
	(0.133)	(0.325)	(0.230)	(0.313)	(0.415)
Oxen	0.102***	0.128	0.06	0.122*	0.270**
	(0.032)	(0.080)	(0.048)	(0.065)	(0.135)
Fertilizer	0.028**	-0.100**	0.015	0.033	0.041
	(0.011)	(0.044)	(0.015)	(0.020)	(0.040)
Hoes	0.038	-0.01	0.049	0.094*	0.025
	(0.024)	(0.063)	(0.034)	(0.051)	(0.080)
Ploughs	0.011	0.064	0.054**	0.015	-0.106
	(0.016)	(0.044)	(0.027)	(0.033)	(0.069)
Shannon index	0.067*	0.028	0.031	0.161*	0.03
	(0.036)	(0.060)	(0.056)	(0.091)	(0.094)
Area (square)	0.031	0.063	-0.157***	-0.005	0.063
	(0.032)	(0.063)	(0.050)	(0.086)	(0.070)
Household size (square)	0.038	0.176	0.226	-0.431**	0.175
	(0.082)	(0.153)	(0.141)	(0.197)	(0.218)
Oxen (square)	0.014***	0.019*	0.008	0.016*	0.036*
	(0.005)	(0.011)	(0.007)	(0.009)	(0.019)
Fertilizer (square)	0.004**	-0.014*	0.002	0.005**	0.006
	(0.002)	(0.007)	(0.002)	(0.003)	(0.006)
Hoes (square)	0.005	-0.003	0.006	0.009	0.01
	(0.003)	(0.009)	(0.005)	(0.007)	(0.012)
Ploughs (square)	0.001	0.007	0.004	0.004	-0.015
	(0.002)	(0.005)	(0.003)	(0.004)	(0.010)
Shannon index (square)	0.010**	0.004	0.003	0.025**	0.003
	(0.005)	(0.008)	(0.008)	(0.012)	(0.013)
Area*Household size	-0.071*	-0.033	-0.018	0.067	-0.028
	(0.039)	(0.067)	(0.067)	(0.106)	(0.106)
Area*Oxen	0	-0.002	0.003	0.006	-0.004
	(0.003)	(0.006)	(0.004)	(0.006)	(0.008)
Area*Fertilizer	0	0	-0.001	-0.006	-0.003
	(0.002)	(0.006)	(0.004)	(0.005)	(0.006)
Area*Hoes	0.002	-0.003	0.001	0.001	0.014**
	(0.003)	(0.005)	(0.005)	(0.005)	(0.007)
Area*Ploughs	0	0.007	-0.008	0.003	-0.009
	(0.003)	(0.004)	(0.006)	(0.008)	(0.009)
Area*Shannon index	-0.005	-0.008	-0.008	0.009	-0.024**
	(0.003)	(0.006)	(0.005)	(0.011)	(0.009)
Household size*Oxen	-0.002	-0.004	0.003	-0.006	-0.008
	(0.004)	(0.008)	(0.006)	(0.009)	(0.014)
Household size*Fertilizer	0	0.017	0.002	0.001	-0.001
	(0.004)	(0.011)	(0.006)	(0.009)	(0.013)
Household size*Hoes	-0.001	0.006	0.001	-0.012	0.014
	(0.004)	(0.007)	(0.007)	(0.008)	(0.013)
Household size*Ploughs	-0.003	-0.014	-0.013	0.009	-0.008
	(0.004)	(0.009)	(0.008)	(0.010)	(0.013)
Household size*Shannon index	0.007	0.005	-0.001	0.013	-0.008
	(0.005)	(0.007)	(0.008)	(0.013)	(0.011)
Oxen*Fertilizer	0	-0.001*	0	0	0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Oxen*Hoes	0	0	0	0	0.001
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Oxen*Ploughs	0	0	0	0	-0.002**
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Oxen*Shannon index	0	0	0	-0.002*	0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Fertilizer*Hoes	0.001**	0.002**	0	0	0.001
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Fertilizer*Ploughs	0.000*	0	0	0	0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Fertilizer*Shannon index	0	0	0	0	-0.001*
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Hoes*Ploughs	0	0	-0.001*	0.001	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Hoes*Shannon index	0	0.002***	0	0	-0.003**
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Ploughs*Shannon index	0	0	0	-0.001	0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	6.408***	5.198***	6.413***	5.808***	5.728***
	(0.134)	(0.431)	(0.219)	(0.316)	(0.528)
Elasticity of Shannon index	0.038	0.013	0.016	0.163	0.012
p-value	0.008	0.318	0.616	0.013	0.772
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	617	148	237	156	76
Number of observations	3702	888	1422	936	456
Average obs. per household	6	6	6	6	6
R-squared a	0.544	0.632	0.534	0.549	0.42
R-squared w	0.558	0.653	0.555	0.573	0.484

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese since many of these dummies are time-invariant which would be incompatible with the fixed effects. Instead 0 values are assigned the value of 0.000001.

Table B22: Parametric translog teff only (Balanced Panel)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.588***	0.609*	0.472***	0.601***	-0.056
	(0.122)	(0.324)	(0.161)	(0.215)	(0.400)
Household size	0.114	-0.024	-0.305	0.505*	-0.083
	(0.190)	(0.765)	(0.392)	(0.282)	(0.535)
Oxen	0.157***	0.151	0.086	0.092	0.447**
	(0.042)	(0.113)	(0.080)	(0.065)	(0.173)
Fertilizer	0.055***	-0.141**	0.033	0.053**	0.115**
	(0.015)	(0.059)	(0.027)	(0.020)	(0.052)
Hoes	0.014	-0.043	-0.078	0.075	0.11
	(0.033)	(0.069)	(0.061)	(0.049)	(0.119)
Ploughs	-0.009	0.106	-0.051	0.004	-0.179*
	(0.024)	(0.072)	(0.041)	(0.037)	(0.099)
Shannon index	0.185***	0.153	0.002	0.386***	0.055
	(0.056)	(0.099)	(0.078)	(0.086)	(0.179)
Area (square)	0.129**	0.301***	0.016	-0.296**	0.188*
	(0.055)	(0.113)	(0.106)	(0.113)	(0.107)
Household size (square)	-0.055	0.287	0.272	-0.452**	-0.022
	(0.121)	(0.453)	(0.213)	(0.196)	(0.262)
Oxen (square)	0.021***	0.015	0.011	0.015*	0.056**
	(0.006)	(0.016)	(0.011)	(0.009)	(0.023)
Fertilizer (square)	0.006***	-0.019**	0.004	0.004*	0.009
	(0.002)	(0.009)	(0.004)	(0.003)	(0.007)
Hoes (square)	0.002	-0.01	-0.009	0.006	0.027
	(0.005)	(0.010)	(0.008)	(0.007)	(0.017)
Ploughs (square)	-0.001	0.014*	-0.012**	0.001	-0.021
	(0.003)	(0.008)	(0.006)	(0.004)	(0.014)
Shannon index (square)	0.022***	0.024*	-0.005	0.050***	0
	(0.008)	(0.012)	(0.010)	(0.011)	(0.024)
Area*Household size	-0.111*	-0.18	-0.003	0.142	0.109
	(0.064)	(0.184)	(0.099)	(0.125)	(0.173)
Area*Oxen	0.001	0.005	-0.001	0.013	-0.001
	(0.004)	(0.009)	(0.007)	(0.009)	(0.011)
Area*Fertilizer	-0.001	-0.001	0	-0.031***	-0.003
	(0.003)	(0.010)	(0.007)	(0.009)	(0.012)
Area*Hoes	0.001	-0.005	0	0.004	0.024**
	(0.004)	(0.008)	(0.007)	(0.007)	(0.010)
Area*Ploughs	0	0.005	-0.018	0.014	-0.028**
	(0.005)	(0.011)	(0.012)	(0.009)	(0.011)
Area*Shannon index	-0.017***	-0.026*	-0.025***	-0.008	-0.035***
	(0.006)	(0.015)	(0.009)	(0.020)	(0.013)
Household size*Oxen	-0.006	-0.01	-0.006	-0.001	-0.040*
	(0.006)	(0.014)	(0.009)	(0.010)	(0.021)
Household size*Fertilizer	-0.007	0.024	0	0	-0.025
	(0.006)	(0.021)	(0.009)	(0.010)	(0.021)
Household size*Hoes	0.003	0.01	0.013	-0.016	0.034
	(0.006)	(0.016)	(0.010)	(0.010)	(0.023)
Household size*Ploughs	0.003	-0.033	-0.001	-0.002	0.011
	(0.007)	(0.021)	(0.011)	(0.011)	(0.020)
Household size*Shannon index	-0.002	0.008	-0.014	-0.01	-0.027
	(0.008)	(0.026)	(0.013)	(0.016)	(0.021)
Oxen*Fertilizer	0	0.001	0	0.001	0
	(0.000)	(0.002)	(0.001)	(0.001)	(0.002)
Oxen*Hoes	0	0	-0.001	0	-0.002
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Oxen*Ploughs	0	0.003**	0.002*	0	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Oxen*Shannon index	0	-0.001	0	-0.001	0
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Fertilizer*Hoes	0	0.003*	0	0	0.001
	(0.000)	(0.002)	(0.001)	(0.001)	(0.001)
Fertilizer*Ploughs	0.001*	-0.003**	0.002**	0	0.002
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Fertilizer*Shannon index	0	-0.001	0	0	0
	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)
Hoes*Ploughs	0	-0.001	-0.001	0	0
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Hoes*Shannon index	0.001	0.004**	0.001*	0.002	-0.002
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Ploughs*Shannon index	0	-0.002	0.001	-0.003*	0.004***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
Constant	6.398***	5.687***	6.965***	5.719***	4.995***
	(0.184)	(0.766)	(0.402)	(0.280)	(0.874)
Elasticity of Shannon index	0.157***	0.161*	-0.043	0.359***	0.0333
p-value	0.002	0.056	0.547	0.000	0.803
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	400	85	118	125	72
Number of observations	1882	384	483	712	303
Average obs. per household	4.705	4.518	4.093	5.696	4.208
R-squared a	0.525	0.341	0.596	0.622	0.557
R-squared w	0.547	0.42	0.638	0.646	0.631

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese since many of these dummies are time-invariant which would be incompatible with the fixed effects. Instead 0 values are assigned the value of 0.000001.

