GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

GlobalFood
www.uni-goettingen.de/globalfood

RTG 1666 GlobalFood

Transformation of Global Agri-Food Systems:
Trends, Driving Forces, and Implications for Developing Countries

Georg-August-University of Göttingen

GlobalFood Discussion Papers

No. 98

Small producer participation in export vegetable supply chains and household labour allocation in Tanzania: an age-disaggregated approach

Marwan Benali
Bernhard Brümmer
Victor Afari-Sefa

May 2017

RTG 1666 GlobalFood · Heinrich Düker Weg 12 · 37073 Göttingen · Germany
www.uni-goettingen.de/globalfood

ISSN (2192-3248)

Suggested Citation:

Benali, M., B. Brümmer, V. Afari-Sefa (2017). Small producer participation in export vegetable supply chains and household labour allocation in Tanzania: an age-disaggregated approach. GlobalFood Discussion Paper 98, University of Göttingen. http://www.uni-goettingen.de/de/213486.html.

Small producer participation in export vegetable supply chains and household labour allocation in Tanzania: an age-disaggregated approach

Marwan Benali[1*], Bernhard Brümmer[1], Victor Afari-Sefa[2]

[1] *University of Goettingen, Department of Agricultural Economics and Rural Development, Germany.*
[2] *World Vegetable Center, Regional office for West and Central Africa – Coastal and humid regions, Cotonou, Benin.*
** Contact author: marwan.benali@agr.uni-goettingen.de*

ABSTRACT

High-value agricultural supply chains have been playing an increasingly important role in developing countries and have had significant effects on the rural labour markets. This paper analyses the simultaneous effects of small producer participation in the latter on both household hired labour demand and off-farm labour supply, using an age-disaggregated approach. Failing to reject the separability hypothesis as well as the exogeneity of small producer participation in export supply chains, we apply lognormal double-hurdle models and find that participation in vegetable export supply chains in Tanzania affects positively a household's decision to hire labour from all age groups. We also find that it increases the unconditional overall level of hired labour demand, while the age-disaggregated analysis shows that these effects benefit mostly rural youth. However, no evidence of an effect on household off-farm labour supply is found.

JEL Codes: I31, J43, O12, Q12

Keywords: export supply chains; hired labour; off-farm labour; small producers; rural youth

Acknowledgements:

The authors are grateful to Prof. Steven T. Yen for sharing in-depth insights on the Multivariate Sample-Selection Model and his software code for this model. We are also grateful to Lutz Depenbusch, Prof. Matin Qaim and David Schwebel for their comments on previous versions of this paper. We also thank Ileana Grandelis, Cristina Rapone, Bernd Seiffert, Peter Wobst and the participants at the presentation to the FAO Technical Network on Decent Rural Employment on July 19, 2017 for their helpful comments on an earlier version of the paper. The financial support to this research received from the German Research Foundation (DFG) through the GlobalFood Research Training Group (RTG 1666), the Foundation fiat panis and the World Vegetable Center is gratefully acknowledged. Marwan Benali also acknowledges the financial support received from the German Academic Exchange Service (DAAD) for his doctoral studies. The data collection process and field survey were implemented in close collaboration with the World Vegetable Center regional office for Eastern and Southern Africa in Arusha, Tanzania. All remaining errors are solely ours.

1. Introduction

Through the past years, global agro-food systems have witnessed the emergence and consolidation of domestic and export high-value supply chains, in particular in developing countries, such as African countries who have been supplying an increasing share of high-value agricultural products, in particular fresh horticultural commodities, to developed countries (Maertens et al., 2012). Amongst others, this process has been pushed by the increased demand for higher quality and more diverse products in the latter (Humphrey et al., 2004). As a result, these supply chains have had important effects in terms of rural development through various pathways. Indeed, while the exclusion of small producers can potentially be a consequence of the above-mentioned process (Reardon and Barrett, 2000; Weatherspoon and Reardon, 2003; Humphrey et al., 2004), positive effects through both the product and labour markets have been noted (Maertens et al., 2012). For instance and through the former, positive income and price effects for participating small producers have been found (Maertens and Swinnen, 2009; Neven et al., 2009; Rao and Qaim, 2011).