Table B23: Parametric translog no teff (Balanced Panel)

	All	N. Highlands	C. Highlands	Other	Enset
Area	0.601***	0.534*	0.575***	-0.079	
	(0.101)	(0.309)	(0.179)	(0.430)	
Household size	-0.159	-0.283	-0.126	-0.594	
	(0.195)	(0.348)	(0.301)	(1.510)	
Oxen	0.055	0.028	0.055	-0.071	
	(0.053)	(0.132)	(0.063)	(0.365)	
Fertilizer	0.002	-0.053	0.023	-0.046	
	(0.017)	(0.072)	(0.019)	(0.077)	
Hoes	0.061	0.137	0.119***	-0.015	
	(0.041)	(0.145)	(0.045)	(0.172)	
Ploughs	0.032	0.046	0.079**	0.094	
	(0.027)	(0.070)	(0.036)	(0.109)	
Shannon index	-0.029	-0.048	0.057	0.104	
	(0.057)	(0.086)	(0.093)	(0.163)	
Area (square)	-0.037	-0.206	-0.216***	0.202	
	(0.045)	(0.149)	(0.066)	(0.202)	
Household size (square)	0.185	0.281**	0.185	0.252	
	(0.112)	(0.141)	(0.189)	(0.857)	
Oxen (square)	0.008	0.009	0.008	-0.017	
	(0.008)	(0.020)	(0.009)	(0.053)	
Fertilizer (square)	0.001	-0.008	0.003	-0.004	
	(0.003)	(0.013)	(0.003)	(0.011)	
Hoes (square)	0.007	0.018	0.014**	-0.007	
	(0.006)	(0.021)	(0.006)	(0.023)	
Ploughs (square)	0.002	0.003	0.008*	0.008	
	(0.003)	(0.009)	(0.004)	(0.012)	
Shannon index (square)	-0.003	-0.01	0.007	0.009	
	(0.008)	(0.012)	(0.013)	(0.022)	
Area*Household size	-0.05	-0.097	0.017	0.333	
	(0.050)	(0.109)	(0.091)	(0.213)	
Area*Oxen	-0.001	-0.005	0.003	-0.005	
	(0.004)	(0.010)	(0.006)	(0.013)	
Area*Fertilizer	0.007**	0.003	-0.003	-0.002	
	(0.003)	(0.010)	(0.006)	(0.012)	
Area*Hoes	0.003	0.006	0	0.01	
	(0.004)	(0.008)	(0.005)	(0.012)	
Area*Ploughs	0.003	0.009	-0.003	0.007	
	(0.005)	(0.008)	(0.008)	(0.022)	
Area*Shannon index	-0.005	0.005	-0.003	0.01	
	(0.004)	(0.010)	(0.007)	(0.017)	
Household size*Oxen	0	0.001	0.007	-0.021	
	(0.006)	(0.010)	(0.009)	(0.026)	
Household size*Fertilizer	0.007	0.01	-0.002	0.023	
	(0.005)	(0.016)	(0.007)	(0.022)	
Household size*Hoes	-0.003	0.003	-0.004	-0.008	
	(0.006)	(0.009)	(0.010)	(0.023)	
Household size*Ploughs	-0.01	-0.011	-0.014	-0.021	
	(0.007)	(0.010)	(0.012)	(0.039)	
Household size*Shannon index	0.01	0.001	0	0.002	
	(0.007)	(0.009)	(0.011)	(0.034)	
Oxen*Fertilizer	-0.001	-0.002**	-0.001	0.002	
	(0.000)	(0.001)	(0.000)	(0.001)	
Oxen*Hoes	0	-0.001	0.001**	0	
	(0.000)	(0.001)	(0.001)	(0.001)	
Oxen*Ploughs	-0.001**	-0.001	-0.001	-0.003	
	(0.000)	(0.001)	(0.001)	(0.002)	
Oxen*Shannon index	0	-0.001	0	-0.001	
	(0.000)	(0.001)	(0.001)	(0.002)	
Fertilizer*Hoes	0.001*	0.002*	0	0	
	(0.000)	(0.001)	(0.001)	(0.002)	
Fertilizer*Ploughs	0	0	0	0.001	
	(0.000)	(0.002)	(0.001)	(0.001)	
Fertilizer*Shannon index	0	0	0	0.001	
	(0.000)	(0.001)	(0.001)	(0.002)	
Hoes*Ploughs	0	0.001	-0.001	0	
	(0.001)	(0.001)	(0.001)	(0.002)	
Hoes*Shannon index	0	0.001	0	0.001	
	(0.000)	(0.001)	(0.001)	(0.002)	
Ploughs*Shannon index	0.001	0.001	0.001	0.001	
	(0.001)	(0.001)	(0.001)	(0.002)	
Constant	6.423***	5.235***	6.177***	7.682***	
	(0.208)	(0.624)	(0.282)	(1.650)	
Elasticity of Shannon index	0.006	0.026	0.027	0.061	
p-value	0.52	0.218	0.555	0.347	
Fixed effects	✓	✓	✓	✓	✓
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	419	108	188	57	
Number of observations	1820	504	939	224	
Average obs. per household	4.344	4.667	4.995	3.93	
R-squared a	0.588	0.736	0.523	0.379	
R-squared w	0.611	0.763	0.554	0.502	

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands. Numbers in parentheses represent clustered standard errors at the household level. As explained in the methodology section, this specification does not include the adjustment proposed by Battese since many of these dummies are time-invariant which would be incompatible with the fixed effects. Instead 0 values are assigned the value of 0.000001.

Table B24: Parametric translog full (Battese transformation)

	All	N. Highlands	C. Highlands	Other	Enset
Dummy fertilizer	-0.224***	-0.623**	-0.235*	-0.327**	-0.088
	(0.073)	(0.268)	(0.122)	(0.156)	(0.179)
Dummy oxen	-0.090***	-0.165***	-0.058	-0.200***	-0.027
	(0.028)	(0.056)	(0.046)	(0.058)	(0.086)
Dummy hoe	-0.012	0.065	-0.022	-0.081	-0.029
	(0.026)	(0.048)	(0.046)	(0.052)	(0.095)
Dummy plough	-0.064**	0.026	-0.079	-0.003	-0.161*
	(0.032)	(0.064)	(0.056)	(0.068)	(0.085)
Dummy Shannon index	-0.213***	-0.183***	-0.133**	-0.308***	-0.158
	(0.032)	(0.063)	(0.053)	(0.091)	(0.147)
Area	0.574***	0.424***	0.725***	0.434***	0.439**
	(0.049)	(0.094)	(0.098)	(0.135)	(0.181)
Household size	-0.013	0.101	-0.088	0.352*	-0.808**
	(0.087)	(0.170)	(0.153)	(0.201)	(0.317)
Oxen	0.426***	0.662*	0.320*	0.071	0.862
	(0.124)	(0.373)	(0.193)	(0.258)	(0.754)
Fertilizer	-0.150***	-0.506**	-0.128*	-0.152*	-0.374**
	(0.044)	(0.233)	(0.065)	(0.090)	(0.162)
Hoes	0.017	-0.499**	0.369**	-0.019	0.022
	(0.098)	(0.253)	(0.165)	(0.192)	(0.393)
Ploughs	-0.036	0.188	-0.076	0.125	-0.105
	(0.074)	(0.169)	(0.111)	(0.152)	(0.536)
Shannon index	0.129**	-0.105	0.106	0.584**	0.057
	(0.055)	(0.184)	(0.182)	(0.236)	(0.179)
Area (square)	0.011	-0.024	-0.083*	0.018	-0.002
	(0.020)	(0.042)	(0.045)	(0.052)	(0.060)
Household size (square)	0.059	0.053	0.039	-0.165	0.429**
	(0.056)	(0.114)	(0.097)	(0.125)	(0.199)
Oxen (square)	-0.131	-0.518	-0.174	0.238	-0.344
	(0.119)	(0.572)	(0.178)	(0.221)	(0.581)
Fertilizer (square)	0.076***	0.112	0.064***	0.088***	0.128***
	(0.013)	(0.090)	(0.018)	(0.024)	(0.042)
Hoes (square)	0.034	0.011	0.107	-0.029	-0.194
	(0.069)	(0.178)	(0.099)	(0.135)	(0.317)
Ploughs (square)	0.04	-0.02	0.06	0.09	0.177
	(0.040)	(0.097)	(0.057)	(0.085)	(0.254)
Shannon index (square)	0.011**	0.007	0.003	0.035	-0.024
	(0.005)	(0.019)	(0.012)	(0.024)	(0.026)
Area*Household size	-0.034	0.011	-0.025	0.006	-0.033
	(0.025)	(0.050)	(0.051)	(0.068)	(0.087)
Area*Oxen	0.084**	0.044	0.073	0.302***	0.005
	(0.037)	(0.081)	(0.064)	(0.088)	(0.182)
Area*Fertilizer	-0.004	0.004	-0.025*	-0.022	-0.031
	(0.007)	(0.031)	(0.014)	(0.016)	(0.030)
Area*Hoes	0.018	-0.026	0.107*	-0.122**	0.093
	(0.028)	(0.074)	(0.057)	(0.056)	(0.090)
Area*Ploughs	0.01	0.033	-0.055	-0.017	0.008
	(0.021)	(0.043)	(0.038)	(0.051)	(0.115)
Area*Shannon index	0.012	-0.02	0.108	0.142*	0.055
	(0.014)	(0.088)	(0.076)	(0.083)	(0.046)
Household size*Oxen	-0.045	-0.092	0.023	-0.049	-0.158
	(0.061)	(0.148)	(0.097)	(0.118)	(0.352)
Household size*Fertilizer	-0.009	0.077	0.009	-0.034	0.043
	(0.011)	(0.047)	(0.018)	(0.023)	(0.047)
Household size*Hoes	0.021	0.241*	-0.07	0.029	0.033
	(0.046)	(0.136)	(0.082)	(0.084)	(0.177)
Household size*Ploughs	0.026	-0.055	0.045	0.02	-0.069
	(0.035)	(0.077)	(0.055)	(0.078)	(0.188)
Household size*Shannon index	0.005	0.09	-0.102	-0.023	-0.109
	(0.021)	(0.097)	(0.093)	(0.126)	(0.078)
Oxen*Fertilizer	-0.028**	-0.059	-0.011	-0.02	-0.054
	(0.014)	(0.056)	(0.022)	(0.030)	(0.073)
Oxen*Hoes	-0.035	0.04	-0.057	0.061	0.072
	(0.050)	(0.170)	(0.078)	(0.096)	(0.239)
Oxen*Ploughs	-0.026	-0.112	0.03	-0.159**	-0.044
	(0.038)	(0.101)	(0.056)	(0.079)	(0.235)
Oxen*Shannon index	-0.01	0.186	0.029	-0.133**	0.269
	(0.034)	(0.118)	(0.103)	(0.063)	(0.648)
Fertilizer*Hoes	0.011	0.014	-0.017	0.026	0.084
	(0.012)	(0.057)	(0.019)	(0.027)	(0.052)
Fertilizer*Ploughs	0.004	-0.025	0.002	-0.02	0.042
	(0.009)	(0.036)	(0.013)	(0.020)	(0.064)
Fertilizer*Shannon index	-0.004	-0.072	0.023	-0.035	0.005
	(0.007)	(0.058)	(0.023)	(0.035)	(0.030)
Hoes*Ploughs	-0.046*	0.045	-0.114***	0.019	-0.034
	(0.026)	(0.066)	(0.038)	(0.057)	(0.129)
Hoes*Shannon index	-0.023	0.079	0.037	-0.395***	0.12
	(0.043)	(0.073)	(0.079)	(0.135)	(0.322)
Ploughs*Shannon index	-0.008	0	-0.101*	-0.119	0.204**
	(0.018)	(0.033)	(0.059)	(0.106)	(0.102)
Constant	7.015***	6.145***	6.211***	5.898***	6.144***
	(0.175)	(0.316)	(0.193)	(0.267)	(0.405)
Elasticity of Shannon index	0.111	0.072	0.002	0.264	-0.087
p-value	0.002	0.407	0.97	0	0.709
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	617	148	237	156	76
Number of observations	3702	888	1422	936	456
Average obs. per household	6	6	6	6	6
R-squared a	0.781	0.742	0.65	0.635	0.481

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table B25: Parametric translog teff only (Battese transformation, balanced sample)

	All	N. Highlands	C. Highlands	Other	Enset
Dummy fertilizer	-0.188*	0.014	-0.217	-0.337**	-0.055
	(0.096)	(0.407)	(0.156)	(0.158)	(0.277)
Dummy oxen	-0.071*	-0.121	-0.013	-0.056	-0.005
	(0.040)	(0.097)	(0.081)	(0.065)	(0.095)
Dummy hoe	-0.028	0.05	-0.045	-0.083	0.075
	(0.037)	(0.086)	(0.069)	(0.054)	(0.118)
Dummy plough	-0.068	0.105	0.018	-0.065	-0.180*
	(0.048)	(0.114)	(0.110)	(0.080)	(0.101)
Dummy Shannon index	-0.404***	-0.316**	-0.123	-0.346***	-0.597***
	(0.057)	(0.145)	(0.111)	(0.126)	(0.169)
Area	0.613***	0.474***	0.666***	0.781***	0.393*
	(0.072)	(0.165)	(0.187)	(0.199)	(0.228)
Household size	-0.018	-0.029	-0.059	0.405*	-1.422***
	(0.130)	(0.308)	(0.282)	(0.225)	(0.464)
Oxen	0.251	0.282	0.176	-0.14	1.374
	(0.169)	(0.492)	(0.394)	(0.254)	(1.058)
Fertilizer	-0.092	0.309	-0.106	-0.084	-0.419*
	(0.057)	(0.435)	(0.087)	(0.089)	(0.227)
Hoes	-0.085	-0.639**	-0.062	-0.007	0.881*
	(0.123)	(0.317)	(0.260)	(0.192)	(0.533)
Ploughs	-0.036	0.336	-0.106	0.034	-0.497
	(0.099)	(0.242)	(0.191)	(0.152)	(0.711)
Shannon index	0.103	0.476	-0.23	0.703**	0.476**
	(0.101)	(0.416)	(0.279)	(0.317)	(0.212)
Area (square)	0.056**	0.130*	-0.079	-0.176*	0.001
	(0.029)	(0.075)	(0.101)	(0.094)	(0.097)
Household size (square)	0.079	0.14	-0.037	-0.233	0.728***
	(0.082)	(0.222)	(0.182)	(0.152)	(0.250)
Oxen (square)	-0.103	-0.975	0.117	0.127	-0.251
	(0.154)	(0.713)	(0.483)	(0.204)	(0.982)
Fertilizer (square)	0.072***	-0.232	0.051*	0.061***	0.161***
	(0.016)	(0.177)	(0.026)	(0.024)	(0.061)
Hoes (square)	0.031	-0.173	0.387**	-0.005	-1.103**
	(0.091)	(0.236)	(0.182)	(0.127)	(0.435)
Ploughs (square)	0.021	-0.005	0.051	-0.007	0.45
	(0.055)	(0.123)	(0.099)	(0.083)	(0.311)
Shannon index (square)	0.012	0.190***	-0.02	0.411	0.014
	(0.009)	(0.058)	(0.021)	(0.335)	(0.033)
Area*Household size	-0.076**	-0.103	-0.012	0.069	-0.097
	(0.038)	(0.102)	(0.104)	(0.109)	(0.111)
Area*Oxen	0.150***	0.124	0.076	0.272***	0.353
	(0.055)	(0.121)	(0.146)	(0.089)	(0.314)
Area*Fertilizer	-0.01	-0.021	-0.038	-0.080***	0.015
	(0.011)	(0.050)	(0.026)	(0.023)	(0.043)
Area*Hoes	0.029	0.012	0.098	-0.035	0.349***
	(0.039)	(0.116)	(0.094)	(0.077)	(0.129)
Area*Ploughs	0.024	0.052	-0.034	0.058	-0.009
	(0.030)	(0.072)	(0.067)	(0.070)	(0.145)
Area*Shannon index	0.003	-0.131	-0.257	0.172	0.205
	(0.035)	(0.132)	(0.165)	(0.129)	(0.220)
Household size*Oxen	0.056	0.179	0.109	0.042	-0.121
	(0.082)	(0.228)	(0.192)	(0.113)	(0.551)
Household size*Fertilizer	-0.033**	0.02	0.023	-0.032	0.045
	(0.014)	(0.106)	(0.027)	(0.025)	(0.059)
Household size*Hoes	0.046	0.367*	0.009	-0.025	0.072
	(0.059)	(0.194)	(0.142)	(0.085)	(0.225)
Household size*Ploughs	0.011	-0.182	0.05	-0.025	-0.067
	(0.049)	(0.130)	(0.100)	(0.083)	(0.213)
Household size*Shannon index	0.05	-0.096	0.138	-0.04	-0.081
	(0.058)	(0.265)	(0.157)	(0.157)	(0.174)
Oxen*Fertilizer	-0.041**	0.116	-0.044	-0.002	-0.121
	(0.018)	(0.110)	(0.035)	(0.028)	(0.113)
Oxen*Hoes	-0.05	-0.136	-0.226*	-0.018	-0.201
	(0.064)	(0.217)	(0.133)	(0.092)	(0.377)
Oxen*Ploughs	0.013	0.055	0.107	-0.051	-0.111
	(0.050)	(0.131)	(0.098)	(0.077)	(0.360)
Oxen*Shannon index	0.069	-0.06	0.099	-0.007	-0.335
	(0.093)	(0.255)	(0.203)	(0.155)	(0.804)
Fertilizer*Hoes	0.018	0.107	0	0.036	0.021
	(0.014)	(0.092)	(0.025)	(0.027)	(0.066)
Fertilizer*Ploughs	0.001	-0.154*	-0.003	0.01	0.068
	(0.011)	(0.081)	(0.018)	(0.021)	(0.080)
Fertilizer*Shannon index	-0.005	-0.141	0.008	-0.058	0.02
	(0.016)	(0.096)	(0.037)	(0.038)	(0.090)
Hoes*Ploughs	-0.024	0.114	-0.170***	0.006	0.043
	(0.033)	(0.079)	(0.063)	(0.059)	(0.166)
Hoes*Shannon index	0.016	0.053	-0.014	-0.321**	-0.05
	(0.057)	(0.085)	(0.137)	(0.139)	(0.384)
Ploughs*Shannon index	-0.045	0.142	-0.02	-0.091	0.309
	(0.032)	(0.096)	(0.104)	(0.118)	(0.281)
Constant	6.040***	5.556***	6.426***	5.341***	6.189***
	(0.571)	(0.483)	(0.378)	(0.286)	(0.614)
Elasticity of Shannon index	0.179	0.298	-0.023	0.339	0.184
p-value	0	0.006	0.783	0	0.496
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	400	85	118	125	72
Number of observations	1882	384	483	712	303
Average obs. per household	4.705	4.518	4.093	5.696	4.208
R-squared a	0.767	0.486	0.729	0.693	0.543

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table B26: Parametric translog no teff (Battese transformation, balanced sample)

	All	N. Highlands	C. Highlands	Other	Enset
Dummy fertilizer	-0.207*	-0.895**	-0.261	-0.465	0.079
	(0.115)	(0.409)	(0.189)	(0.485)	(0.293)
Dummy oxen	-0.106***	-0.156**	-0.071	-0.295**	0.012
	(0.039)	(0.070)	(0.059)	(0.115)	(0.187)
Dummy hoe	-0.001	0.116*	-0.05	-0.076	-0.238
	(0.038)	(0.060)	(0.063)	(0.134)	(0.163)
Dummy plough	-0.06	-0.035	-0.081	-0.019	-0.139
	(0.044)	(0.078)	(0.069)	(0.137)	(0.160)
Dummy Shannon index	-0.155***	-0.157	-0.190**	-0.360*	1.631
	(0.052)	(0.101)	(0.089)	(0.208)	(1.250)
Area	0.550***	0.252	0.721***	0.386	0.935***
	(0.079)	(0.233)	(0.134)	(0.340)	(0.353)
Household size	-0.017	0.091	-0.037	0.176	-0.125
	(0.123)	(0.233)	(0.192)	(0.652)	(0.577)
Oxen	0.561***	0.899	0.383	1.776	0.129
	(0.188)	(0.732)	(0.239)	(1.339)	(1.270)
Fertilizer	-0.144**	-0.582*	-0.149	-0.473	0.278
	(0.070)	(0.336)	(0.099)	(0.325)	(0.399)
Hoes	0.185	-0.707	0.629***	-0.155	0.942
	(0.173)	(0.707)	(0.221)	(0.744)	(0.718)
Ploughs	-0.01	0.321	-0.081	0.434	-0.308
	(0.112)	(0.308)	(0.140)	(0.480)	(1.680)
Shannon index	0.054	-0.15	0.265	0.048	-3.619
	(0.102)	(0.408)	(0.325)	(0.743)	(2.743)
Area (square)	-0.034	-0.15	-0.066	0.123	-0.021
	(0.033)	(0.115)	(0.056)	(0.145)	(0.108)
Household size (square)	0.05	0.067	0.083	-0.04	0.04
	(0.079)	(0.139)	(0.120)	(0.403)	(0.423)
Oxen (square)	-0.051	-0.436	-0.253	5.673*	-2.2
	(0.188)	(1.174)	(0.206)	(2.917)	(1.358)
Fertilizer (square)	0.061***	0.143	0.082***	0.170*	-0.024
	(0.020)	(0.120)	(0.026)	(0.099)	(0.090)
Hoes (square)	0.009	0.256	0.008	-0.125	0.194
	(0.107)	(0.355)	(0.128)	(0.633)	(0.565)
Ploughs (square)	0.034	-0.025	0.05	0.459	-0.221
	(0.062)	(0.181)	(0.072)	(0.345)	(0.613)
Shannon index (square)	-0.011	0.02	0.202	0.039	-0.331
	(0.013)	(0.034)	(0.254)	(0.053)	(0.493)
Area*Household size	-0.015	0.038	0.011	0.096	-0.269
	(0.038)	(0.088)	(0.066)	(0.171)	(0.168)
Area*Oxen	0.004	-0.069	0.002	0.048	0.299
	(0.054)	(0.183)	(0.078)	(0.583)	(0.464)
Area*Fertilizer	0.013	0.065	-0.033*	-0.046	0.028
	(0.012)	(0.060)	(0.020)	(0.043)	(0.059)
Area*Hoes	0.081*	0.001	0.224***	-0.105	0.088
	(0.048)	(0.168)	(0.078)	(0.170)	(0.151)
Area*Ploughs	0.004	0.062	-0.043	0.072	-0.196
	(0.035)	(0.086)	(0.052)	(0.155)	(0.582)
Area*Shannon index	0.052**	-0.189	0.225**	-0.016	-0.414
	(0.024)	(0.191)	(0.102)	(0.221)	(0.999)
Household size*Oxen	-0.189**	-0.254	-0.068	-2.215**	1.311**
	(0.094)	(0.225)	(0.119)	(0.997)	(0.657)
Household size*Fertilizer	0.017	0.076	-0.011	0.027	-0.094
	(0.016)	(0.061)	(0.024)	(0.076)	(0.142)
Household size*Hoes	-0.007	0.327	-0.069	-0.055	-0.717**
	(0.081)	(0.298)	(0.105)	(0.347)	(0.344)
Household size*Ploughs	0.027	-0.09	0.025	-0.146	-0.147
	(0.051)	(0.111)	(0.071)	(0.277)	(0.629)
Household size*Shannon index	-0.041	0.013	-0.09	0.191	0.261
	(0.030)	(0.184)	(0.132)	(0.370)	(1.743)
Oxen*Fertilizer	0	-0.083	0.017	0.25	-0.31
	(0.022)	(0.078)	(0.030)	(0.167)	(0.267)
Oxen*Hoes	-0.079	0.043	0.012	-0.182	-0.927*
	(0.084)	(0.463)	(0.102)	(0.606)	(0.473)
Oxen*Ploughs	-0.069	-0.392	-0.049	-1.25	-0.764
	(0.062)	(0.241)	(0.075)	(0.756)	(0.736)
Oxen*Shannon index	-0.06	0.255	-0.105	-0.271**	0
	(0.045)	(0.238)	(0.131)	(0.112)	.
Fertilizer*Hoes	-0.006	-0.092	-0.068**	0.105	0.303***
	(0.022)	(0.108)	(0.030)	(0.089)	(0.105)
Fertilizer*Ploughs	0.01	-0.004	0.014	-0.092*	0.124
	(0.015)	(0.048)	(0.020)	(0.054)	(0.225)
Fertilizer*Shannon index	0.032*	-0.004	0.025	0.031	-0.352
	(0.017)	(0.087)	(0.033)	(0.099)	(0.665)
Hoes*Ploughs	-0.065	-0.032	-0.059	-0.116	0.53
	(0.042)	(0.174)	(0.051)	(0.168)	(0.596)
Hoes*Shannon index	-0.115	-0.484	0.126	-0.435	-1.615
	(0.087)	(0.390)	(0.109)	(0.603)	(2.605)
Ploughs*Shannon index	0.019	0.036	-0.154*	-0.086	-0.166
	(0.025)	(0.052)	(0.083)	(0.343)	(1.427)
Constant	6.924***	6.599***	6.176***	6.984***	3.919***
	(0.226)	(0.507)	(0.282)	(0.819)	(1.393)
Elasticity of Shannon index	0.009	0.061	0.083	0.295	-3.59
p-value	0.903	0.774	0.444	0.304	0.246
Fixed effects					
Village-year fixed effects	✓	✓	✓	✓	✓
Number of households	419	108	188	57	66
Number of observations	1820	504	939	224	153
Average obs. per household	4.344	4.667	4.995	3.93	2.32
R-squared a	0.793	0.73	0.613	0.485	0.509

Notes: N. Highlands refers to Northern Highlands. C. Highlands refers to Central highlands.