High-value agricultural supply chains can also have direct and indirect effects on and through the labour markets, respectively (Maertens et al., 2012). Indeed, direct positive effects of these high-value supply chains on on-farm hired labour demand have been recorded (Neven et al., 2009; Maertens et al., 2012; Rao and Qaim, 2013). On the other hand, export supply chains may also generate and provide off-farm employment opportunities to poor rural households in developing countries, mostly as employed workers in the associated agro-processing sector (Humphrey et al., 2004; Maertens and Swinnen, 2009; Maertens et al., 2012). Participation in these supply chains *via* the labour markets has positive effects on income, agricultural production and poverty reduction (Maertens, 2009; Maertens and Swinnen, 2009; Maertens et al., 2012). These labour effects, through both the on-farm and off-farm labour markets have also been particularly important for women labourers (Maertens et al., 2012; Rao and Qaim, 2013).

Labour and employment generation as pathways towards poverty reduction

Such positive effects on labour and employment generation are relevant when one considers the importance of rural employment for development and poverty reduction. Indeed, off-farm labour can be seen as a livelihood strategy through income diversification, income risk reduction or the take-up of more profitable opportunities (Reardon, 1997; Barrett et al., 2001). As such and in the case of Sub-Saharan Africa, off-farm income is often positively correlated with household welfare and income diversification affects positively consumption and earn-

ings (Barrett et al., 2001). Similarly, on-farm labour, through hired and agricultural wage labour is an important income source, in particular for the poorer households (Ellis and Mdoe, 2003; Rao and Qaim, 2013), also considering that most of the hired labourers are usually small producers and landless labourers (Weinberger and Lumpkin, 2007).

While rural labour and employment constitute indeed an important livelihood strategy, it is particularly relevant for the rural youth in developing countries, whom we define in this paper as the individuals aged between 15 and 34, following the African Union (2006) definition. Youth unemployment and underemployment have been a major challenge in developing countries (White, 2012; Bezu and Holden, 2014), including in rural areas, where youth are a particularly vulnerable group of the population, facing higher levels of poverty (African Development Bank et al., 2012) and challenges in reaching sustainable livelihoods (Food and Agriculture Organization of the United Nations et al., 2014). As such, rural youth face specific constraints in particular in terms of access to land and farming activities and may eventually end up turning away from agriculture (White, 2012; Bezu and Holden, 2014). Therefore, it seems relevant to pay a particular attention to the potential direct employment and labour opportunities high-value agricultural supply chains may create for rural youth, considering their high labour intensity and the potential competitive advantage youth could have in taking up on-farm labour as casual hired labourers. On the other hand, youth in developing countries may also be more inclined towards taking-up non-farm activities since a large share of this group involved in the non-farm sector in rural areas in Africa (African Development Bank et al., 2012).

Labour allocation and decision at the household level

Based on the seminal work of Singh et al. (1986), agricultural household models have been used to analyze the microeconomic behavior of farm families and households. In the context of small producers and rural households, the allocation of available labour between farming and household activities is subject to a common decision and not fixed by institutional arrangements. An important assumption of these models is related to the separability of the production and consumption sides of the agricultural households (Lopez, 1986; Singh et al., 1986) which allows amongst others for a distinct analysis of the off-farm, family on-farm and hired labour decisions (Wang et al., 2007). In many developing countries, factor markets fail, which questions this assumption and may lead to a situation of non-separability (Lopez, 1986; Taylor and Adelman, 2003) in which households' production and consumption decisions are

both affected by the household's preferences (Le, 2010), and should then be considered simultaneously (Sadoulet and de Janvry, 1995).

This is important to consider for the household labour allocation of the producers supplying high-value agricultural supply chains. Indeed, while the potential positive effect on on-farm hired labour demand has been mentioned earlier, participating households' off-farm labour supply could be affected through a potential substitution of family labour by cheaper hired labour (Rao and Qaim, 2013), potentially offering their members more time to allocate to off-farm activities. Moreover, Maertens and Swinnen (2009) have stressed that, in their research setting, the restructuration of the French beans export supply chains in Senegal was accompanied by a shift of various producers from contract farming to working as an employee in this sector. One could thus contemplate that participation in export supply chains as supplier could also lead some of the members from contracted households to enter in parallel these supply chains as agro-processing employees. Furthermore, since profitable off-farm activities are generally more accessible to better-off households (Barrett et al., 2001; Mduma and Wobst, 2005) and associated with higher incomes (Ellis and Mdoe, 2003), one could thus assume that the profit generated from the participation in these supply chains could provide the households with the adequate capital to invest towards more profitable self-employment enterprises and other off-farm activities. On the other hand, participation in these more lucrative supply chains may lead producers to specialize themselves in this specific farming activity and hence reduce their level of off-farm activities. For instance, Huang et al. (2009) have showed in the context of China that higher levels of horticultural production were overall linked to lower levels of off-farm employment. Thus, looking into the effects of participation in high-value agricultural supply chains on both participating households' hired labour demand and off-farm labour supply would provide more in-depth insights on its effects on their household labour allocation process, including for youth, which has to the best of our knowledge not been assessed in this specific literature.