Table B27: Semi-parametric model: Parametric component (Full sample), Balanced sample

	All	Teff	No teff
Area	0.609***	0.723***	0.572***
	(0.087)	(0.134)	(0.110)
Household size	-0.22	-0.048	-0.228
	(0.145)	(0.195)	(0.238)
Oxen	0.085**	0.114**	0.058
	(0.041)	(0.052)	(0.067)
Fertilizer	0.023*	0.031*	0.012
	(0.013)	(0.017)	(0.020)
Hoes	0.034	0.019	0.055
	(0.028)	(0.037)	(0.043)
Ploughs	0.014	0.003	0.041
	(0.021)	(0.030)	(0.031)
Area (square)	-0.001	0.015	-0.026
	(0.015)	(0.025)	(0.020)
Household size (square)	0.082*	0.026	0.089
	(0.046)	(0.061)	(0.072)
Oxen (square)	0.005*	0.007*	0.004
	(0.003)	(0.004)	(0.005)
Fertilizer (square)	0.002**	0.002*	0.001
	(0.001)	(0.001)	(0.002)
Hoes (square)	0.002	0.001	0.003
	(0.002)	(0.003)	(0.003)
Ploughs (square)	0.001	0.001	0.002
	(0.001)	(0.002)	(0.002)
Area*Household size	-0.059	-0.133**	-0.023
	(0.045)	(0.068)	(0.055)
Area*Oxen	-0.001	0.001	-0.001
	(0.003)	(0.004)	(0.004)
Area*Fertilizer	0	-0.004	0.005
	(0.003)	(0.004)	(0.004)
Area*Hoes	0.007**	0.006	0.007*
	(0.003)	(0.004)	(0.004)
Area*Ploughs	0	-0.004	0.008**
	(0.003)	(0.004)	(0.004)
Household size*Oxen	-0.004	-0.005	-0.002
	(0.005)	(0.007)	(0.008)
Household size*Fertilizer	0.003	-0.001	0.007
	(0.005)	(0.006)	(0.007)
Household size*Hoes	-0.002	-0.002	-0.003
	(0.004)	(0.007)	(0.006)
Household size*Ploughs	-0.007	-0.004	-0.014
	(0.006)	(0.007)	(0.008)
Oxen*Fertilizer	0	0	-0.001
	(0.000)	(0.000)	(0.000)
Oxen*Hoes	0	0	0
	(0.000)	(0.000)	(0.000)
Oxen*Ploughs	-0.001	0	-0.001*
	(0.000)	(0.001)	(0.001)
Fertilizer*Hoes	0.000*	0	0.001**
	(0.000)	(0.000)	(0.000)
Fertilizer*Ploughs	0.001*	0.001**	0
	(0.000)	(0.000)	(0.000)
Hoes*Ploughs	-0.001*	-0.001**	0
	(0.000)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of households	617	400	419
Number of observations	3085	1582	1503
Average obs. per household	5.000	3.955	3.587112
R-squared a	0.475	0.482	0.485

Table B28: Semi-parametric model: Parametric component (Northern Highlands), Balanced sample

	All	Teff	No teff
Area	0.466***	0.388	0.902***
	(0.150)	(0.291)	(0.284)
Household size	-0.233	-0.384	-0.337
	(0.372)	(0.639)	(0.473)
Oxen	0.093	0.188	-0.034
	(0.099)	(0.120)	(0.153)
Fertilizer	-0.051	-0.109**	-0.048
	(0.044)	(0.050)	(0.074)
Hoes	-0.078	-0.049	-0.054
	(0.071)	(0.079)	(0.165)
Ploughs	0.085	0.102	0.054
	(0.052)	(0.079)	(0.089)
Area (square)	0.032	0.036	0.007
	(0.031)	(0.052)	(0.064)
Household size (square)	0.092	0.175	0.058
	(0.104)	(0.192)	(0.135)
Oxen (square)	0.006	0.01	-0.002
	(0.007)	(0.009)	(0.012)
Fertilizer (square)	-0.004	-0.008**	-0.005
	(0.004)	(0.004)	(0.007)
Hoes (square)	-0.006	-0.007	-0.004
	(0.005)	(0.005)	(0.012)
Ploughs (square)	0.006*	0.007*	0.003
	(0.003)	(0.004)	(0.006)
Area*Household size	0.028	-0.01	-0.103
	(0.078)	(0.158)	(0.105)
Area*Oxen	0.002	0.007	0.015
	(0.006)	(0.008)	(0.011)
Area*Fertilizer	-0.004	-0.008	0.006
	(0.006)	(0.007)	(0.012)
Area*Hoes	0.008	-0.005	0.008
	(0.005)	(0.009)	(0.009)
Area*Ploughs	0.004	0.008	0.008
	(0.005)	(0.009)	(0.009)
Household size*Oxen	-0.009	-0.018	-0.007
	(0.011)	(0.018)	(0.012)
Household size*Fertilizer	0.006	0.013	-0.003
	(0.011)	(0.019)	(0.016)
Household size*Hoes	0.01	0.015	0.012
	(0.009)	(0.017)	(0.012)
Household size*Ploughs	-0.016	-0.041**	-0.009
	(0.010)	(0.018)	(0.012)
Oxen*Fertilizer	-0.002**	0.001	-0.004***
	(0.001)	(0.001)	(0.001)
Oxen*Hoes	0	0	0
	(0.001)	(0.001)	(0.001)
Oxen*Ploughs	0	0.003*	-0.002
	(0.001)	(0.002)	(0.001)
Fertilizer*Hoes	0.002**	0.005***	0.002**
	(0.001)	(0.001)	(0.001)
Fertilizer*Ploughs	0	-0.004***	0.001
	(0.001)	(0.002)	(0.002)
Hoes*Ploughs	0	-0.002	0
	(0.001)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of households	148	85	108
Number of observations	740	327	413
Average obs. per household	5	3.847059	3.824074
R-squared a	0.567	0.342	0.669

Table B29: Semi-parametric model: Parametric component (Central Highlands), Balanced sample

	All	Teff	No teff
Area	0.691***	0.699***	0.729***
	(0.136)	(0.193)	(0.172)
Household size	-0.268	-0.189	-0.205
	(0.262)	(0.329)	(0.350)
Oxen	0.031	0.005	0.031
	(0.065)	(0.095)	(0.083)
Fertilizer	0.023	0.077**	0.021
	(0.018)	(0.030)	(0.022)
Hoes	0.072**	0.01	0.115**
	(0.035)	(0.055)	(0.046)
Ploughs	0.039	-0.021	0.069*
	(0.029)	(0.045)	(0.038)
Area (square)	-0.100***	-0.100*	-0.119***
	(0.024)	(0.053)	(0.027)
Household size (square)	0.132	0.092	0.123
	(0.081)	(0.095)	(0.110)
Oxen (square)	0.002	0.002	0.002
	(0.005)	(0.007)	(0.006)
Fertilizer (square)	0.002	0.005**	0.002
	(0.001)	(0.002)	(0.002)
Hoes (square)	0.004*	-0.001	0.007**
	(0.002)	(0.004)	(0.003)
Ploughs (square)	0.001	0	0.003
	(0.002)	(0.004)	(0.002)
Area*Household size	-0.083	-0.08	-0.08
	(0.073)	(0.101)	(0.090)
Area*Oxen	0.004	0.007	0.003
	(0.005)	(0.007)	(0.007)
Area*Fertilizer	-0.004	0.002	-0.011
	(0.005)	(0.008)	(0.007)
Area*Hoes	0	0.005	-0.003
	(0.005)	(0.007)	(0.006)
Area*Ploughs	-0.004	-0.026**	0.005
	(0.006)	(0.011)	(0.007)
Household size*Oxen	0.003	0.017	-0.002
	(0.008)	(0.012)	(0.011)
Household size*Fertilizer	0.004	-0.009	0.004
	(0.008)	(0.011)	(0.009)
Household size*Hoes	-0.003	-0.017	-0.002
	(0.008)	(0.012)	(0.010)
Household size*Ploughs	-0.016*	0.004	-0.022*
	(0.009)	(0.013)	(0.012)
Oxen*Fertilizer	0	0	0
	(0.000)	(0.001)	(0.001)
Oxen*Hoes	0	0	0.001*
	(0.000)	(0.001)	(0.001)
Oxen*Ploughs	0	0.001	-0.001
	(0.001)	(0.002)	(0.001)
Fertilizer*Hoes	0	0	0
	(0.000)	(0.001)	(0.001)
Fertilizer*Ploughs	0	0.001	-0.001
	(0.001)	(0.001)	(0.001)
Hoes*Ploughs	-0.001	-0.003***	-0.001
	(0.001)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of households	237	118	188
Number of observations	1185	400	785
Average obs. per household	5	3.39	4.17
R-squared a	0.387	0.431	0.395

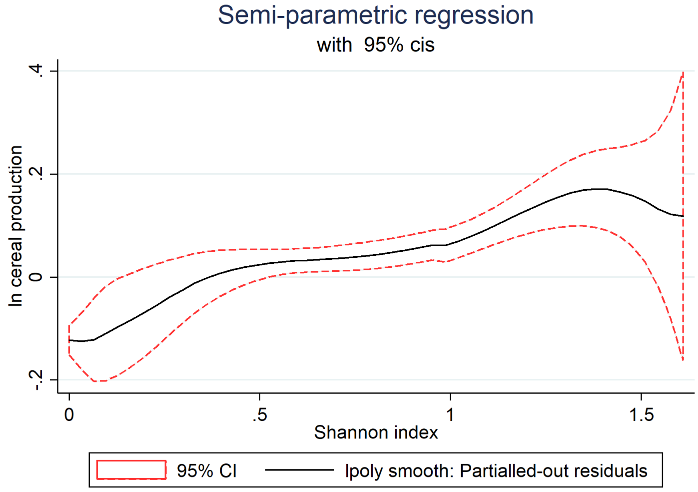
Table B30: Semi-parametric model: Parametric component (Arusi/Bale (Other)), Balanced sample

	All	Teff	No teff
Area	0.441*	0.668**	0.445
	(0.241)	(0.311)	(0.392)
Household size	0.187	0.668**	-0.711
	(0.280)	(0.280)	(0.891)
Oxen	0.088	0.062	0.18
	(0.077)	(0.086)	(0.243)
Fertilizer	-0.006	0.01	-0.062
	(0.022)	(0.023)	(0.068)
Hoes	0.1	0.093	0.105
	(0.060)	(0.067)	(0.129)
Ploughs	-0.03	-0.008	-0.112
	(0.045)	(0.050)	(0.103)
Area (square)	-0.001	-0.084	0.072
	(0.040)	(0.073)	(0.080)
Household size (square)	-0.075	-0.198*	0.13
	(0.096)	(0.107)	(0.280)
Oxen (square)	0.006	0.005	0.012
	(0.005)	(0.006)	(0.018)
Fertilizer (square)	0.001	0.001	-0.001
	(0.001)	(0.002)	(0.006)
Hoes (square)	0.005	0.005	0.003
	(0.004)	(0.005)	(0.009)
Ploughs (square)	0.001	0.001	-0.006
	(0.003)	(0.003)	(0.007)
Area*Household size	-0.016	-0.036	-0.029
	(0.121)	(0.179)	(0.182)
Area*Oxen	-0.006	0.004	-0.018
	(0.006)	(0.010)	(0.013)
Area*Fertilizer	0.004	-0.015**	0.014
	(0.004)	(0.007)	(0.009)
Area*Hoes	0.004	-0.001	0.009
	(0.006)	(0.009)	(0.011)
Area*Ploughs	0.003	0.005	0.01
	(0.007)	(0.010)	(0.013)
Household size*Oxen	0	0.006	-0.012
	(0.010)	(0.012)	(0.020)
Household size*Fertilizer	0.008	0.005	0.035**
	(0.009)	(0.010)	(0.015)
Household size*Hoes	-0.015	-0.01	-0.035*
	(0.009)	(0.011)	(0.019)
Household size*Ploughs	0.013	-0.001	0.01
	(0.011)	(0.013)	(0.025)
Oxen*Fertilizer	0	0	0.001
	(0.001)	(0.001)	(0.001)
Oxen*Hoes	0	0	0
	(0.000)	(0.001)	(0.001)
Oxen*Ploughs	-0.001*	-0.001	-0.002
	(0.001)	(0.001)	(0.001)
Fertilizer*Hoes	0	0	0
	(0.001)	(0.001)	(0.001)
Fertilizer*Ploughs	0	0	0.002**
	(0.001)	(0.001)	(0.001)
Hoes*Ploughs	0	0	-0.002
	(0.001)	(0.001)	(0.001)
Village-year fixed effects	✓	✓	✓
Number of households	156	125	57
Number of observations	780	590	190
Average obs. per household	5	4.72	3.333333
R-squared a	0.528	0.561	0.495

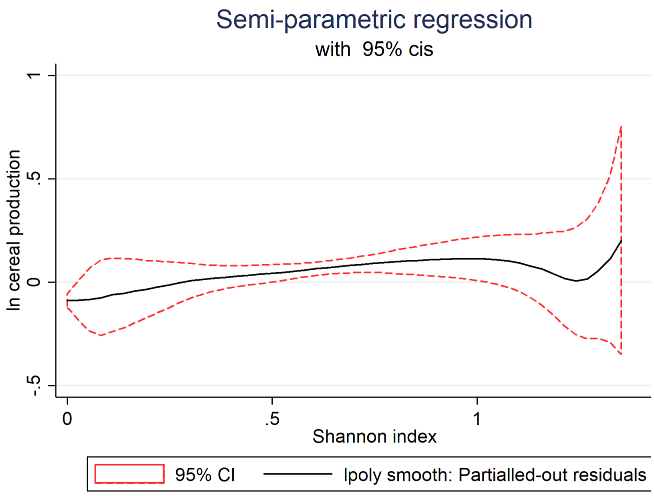
Table B31: Semi-parametric model: Parametric component (Enset), Balanced sample

	All	Teff	No teff
Area	0.556*	0.906**	0.444
	(0.303)	(0.408)	(0.470)
Household size	-0.483	-0.887	-1.345
	(0.606)	(0.808)	(1.533)
Oxen	0.179	0.410*	-0.221
	(0.180)	(0.216)	(0.423)
Fertilizer	0.028	0.017	0.013
	(0.044)	(0.057)	(0.156)
Hoes	0.013	0.126	-0.225
	(0.096)	(0.130)	(0.235)
Ploughs	-0.009	-0.05	0.06
	(0.117)	(0.117)	(0.197)
Area (square)	0.015	0.028	-0.009
	(0.033)	(0.046)	(0.059)
Household size (square)	0.198	0.226	0.526
	(0.155)	(0.177)	(0.433)
Oxen (square)	0.012	0.027*	-0.014
	(0.013)	(0.015)	(0.033)
Fertilizer (square)	0.002	0.001	0.002
	(0.003)	(0.004)	(0.007)
Hoes (square)	0.005	0.014	-0.014
	(0.007)	(0.009)	(0.017)
Ploughs (square)	0	-0.003	0
	(0.008)	(0.008)	(0.013)
Area*Household size	-0.106	-0.235	-0.039
	(0.138)	(0.178)	(0.194)
Area*Oxen	-0.002	-0.002	0.004
	(0.009)	(0.009)	(0.013)
Area*Fertilizer	-0.009	-0.024**	0.007
	(0.007)	(0.011)	(0.013)
Area*Hoes	0.005	0.008	0.005
	(0.009)	(0.011)	(0.016)
Area*Ploughs	-0.005	0.005	-0.008
	(0.009)	(0.011)	(0.015)
Household size*Oxen	-0.008	-0.019	0.015
	(0.016)	(0.017)	(0.031)
Household size*Fertilizer	0.004	0	0.021
	(0.013)	(0.016)	(0.056)
Household size*Hoes	0.026	0.033	0.034
	(0.016)	(0.020)	(0.034)
Household size*Ploughs	-0.015	-0.017	-0.031
	(0.018)	(0.021)	(0.033)
Oxen*Fertilizer	0.002	0.003**	0.001
	(0.001)	(0.001)	(0.003)
Oxen*Hoes	0.001	0.001	0
	(0.001)	(0.001)	(0.002)
Oxen*Ploughs	-0.003**	-0.003**	0.001
	(0.001)	(0.001)	(0.004)
Fertilizer*Hoes	0.001	0	0.003
	(0.001)	(0.001)	(0.003)
Fertilizer*Ploughs	0.001	0.003**	-0.004
	(0.001)	(0.001)	(0.003)
Hoes*Ploughs	-0.001	-0.002*	-0.001
	(0.001)	(0.001)	(0.002)
Village-year fixed effects	✓	✓	✓
Number of households	76	72	66
Number of observations	380	265	115
Average obs. per household	5	3.680556	1.742424
R-squared a	0.448	0.571	0.158

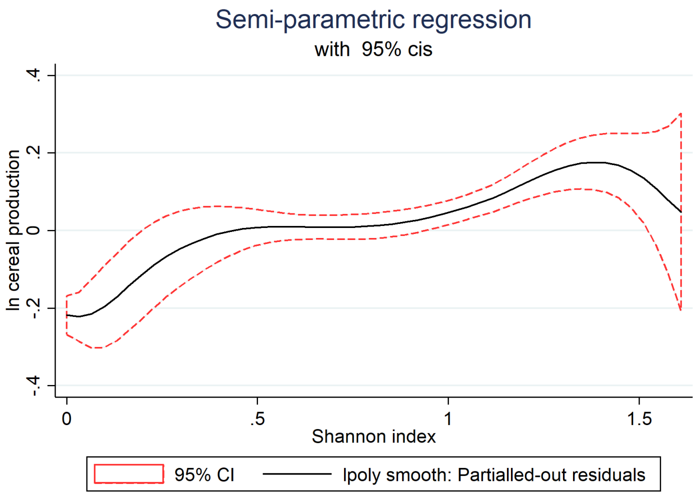
Figure B11: Effect of Shannon index Semi parametric Full sample (Balanced sample)



(a) **Full sample**

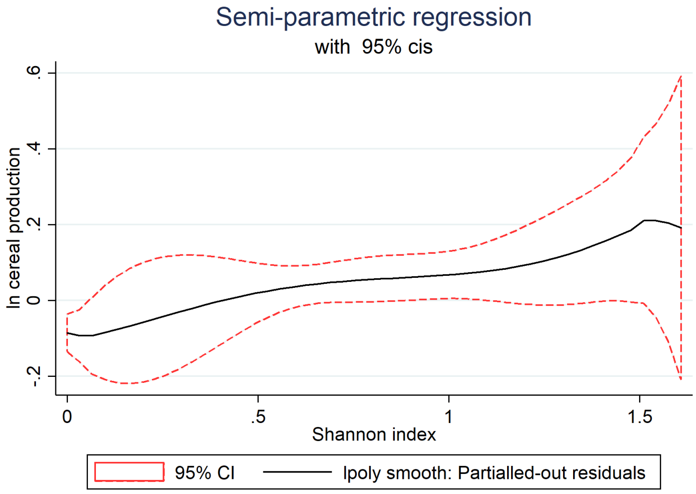


(b) **Non teff-producing households**

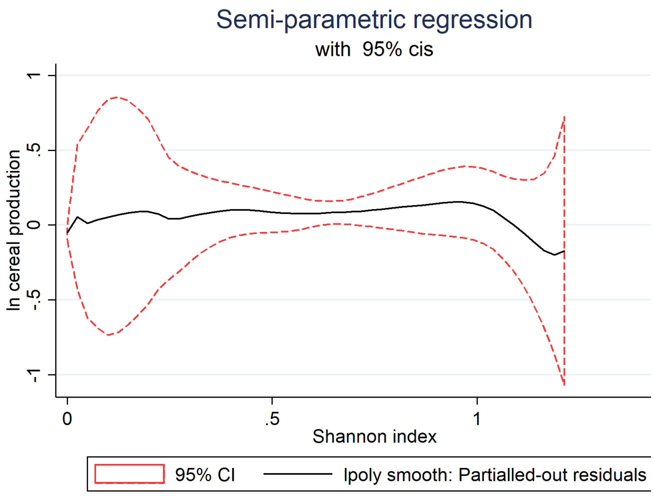


(c) **Teff-producing households**

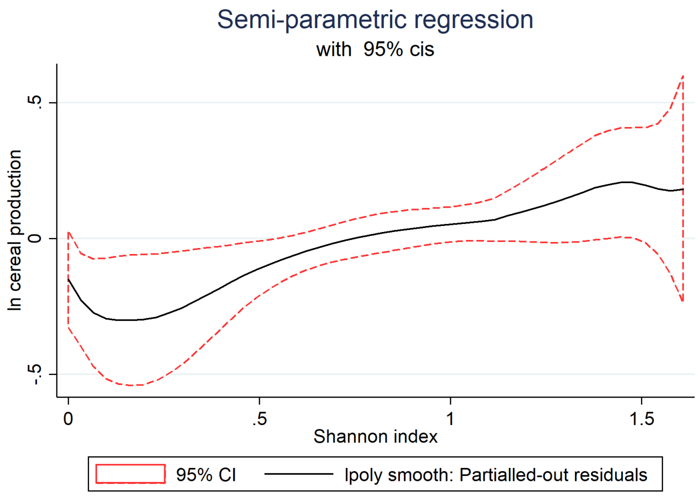
Figure B12: Effect of Shannon index Semi parametric Northern Highlands (Balanced sample)