This paper is organized as follows: **Section 2** presents the context and the data collection; **Section 3** provides some descriptive statistics; **Section 4** elicits the econometric approach; **Section 5** presents and comments the results of the analysis while **Section 6** concludes the paper.

2. Context and data collection

Export and traditional vegetable supply chains in Tanzania

This paper focuses on the case of high-value vegetable export supply chains in Tanzania, in particular in the Arumeru and Arusha districts, in the northern Highlands region, where most of the country's horticultural exporters are located due to the adequate climate and infrastructures as well as the existing markets and supporting institutions (Horticultural Development Council of Tanzania, 2010). These exporters source a large share of their produce, mostly French beans and snap peas, which are the crops of focus of this paper, from small producers. These agro-exporters mostly work with small producers through producer organizations[1] to which they are linked *via* contract farming agreements, of which main terms can vary from an exporter to the other. A common feature of these contracts is the collection of the produce by the exporters *via* producer collection centers managed by the producer organizations, before the produce is processed in agro-processing centers.

On the other hand, traditional vegetable supply chains in the area are less concentrated and rely more on spot transactions through vegetable middlemen[2] who either collect the vegetable produce directly from the producers' vegetable plots and harvest themselves or buy directly from the producers after they have harvested. Exotic and traditional vegetable crops (*e.g.* tomatoes, carrots, onions, African nightshade, eggplant etc.), of supposedly lower quality than those sold in the export supply chains constitute the bulk of the produce exchanged and sold in these traditional supply chains. These mostly rely on the wholesale and retail markets in the Kilombero outlet, located in the city of Arusha as well as some minor retail markets in the surroundings.

Data collection and survey

The data for our analysis were collected between July and September 2015. The sampling strategy involved an initial identification of the relevant producer groups involved in these export supply chains *via* key informant interviews with the export companies. We identified ten producer groups located in nine different villages and obtained the complete population

[1] In other words, producer organizations constitute the main link between export companies and small producers, being the main interface for the latter's access and inclusion in the high-value supply chains. While some of these producer organizations already existed before the implementation of these contracts, others were constituted in an *ad hoc* fashion by small producers, with the objective to enter these export markets.

[2] Usually referred to as "collectors" in the area.

lists of their members supplying the high-value export supply chains as well as those of the other vegetable producers in the same villages.

Based on these lists and using a stratified sampling approach, we selected and interviewed 344 small producers, including 157 small producers supplying French beans and snap peas to the exporters and 187 small producers supplying vegetables exclusively to the traditional markets. For this paper, we exploit labour data from these households for the preceding agricultural year (March 2014 - February 2015), when only 87 of these households supplied French beans and snap peas to vegetable export supply chains while 257 supplied their produce exclusively to traditional markets. This modified sample is due to the fact that the data on labour allocation accounted for the abovementioned preceding agricultural year[3].

3. Descriptive statistics

Descriptive statistics on the socio-economic and farm characteristics of the two respective groups in our sample are provided in table 1. With regard to their socio-demographic characteristics, households from both groups seem to be relatively similar. However, they differ significantly with respect to their access to physical and socio-economic infrastructures. Indeed, households involved in the high-value export vegetable supply chains benefit from a higher access to electricity and use more credit (which could be explained by the credit facilities provided by the producer organization).

Moving to the farm characteristics, producers in our sample have relatively small farms (2.7 acres/1.09 ha in average) but producers in export markets allocate almost twice the share of their farmland to vegetable production than those from the control group, which indicates a potential specialization, in line with the descriptive differentiation highlighted in Rao and Qaim (2011). Moreover, producers supplying the export markets irrigate a larger portion of their farm size than the producers in the traditional markets, which could be related to the higher product quality (Humphrey et al., 2004) and irrigation requirements in these supply chains. They also benefit from a higher access to extension services and are located closer to the agro-input markets, which could be linked to their participation in export markets, as they often obtain an large share of their inputs from the exporters.

[Table 1 about here]

[3] We assume that the labour allocation for these producers initially in the treatment group should not have been affected by their participation in export supply chains as it was recorded for the period prior to the latter. As a robustness check, we checked that this change did not affect drastically the final results.

Descriptive information on our main variables of interest, namely hired labour use at the farm level and off-farm labour supply at the household level, both in person-days[4] are provided in tables 2 and 3, respectively. With regard to overall hired labour, producers involved in the export markets use a larger amount (almost twice) of hired labour on their farms, similar to the findings of Rao and Qaim (2013). Furthermore, producers involved in the export markets hire more labour from casual labourers aged 15-34 and 35 years and over, respectively, than the producers supplying the traditional markets, although the difference is statistically significant for the former only. In terms of within-groups differences, both groups use almost three times more labour from the youth cohort, implying that the overall horticultural sector is dominated by young labourers.

[Table 2 about here]

Finally, with regard to the participation in the off-farm labour markets (table 3), households supplying the export markets sell out significantly more labour off their farm than the other households. For both household groups, individuals belonging to the older age cohort rent out a larger quantity of their labour inputs off the farm than the younger members. While it was mentioned in the introduction that youth may be more likely to undertake off-farm activities (Huang et al., 2009; African Development Bank et al., 2012), this could imply that most of these activities are taken up by the household head and their spouse, rather than younger members of a household. Most of the off-farm activities undertaken by the individuals and households in our sample are wage jobs outside of agriculture and self-employment activities, in particular the holding of personal and family shops, running a public transportation motorbike or working as construction worker.

[Table 3 about here]

Finally, the distribution of the different households based on their specific labour regime is displayed in table 4, following the most commonly used regime classification (Sadoulet et al., 1998; Henning and Henningsen, 2007; Wang et al., 2007). A third of the households in the total sample (111 households) participate in both labour markets, which further stresses the stated need to consider in our analysis both sides of the labour markets. Furthermore, a larger number of households participate in one of the two labour markets (196 households), while only a minority behave in an autarkic way (37 households).

[4] On the basis of an eight-hour labour day.

[Table 4 about here]

4. Econometric approach

Separability test

Considering that evidence of factor market failures and non-separability in Tanzania can be found in the literature (Dillon and Barrett, 2014), it is important to test the separability hypothesis in our research context. To do so, we apply the Generalized Separability Test developed by Le (2010), which consists in jointly assessing whether the household preferences affect the production decisions, and whether the shadow wage is equal to the actual wage (Le, 2010). The results of this test are presented in the table A1 in Appendix. Using an instrumental variable approach to address the potential measurement error in the wage variable, this test fails to reject the null hypothesis of separability. One could assume that the labour markets are not entirely failing in our research setting as producers and households may be able to hire labour easily and that some substantial off-farm labour opportunities exist, which seems to be confirmed by the labour regime allocation displayed in table 4. We thus treat on-farm labour hiring and off-farm labour supply as two independent decision processes.

Econometric framework

The econometric approach adopted in this paper follows closely the one used by Rao and Qaim (2013) as the structure of their data and main econometric challenges resemble ours, as well as those implemented by Matshe and Young (2004), Ricker-Gilbert et al. (2011) and Salmon and Tanguy (2016), who used somehow similar approaches.

Labour demand and supply data are usually characterized by a large number of zero observations, for which linear regression models might produce biased estimates (Matshe and Young, 2004; Rao and Qaim, 2013; Salmon and Tanguy, 2016). This censored aspect of the data corresponds in theory to a corner solution configuration, *i.e.* the zeros are actually observed outcomes (Dow and Norton, 2003; Madden, 2008), as the result of a household's actual choice not to participate in a labour market, based on its preferences or potential disability to do so (Matshe and Young, 2004; Rao and Qaim, 2013; Salmon and Tanguy, 2016).

A two-part or double-hurdle model (Cragg, 1971; Blundell et al., 1987; Wooldridge, 2002) appears in this case more adequate than a Tobit estimator as it allows the decision to participate in a given labour market and the decision on the quantity of labour allocated to the latter to be thought as two different processes (Matshe and Young, 2004; Yen, 2005; Rao and

Qaim, 2013; Salmon and Tanguy, 2016). The selection and quantity of labour equations for both on-farm hired labour demand *h* and off-farm labour supply *o* of a household *i* can thus be expressed as follows (Wooldridge, 2002; Matshe and Young, 2004; Rao and Qaim, 2013; Salmon and Tanguy, 2016):

$$d_{ij}^{*} = \alpha z_{ij} + \mu_{ij} \qquad \mu_{ij} \sim \mathrm{N}(0,1), \tag{1}$$

$$y_{ij}^{*} = \beta x_{ij} + \varepsilon_{ij} \qquad \varepsilon_{ij} \sim \mathrm{N}(0, \sigma^2), \qquad j=\mathrm{h,o}\ , \tag{2}$$

where d_{ij}^{*} is the decision to hire on-farm labour or supply labour off the farm ($d_{ij}^{*} = 1$) or not ($d_{ij}^{*} = 0$), y_{ij}^{*} is the related quantity of labour hired or supplied, z_{ij} and x_{ij} are vectors of variables for the selection and level equations, including our main explanatory variable (binary) and control variables, respectively, and ε_{ij} and μ_{ij} are random error terms.