(a) **Full sample**

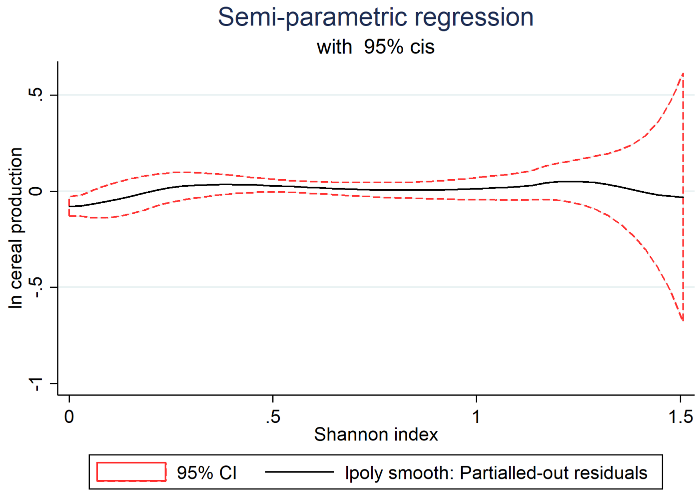


(b) **Non teff-producing households**

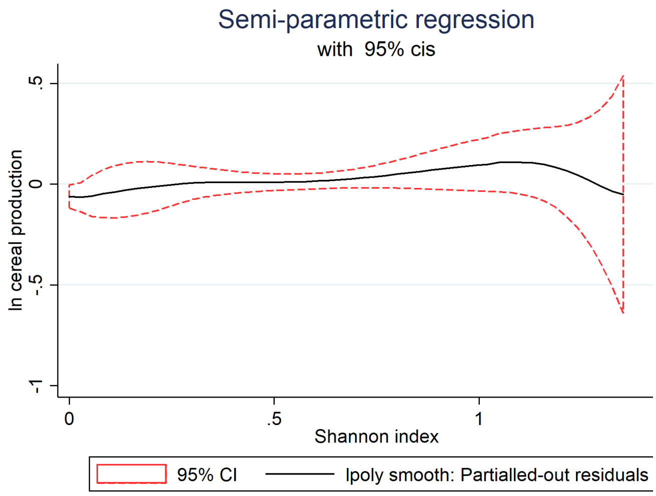


(c) **Teff-producing households**

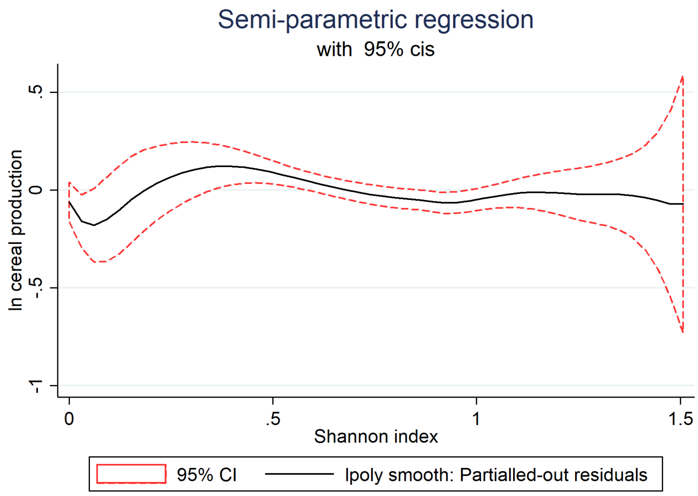
Figure B13: Effect of Shannon index Semi parametric Central Highlands (Balanced sample)



(a) **Full sample**

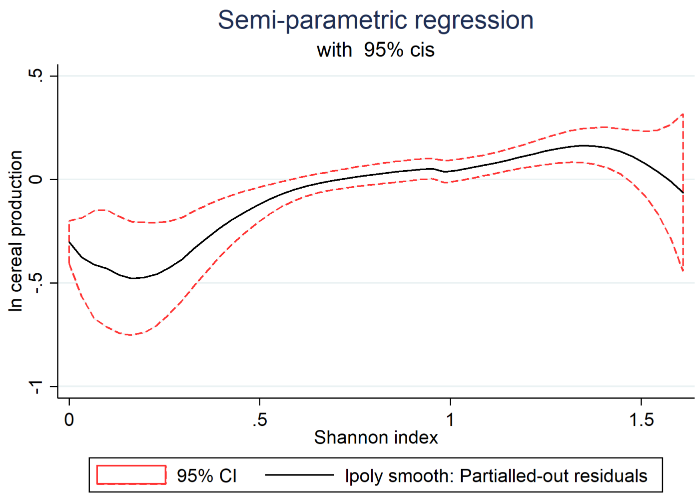


(b) **Non teff-producing households**

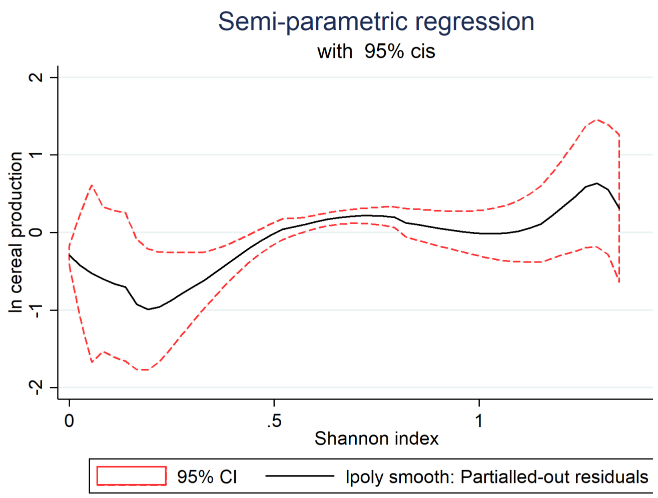


(c) **Teff-producing households**

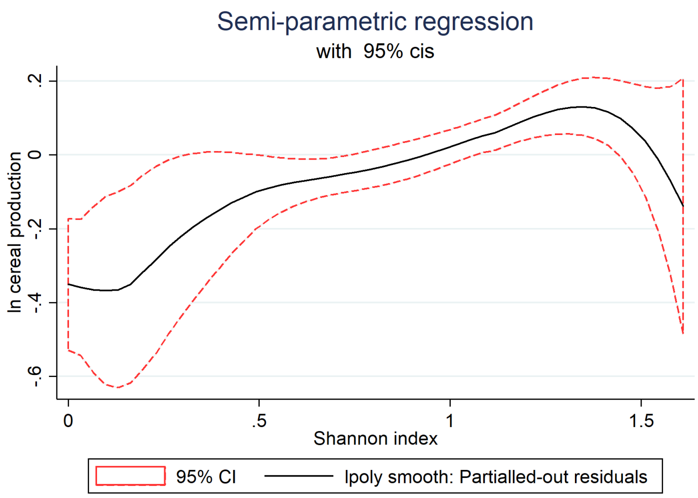
Figure B14: Effect of Shannon index Semi parametric Arussi/Bale (Balanced sample)



(a) **Full sample**

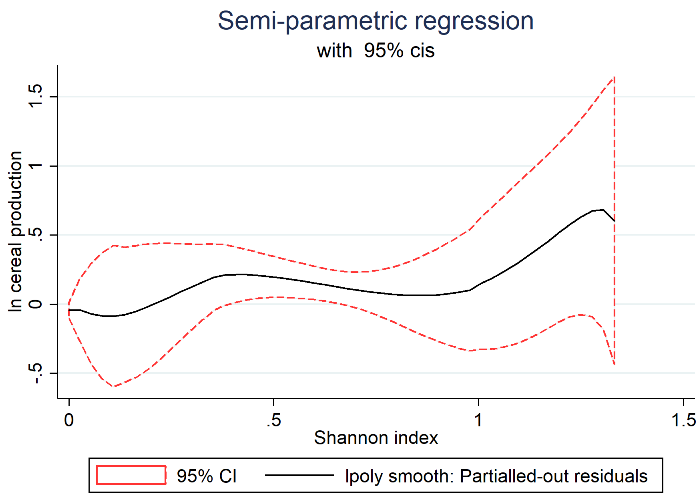


(b) **Non teff-producing households**

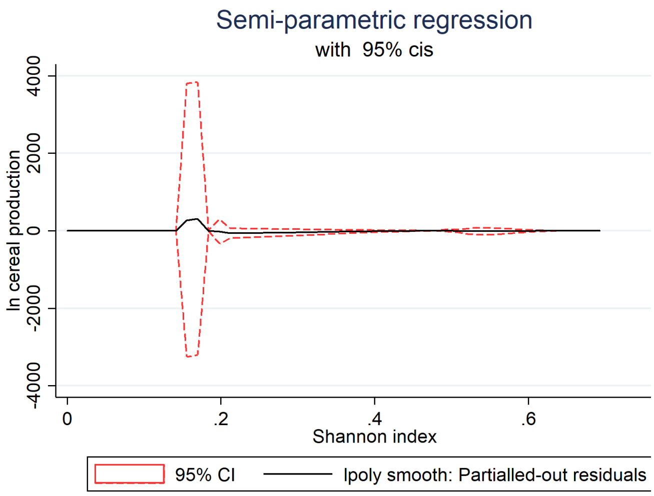


(c) **Teff-producing households**

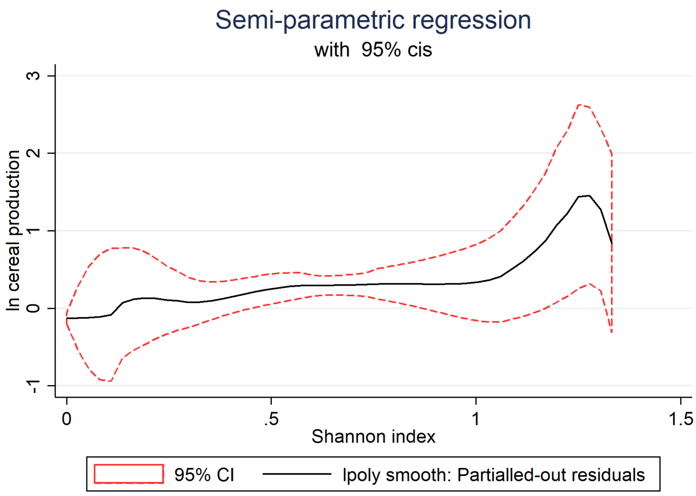
Figure B15: Effect of Shannon index Semi parametric Enset (Balanced sample)