A lognormal double-hurdle model specification

We use the lognormal hurdle specification (Wooldridge, 2002), as transforming the dependent variables can be used to accommodate their positive values (Yen, 2005) and help better address the non-normality of the error terms (Yen and Rosinski, 2008). As a robustness check for the separability test results, we also estimate a Multivariate Sample-Selection Model (MSSM) developed by Yen (2005)[5], which takes into account the potential correlations between on-farm and off-farm labour decisions and allows controlling for the potential sample selection of labour market participation[6]. The coefficients from this model are presented in tables A2 to A4 in the Appendix.

We used likelihood ratio tests to determine the best model between the MSSM and the nested sample selection and double-hurdle models (Yen, 2005; Zampelli and Yen, 2017). These tests' results (available in table A5 in Appendix) fail to reject the double-hurdle model for all age cohorts, which confirms our choice for the latter.

Maximum Likelihood Estimation and marginal effects of the lognormal double-hurdle model

The lognormal double-hurdle model consists in applying to the whole sample a probit model for the participation in a given labour market *j* and an ordinary least squares (OLS) estimation

[5] The Heckman´s bivariate sample selection model (SSM) and the double-hurdle model (DHM), which assumes independence between the selection equations and the corresponding level equations (Cragg, 1971; Yen, 2005; Madden, 2008), are nested in the MSSM (Yen, 2005).
[6] It is in any instance interesting to control for sample selection considering that, as underlined by Mathenge and Tschirley (2015) for the case of off-farm employment, participation in labour markets may be resulting from individuals´ self-selection into the latter.

of the level equations of log-person-days for those with positive labour observations (Wooldridge, 2002; Madden, 2008). This model can be estimated by maximum likelihood method, with the following likelihood function for a household *i* (Wooldridge, 2002):

$$L = 1[y_{ij} = 0]log[1 - \Phi(z_{ij}\alpha)] + 1[y_{ij} > 0]\left\{log\Phi(z_{ij}\alpha) - \log(y_{ij}) - \frac{1}{2}\log(\sigma^2) - \frac{1}{2}\log(2\pi) - \frac{1}{2}[\log(y_{ij}) - x_{ij}\beta]^2/\sigma^2\right\} \quad j=\text{h,o} \ , \quad (3)$$

where the coefficients α are the results of the probit estimation on the decision on whether to hire or supply labour or not. The β coefficients result from the OLS regression of $\log(y_{ij})$ for the observations clearing the first hurdle, while σ is the standard error from this second-part regression (Wooldridge, 2002). Φ (.) represents the normal cumulative distribution function.

To estimate the average marginal effects, we rely on the probability of a household *i* to participate in the on-farm hired labour or the off-farm labour supply markets, which is expressed as:

$$P(y_{ij} > 0 \,|z_{ij}) = \Phi\,(z_{ij}\alpha) \quad (4)$$

The log-transformed dependent variables and non-normality of the level equation residuals require the use of the Duan's smearing estimate for the conditional and unconditional means (Duan, 1983; Duan et al., 1983; Mullahy, 1998) . As a result, the conditional means are represented as follows (Duan, 1983; Duan et al., 1983; Belotti et al., 2015):

$$E(y_{ij}|y_{ij} > 0, x_{ij}) = \exp(x_{ij}\beta) * \ \delta_{ij} \quad (5)$$

Where δ_{ij} is the Duan's smearing estimate defined as (Duan, 1983):

$$\delta_{ij} = \frac{1}{N}\sum_{i=1}^{N}\exp(\varepsilon_{ij}) \quad (6)$$

The unconditional means are represented as follows (Duan, 1983; Mullahy, 1998; Wooldridge, 2002):

$$E(y_{ij}|z_{ij}, x_{ij}) = \Phi\,(z_{ij}\alpha) * \exp(x_{ij}\beta) * \ \delta_{ij} \quad (7)$$

We derive for each model and age cohort the average marginal effects for the decision to participate in a labour market. We also derive the conditional and unconditional average margin-

al effects for the quantity of labour allocated, using the Duan smearing estimate and bootstrapping the standard errors, following the guidelines provided by Belotti et al. (2015)[7].