(a) **Full sample**

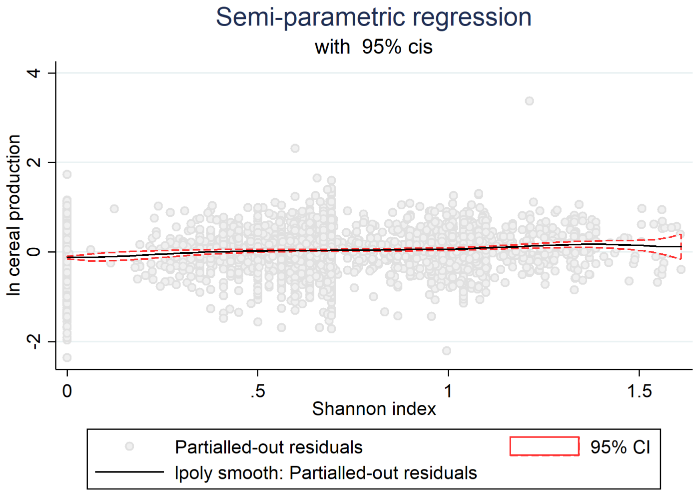


(b) **Non teff-producing households**

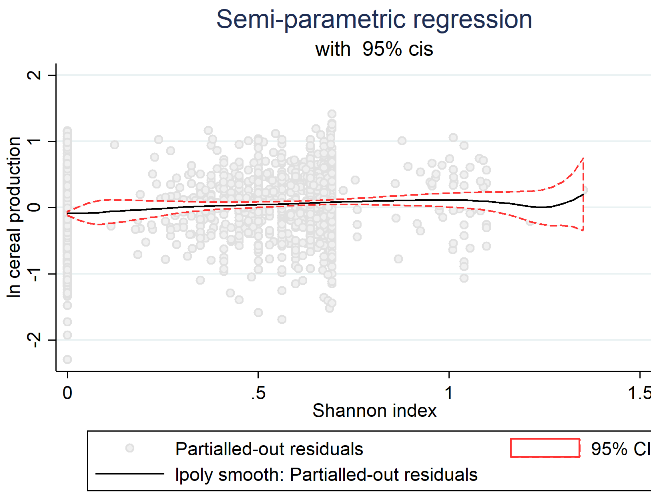


(c) **Teff-producing households**

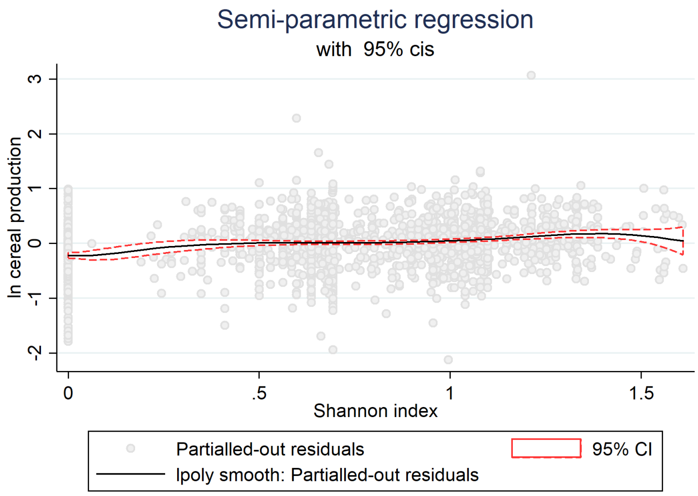
Figure B16: Effect of Shannon index Semi parametric Full sample (Balanced sample, with scatter)



(a) **Full sample**

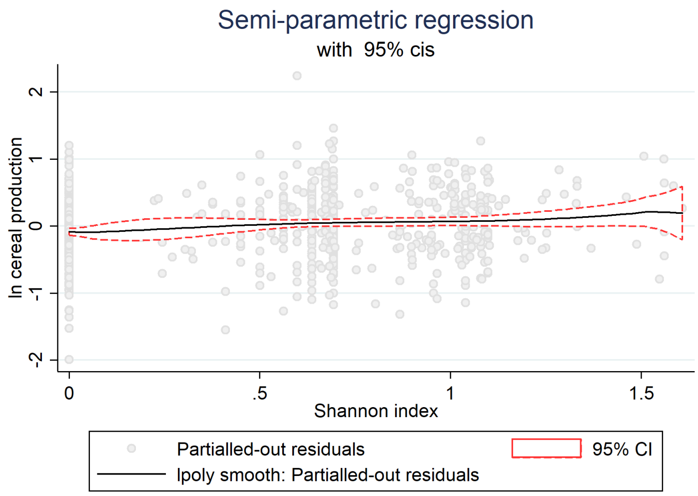


(b) **Non teff-producing households**

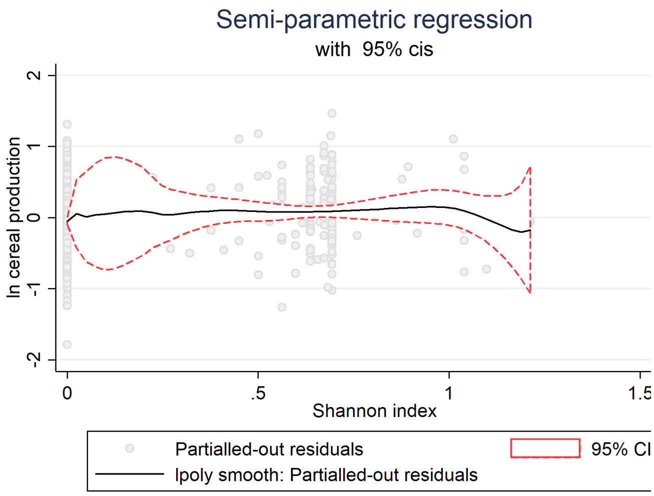


(c) **Teff-producing households**

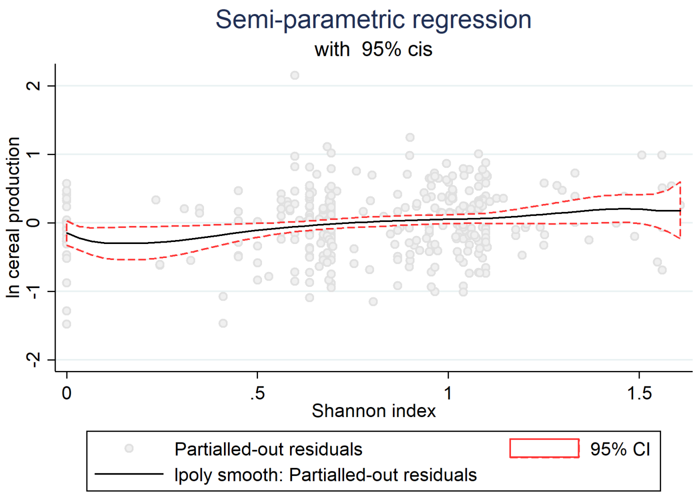
Figure B17: Effect of Shannon index Semi parametric Northern Highlands (Balanced sample, with scatter)



(a) **Full sample**

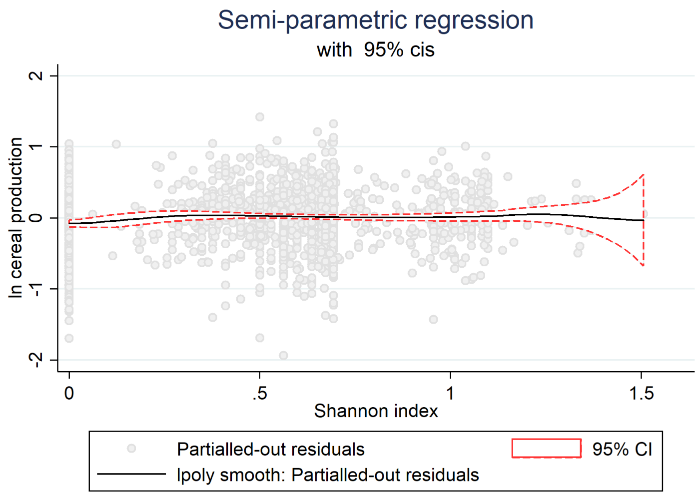


(b) **Non teff-producing households**

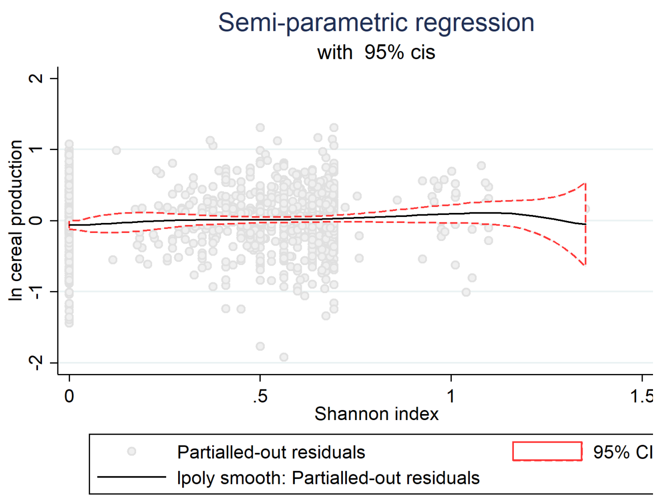


(c) **Teff-producing households**

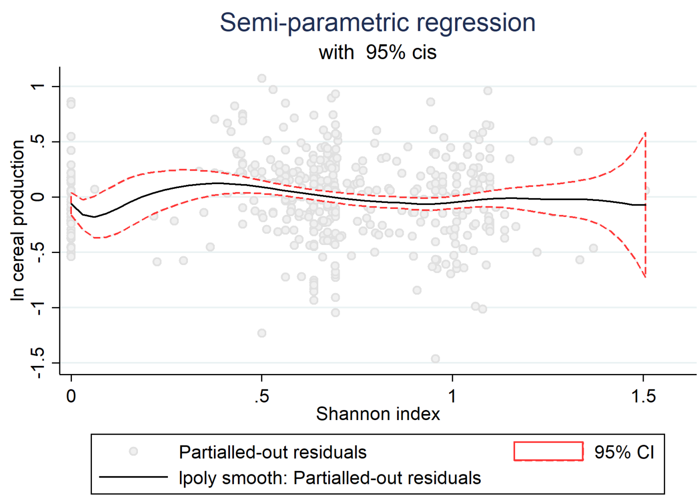
Figure B18: Effect of Shannon index Semi parametric Central Highlands (Balanced sample, with scatter)



(a) **Full sample**

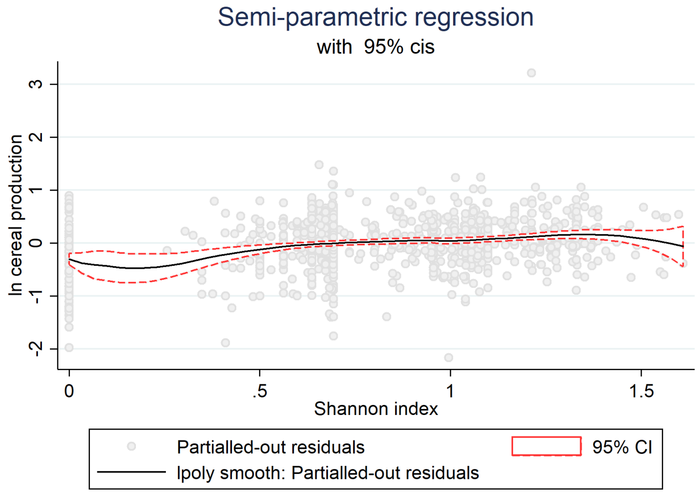


(b) **Non teff-producing households**

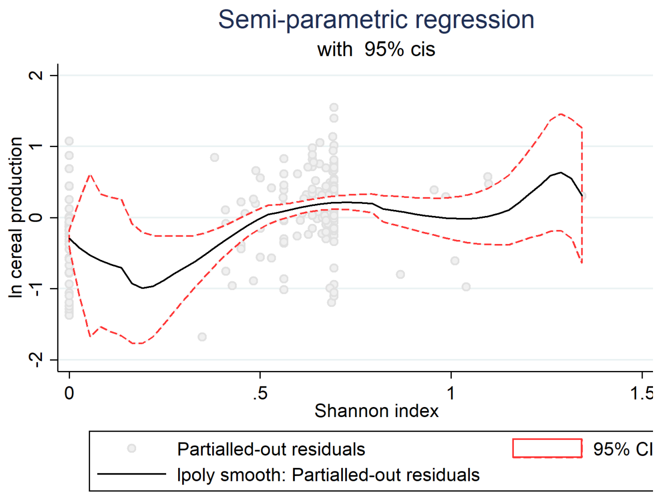


(c) **Teff-producing households**

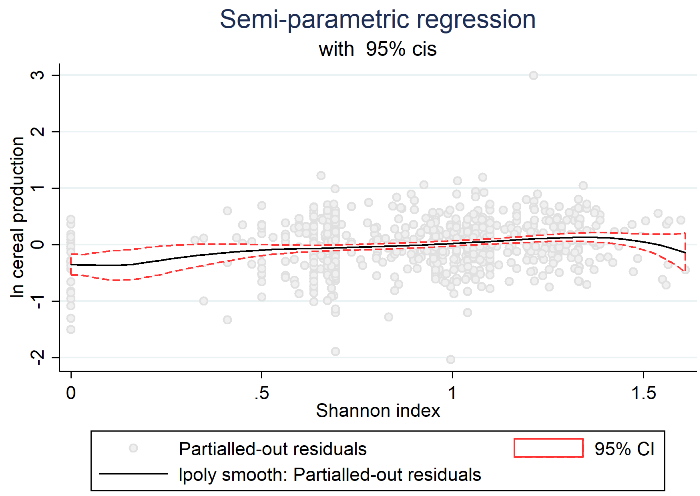
Figure B19: Effect of Shannon index Semi parametric Arussi/Bale (Balanced sample, with scatter)