Endogeneity of the main explanatory variable

The literature has underlined that participation in high-value markets may be endogenous, in particular due to the potential self-selection of producers and the role of non-observable factors (Maertens and Swinnen, 2009; Rao and Qaim, 2011; Barrett et al., 2012; Bellemare, 2012; Rao and Qaim, 2013). We address this issue by using a control function or two-stage residual inclusion approach (Smith and Blundell, 1986; Rivers and Vuong, 1988; Terza et al., 2008), which has already been successfully used in the related literature with a potential endogeneity challenge (Ricker-Gilbert et al., 2011; Rao and Qaim, 2013; Salmon and Tanguy, 2016). It consists of estimating a first stage regression of the endogenous variable on the control variables and the potential instrument(s). In the second stage, the generated residuals are included in the double-hurdle model as a control variable: if they are significant, exogeneity is rejected and their inclusion corrects for endogeneity.

We use the individual distance to the closest produce collection center as an instrument. We believe this is a valid instrument since, the closer a producer is located from these produce collection centers, the more likely they will be to participate in the export supply chains. For instance, the distance to paved road and the availability of transportation means (Hernández et al., 2007; Rao and Qaim, 2011) can influence a producer's likelihood to participate in high-value supply chains. We can thus assume that producers living closer to the market outlet, the produce collection center in this setting, are more likely to participate in these supply chains. Furthermore and as underlined by Andersson et al.(2015), social capital may play an important role in a producer's decision to participate in a specific market. One could thus infer that producers living closer to these collection centers, and *a fortiori* the producer organization's center of activities, may rely on this social capital to get exposed to and enter these specific supply chains.

[7] For this purpose, we used the *twopm* Stata command developed by Belotti et al. (2015). The code developed by Deb et al. (2013) and retrievable online also served as inspiration to compute the Duan smearing estimate eand conditional marginal effects for the second part of the lognormal double-hurdle models.

Dependent and control variables

We use as dependent variables the total hired labour use on the farm and the total labour supplied off the farm by the households through one full year, measured in person-days and disaggregated by age cohorts (15-34 and 35 and over). We first adapted a format used by Chege (2015) to collect information on hired labour use at the farm level. Regarding the data on off-farm labour supply, we adapted a procedure used by the World Bank (The World Bank, 2008) to collect and aggregate at the household level data on the total time spent by the different household members on off-farm activities.

With regard to the control variables, we include the socio-economic characteristics of the household through the household head personal characteristics which can affect labour allocation to farm and off-farm labour (Reardon, 1997; Jolliffe, 2004; Kimhi and Rapaport, 2004; Mduma and Wobst, 2005; Mathenge and Tschirley, 2015). We also control for the household age composition (Kimhi and Rapaport, 2004; Wang et al., 2007) and overall education with the share of school graduates within the household (Wang et al., 2007). We include farm characteristics at the time of the survey, such as the size of the farm land (Mduma and Wobst, 2005; Huang et al., 2009) and the total irrigated area as proxy for access to technology (Rao and Qaim, 2013). Access to extension services may reduce the supervision and research costs for hired labour (Lovo, 2012) and is thus also included. We also include the hired and off-farm labour wages (Wang et al., 2007; Rao and Qaim, 2013) and used the corresponding average wages in the respective village for households not participating in the labour market(s), following Rosenzweig (1980) and Rao and Qaim (2013).

We also take into consideration access to credit (Reardon, 1997; Mduma and Wobst, 2005; Lovo, 2012), the distance to the closest public transportation means (Mduma and Wobst, 2005; Huang et al., 2009; Mathenge and Tschirley, 2015) and division dummies[8] to account for potential geographical and regional disparities, following for instance Rao and Qaim (2013). Finally, we also include a variable on electric power availability as a proxy for the access to public assets for off-farm labour supply (Mduma and Wobst, 2005; Mathenge and Tschirley, 2015) and which can also represent the level of development of the area and labour markets, thus affecting the probability to enter on-farm hired or off-farm supply labour markets (Mduma and Wobst, 2005; Lovo, 2012). We assume this variable would only affect the

[8] Divisions in Tanzania are the third lowest level of administrative layer, below the districts and above the wards and the villages (in the case of rural wards).

probability of entering these specific labour markets without directly affecting the quantity of labour inputs allocated to these markets and thus include it only in the participation equations[9].

5. Results and discussion

Endogeneity test: quality of the instrument and significance of the residuals

The results from the first-stage probit regression, presented in table 5, show that the distance to the collection center affects as expected the participation in export supply chain, validating this choice of instrument[10].

[Table 5 about here]

In the second step of the control function approach, the derived residuals are not significant in any of the selection and level equations, as showed in table 6. Thus, this test fails to reject the exogeneity of participation in export supply chains, which is also in line in some evidence in the literature (Rao and Qaim, 2013). We thus do not include these residuals in the selection and level equations of the lognormal double-hurdle models, following Ricker-Gilbert et al. (2011) or Rao and Qaim (2013).