(a) Full sample

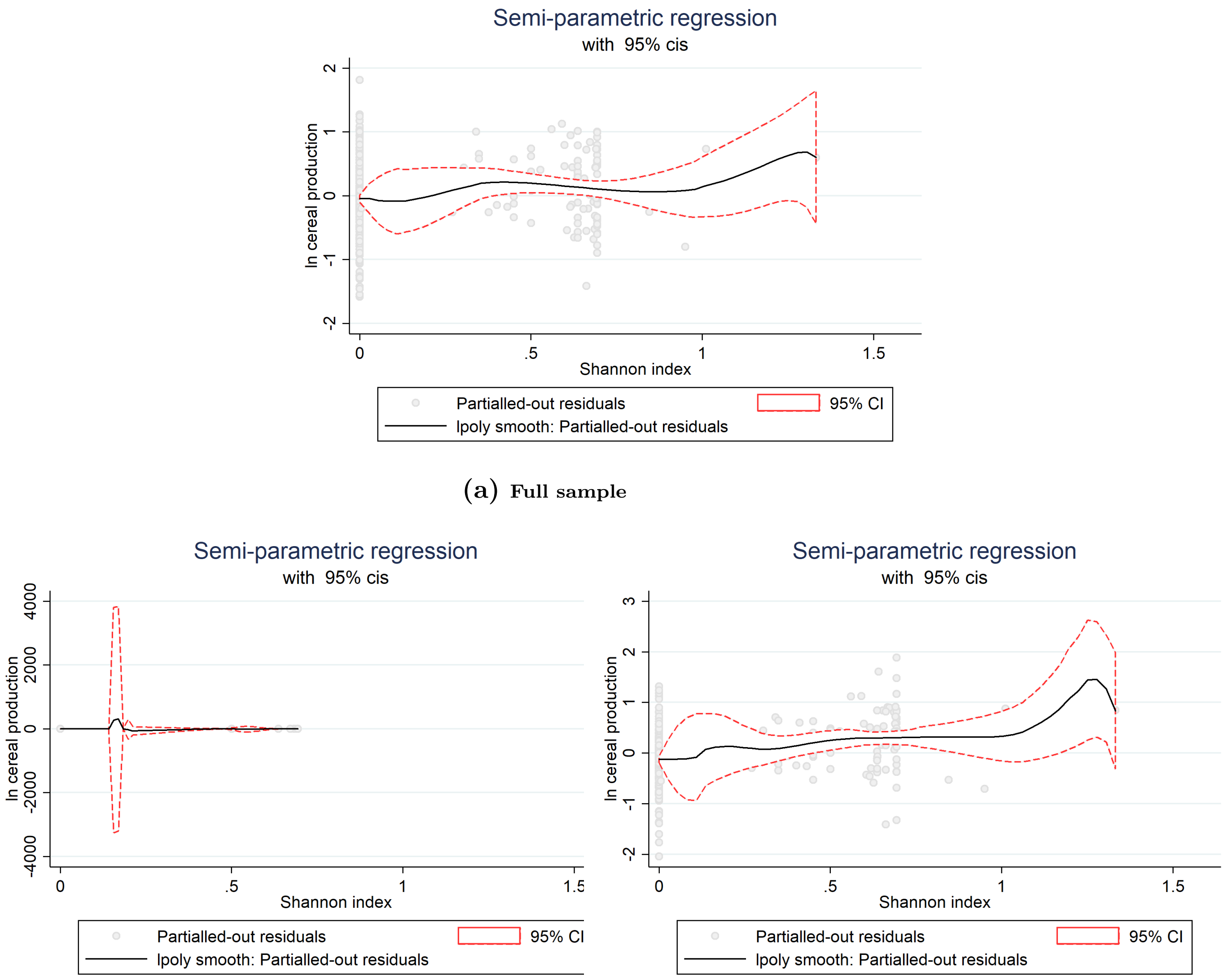


(b) Non teff-producing households



(c) Teff-producing households

Figure B20: Effect of Shannon index Semi parametric Enset (Balanced sample, with scatter)



(a) **Full sample**

(b) **Non teff-producing households**

(c) **Teff-producing households**

Table B32: Bandwidth choice

	All	N. Highlands	C. Highlands	Other	Enset
Main	0.43	0.67	0.51	0.43	0.44
No teff	0.35	0.29	0.46	0.36	0.22
Teff	0.5	0.51	0.4	0.49	0.33

11 Appendix B - Data preparation and Battese correction

11.1 Data preparation

This section summarizes the steps involved in the data preparation and spells out the assumptions that were made in order to create the variables used in the paper.

Step 1: Production variables

- **Step 1.1:** We open each of the data files containing the production aggregates and we change the suffix of each variable, such that the production and area variables end in "ha" and "prd". We then generate a year variable which is equal to the year of the wave. We thus end up with six .dta files corresponding to the year 1994, 1995, 1997, 1999, 2004 and 2009.

- **Step 1.2:** We then append the six .dta files obtained from step 1.1 and generate the total cereal area and the total cereal production which sums the total cultivated area and production of six cereals, namely white teff, black teff, barley, wheat, maize and sorghum. Note: Note: In 1995, the production for the belg season was reported. We summed the production of the belg season of 1995 to the production of the year when it was collected (i.e. 1995).

Step 2: Number of oxen and household size

- **Step 2.1:** From the data aggregates we keep, for each year, the number of oxen and the household size and, as in step 1.1, we generate a year variable that takes the value of the year of the wave.

- **Step 2.2:** We then append the 6 data files for oxen and the 6 data files for household size.

Step 3: Fertilizer

The process used for fertilizer is slightly different from the other variables and required .do files. This is because fertilizer data was not included in the aggregates.

- **Step 3.1:** In each raw file, we sum the total quantity (in kgs) used across different crops for each plot. When the data in kgs is not available, we convert the quantity of fertilizer used into kilograms, using the conversion factors provided (this is the case for the first wave). Once, the plot-level quantity of fertilizer is obtained, we sum the quantity across all plots for a given household to obtain the total fertilizer used at the household level.

- **Step 3.2:** We then append each of the files obtained Step 3.1 and substitute any negative values by a missing value.

Step 4: Assets

Since most of the asset values are not available in the aggregate files, our procedure to obtain these values is similar to that of fertilizer.

- **Step 4.1:** For each year we compute the number of hoes and ploughs.

- **Step 4.2:** We append each of the .dta files obtained from step 4.1.

Step 5: Shannon index

- **Step 5.1:** We generate the proportion of cereal area dedicated to a given cereal. This is calculated by dividing the cereal allocated to a given cereal (as per the aggregate files) by the total cereal area.

- **Step 5.2:** We multiply the negative of the variable generated in step 5.1 times the natural logarithm of this variable for each individual crop.

- **Step 5.3:** We sum the values obtained in step 5.2 across all 6 cereals used in the analysis.

Step 6: Imputed values

There are a number of variables that are missing. In some cases, we impute some values so as to keep as many observations as possible in the analysis. We check, however, that our results are not driven by the imputed values.

In the cases of household size and the number of oxen, very few used observations are imputed. From a total of 5,806 observations, we impute four values in the case of household size and one in the case of oxen. For these variables we simply use the lag or lead value of the variables.

In the case of fertilizer, there is a larger number of imputed values. The qfert variable denotes the variable with no imputed values. Conversely, qfert2 includes imputed values. Specifically, out of 5,806 observations, these variables differ from one another in 373 cases, where we have missing values for the quantity of fertilizer. In these cases, again, we use either lags or leads of the quantity of fertilizer used by that household. The vast majority of these (285) occur in 2004.

In the case of hoes and ploughs, there is also a large number (862) of missing observations. Over 95% of these values (844) occur in 1999 because the format in which the data is available in the raw files differs from all other years. As a result, we simply use lags and leads to impute these values.

In the case of cereal production, there are a number of observations (362 out of 5,806) where the households report a non-0 area of cropped cereal but no cereal production. Similarly, there are a number of cases where households report unlikely yields (144). Specifically, we denote "unlikely yields" as cereal yields below 50 kg/ha and yields exceeding 6000 kgs/ha. For these cases, we use the average yield (among households who do not report an "unlikely yield") and multiply this by the total area cultivated by the farmer. We checked, however, that our results are sensitive to omitting these imputed values.

Step 7: Imputed values

We use a simplified version of the agro-ecological classification used in from Nisrane et al. (2011). Specifically, we merge the Arusi/Bale and the Hararghe agro-ecological zones.

11.2 Battese correction

When a large number of 0 exists for a given variable, the natural logarithm of this variable is not defined. This is a problem if we want to estimate a production function, since using natural logarithms tends to be norm to estimate the typical production functions (Cobb-Douglas and Translog). Typically, practitioners tackle this challenge by either 1) not using households who report 0 values; or 2) substituting the 0 value by a very small number (e.g. 0.0000001). However, Battese (1997) argues that doing this can result in seriously biased estimates of the elasticities of production if the number of 0 observations is very large. The main idea behind this is that households who use a given input may have a different intercept of that of households who do not. Not taking this into account can lead to a biased estimate of the slope parameter.

In practice the procedure requires that an input-use dummy variable[14] be included for all independent variables whose observed values include 0 (fertilizer, number of oxen, number of hoes and number of ploughs). This dummy variable is equal to 1 when the input is not used (observed value of 0), and takes the value of 1 otherwise. In addition to the inclusion of the dummy variable, the method proposed by Battese 1997 requires to transform the input variables such that all 0 values are replaced by a 1.

Algebraically, we can then represent the equations used by equation 1:

$$ln\ y_{it} = \alpha_i + \sum_{k=1}^{k=K)} \beta_k d_{kit} + \sum_{n=1}^{n=N} \beta_n ln(x_{nit}) 0.5 \sum_{n=1}^{n=N} \sum_{m=1}^{m=N} \beta_{nm}\ lnx_{nit} * lnx_{mit} + \sum_{t=1}^{t=T} \sum_{p=1}^{p=P} d_t * d_p + e_{it} \tag{4}$$

As previously explained, for those inputs where 0-values are observed (hoes, ploughs, oxen, Shannon index, fertilizer) we use the transformation proposed by by Battese (1997) and we use the subscript k . The remaining inputs (household members, land under cereal cultivation) do not undergo any transformation.

[14]Consider an input k for which some farmers have a 0 value. Battese (1997) shows that in this case, simply adding a small number may not be the most appropriate solution. Instead, Battese (1997) proposes the inclusion of a dummy variable, d_k which takes a value of 1 when the input is not used (i.e. $d_k = 1$ if k=0 and, conversely, $d_k = 0$ when k¿0). Additionally, for these variables, using the Battese method implies that $k = max(k, d_k)$