[Table 6 about here]

Household labour allocation decision for all age cohorts

The discussion of the results specifically focuses on the average marginal effects for the lognormal double-hurdle models estimated for all age cohorts, which are displayed in tables 7 and 8[11].

[Tables 7 and 8 about here]

Starting with the effects on on-farm hired labour demand (table 7), participation in vegetable export supply chains increases a household's probability to hire labour by about 10 percentage points. The results of the conditional average marginal effects also show that, conditioning on having decided to hire labour, households' hired labour demand is increased by the participation in export supply chains by about 38 person-days over a year. The unconditional average

[9] When including this variable in the two-part models, it did not have any significant effect on the quantities of labour allocated.
[10] Furthermore, this instrument is statistically correlated neither with our variables of interest (quantity of labour hired on-farm and supplied off the farm), nor with any of the residuals from both the selection and level equations of the lognormal double-hurdle for each age-cohort.
[11] The coefficients from the Maximum Likelihood Estimations of the lognormal double-hurdle models for both on-farm hired labour demand and off-farm labour supply are displayed in tables A6 and A7 in the appendix.

marginal effects show that the latter increases a household's on-farm labour demand by about 46 person-days over a year, confirming the labour and employment creation potential of high-value supply chains (Neven et al., 2009; Rao and Qaim, 2013). Inspired by Rao and Qaim (2013), we calculate the increase in hired labour demand participation in vegetable export supply chains would proportionally generate with respect to the hired labour demand of non-participating producers. Since the producers in our control group have used in average around 55.5 person-days of hired labour (table 2), participation in export supply chain would potentially increase the hired labour demand by about 83 percent, which is non-negligible in terms of employment generation and rural development.

This positive effect may be tied to the higher labour intensity of the cultivated export crops as well as the more stringent standards and quality requirements in these supply chains, leading the producers to hire more labour on their farm. Furthermore, the higher prices proposed in these channels may also serve as an incentive to specialize in these vegetables' production (Rao and Qaim, 2011; Rao and Qaim, 2013), directly moving upwards the overall hired labour demand through a higher vegetable area. Based on our observations on-site, specific labour intensive activities of the French beans and snap peas cultivation process such as land preparation and harvesting usually require a large number of casual labourers for a short period.

The unconditional average marginal effects associated to some of the control variables also provide some interesting insights on the overall determinants of households' labour demand and the labour allocation decision process. Indeed, it seems that the total number of household members from all age cohorts – 15 and younger, 15-34 and 35 and over –reduces overall hired labour demand. This makes sense if we consider that these household members´ labour inputs would be used on the family farm for this higher price and profitable line of production and thus reduce the need to hire more labour to perform their tasks, although this could to a certain extent be in contradiction with some of the intuitions of the separability hypothesis.

Moving to the effects on overall off-farm labour supply (table 8), participation in vegetable export supply chains does not seem to affect neither households' decision to supply labour off the farm, nor the quantity of labour inputs allocated to these labour markets. This could be due to the fact that most of the vegetable agro-exporters in our research area have their processing facilities located in a relatively remote place from their sourcing areas, hence not triggering the possibility for the different supplying households' members to also move into these specific wage labour opportunities, as what happened in the French beans sector in Senegal

(Maertens and Swinnen, 2009). Furthermore, producers do not produce vegetables for these supply chains constantly throughout the year, but rather during specific production seasons spanning two-three months in a year, hence giving them the possibility to allocate their household labour inputs throughout the year, potentially allowing on-farm and off-farm labour to be complement rather than substitute. This could potentially limit the direct influence on off-farm labour supply decisions.

The effects associated to the other control variables show interesting insights regarding the decision for a household to enter off-farm labour markets. Interestingly, the number of household members belonging to the 15-34 age cohort increases the total household off-farm labour supply by 25.3 person-days while the number of household members from the older age cohort increases it by 41.5 person-days, hence confirming the trend noted in the descriptive statistics, showing that older household members in our sample tend to work more off the farm. Finally, the effects of some variables on the decision to hire/supply labour go in the opposite direction with respect to the effects on the quantity of labour allocated, which supports our choice for a double-hurdle type model (Yen, 2005).

Household labour allocation decision disaggregated by age cohort

Regarding the age-disaggregated effects on hired labour (table 7), participation in vegetable export supply chains increases farms' likelihood to hire labourers belonging to the 15-34 age cohort by 12 percentage points and labourers aged 35 and over by 13 percentage points, thus affecting the probability to hire labourers from each of these age cohorts in a similar fashion. However, no specific effect is found on the conditional quantities of hired labour demand for both age cohorts. On the other hand, while the unconditional average marginal effect on the hired labour demand for the older age cohort is statistically insignificant[12], the effect of participation in vegetable export supply chains on labour demand for young labourers conveys a statistically significant increase of about 25.6 person-days over a year, which would represent an increase of about 62 percent in comparison to the control group's labour demand (table 2). Considering the abovementioned non-significant conditional average marginal effect, we assume that this effect is mostly driven by the higher number of export-vegetable producers who decide to hire young labourers (79 percent of this group) rather than an increase of the labour demand from the producers already hiring young casual labourers.

[12] Although with a non-negligible magnitude of 43 person-days of labour demand.

We can thus infer from the latter that vegetable export supply chains seem to generate new casual on-farm employment and labour opportunities, in particular for younger labourers, which is a relevant finding considering the youth unemployment rate of 37.2 percent (International Labour Organization, 2017)[13] and the importance of wage labour for the poor in rural areas in Tanzania (Ellis and Mdoe, 2003; Mduma and Wobst, 2005). This effect could be linked to the specific labour intensity of land preparation and harvesting of French beans and snap peas within the context of export horticulture, which may require specific specialized skills in compliance to standards, triggering producers to hire younger labourers. Furthermore, young labourers may be more available in rural areas to take up this specific range of casual labour in the area due to their reduced access to land or other activities, as mentioned in the introduction, and benefit in priority from this labour demand created.

With respect to off-farm labour supply (table 8), results from the age-disaggregated models are in line with the aforementioned results on household overall off-farm labour supply since, for both age cohorts, no evidence of an effect of participation in export vegetable supply chains is found. Besides the aforementioned argument that the agro-processing wage jobs are located too far away from the villages in our sample, the low level of off-farm activities undertaken by youth could also be linked to the lack of attractive off-farm opportunities created along the value chains for them (D. Schwebel, personal communication, 2017).

Finally, our study may present some limitations, in particular with respect the research context. Indeed, the results in this paper are found in a context where separability holds, pointing towards a reasonable functioning of the labour markets. Evidence provided by the literature points to different settings in sub-Saharan Africa (Dillon and Barrett, 2014) and it would thus be interesting to analyze whether similar results would hold in a context of labour market failures. Also, the cross-sectional structure of the dataset and sample size used in this study may presents some further limitations. For instance due to the potential capital needed to access to off-farm activities, in particular self-employment, some effects on off-farm labour supply may need more time be triggered. Thus, additional survey rounds and an equivalent panel dataset, may help better account for these time-differed effects.

[13] This unemployment rate refers to extended definition of unemployment, that is "all persons of working age who were: a) without work during the reference period, *i.e*. were not in paid employment or self-employment; b) currently available for work, i.e. were available for paid employment or self-employment during the reference period, as a percentage of the labour force" applied to the 15-29 age cohort in 2013 (International Labour Organization (2017).

6. Conclusion

The application of a double-hurdle model combined with a control function approach indicates for the case of vegetable export markets in Tanzania that participation in agricultural export supply chains increases the likelihood for a household to hire labour as well as the overall hired labour demand. This is in line with the previous findings of the literature (Neven et al., 2009; Rao and Qaim, 2013) and confirms that high-value supply chains can contribute to poverty reduction through on-farm labour market effects. Furthermore, the age-disaggregated models shows that it also specifically increases the unconditional hired labour demand for the younger labourers, highlighting an employment generation effect particularly marked for the rural youth. This is a relevant result considering that this type of on-farm wage labour is important for the poor (Ellis and Mdoe, 2003; Mduma and Wobst, 2005; Rao and Qaim, 2013).

On the other hand, we have found so far no evidence of a significant effect of participation in export supply chains neither on households' decision to enter off-farm labour markets, nor on the total quantity of labour supplied on the latter. As explained in section 5, this could be tied to the fact that no major labour substitution is taking place in our research context. Furthermore, the potential shift from involvement *via* product markets to participation through labour markets (Maertens and Swinnen, 2009; Maertens et al., 2012) did not materialize.

This research contributes to the current debate on prospects in agriculture for youth, who may eventually also remain active in the agricultural and farming sector, should employment opportunities be offered to them. It is however important to note, based on our on-site observations, that these labour opportunities are concentrated in narrow time periods, mostly for land preparation and harvesting seasons, and thus not necessarily regular or stable wage labour opportunities. Furthermore, as displayed in the table A8 in the Appendix, the hourly wages received by casual labourers hired by participating small producers are somehow similar to the ones received by casual labourers working on farms not supplying the export supply chains. This positive effect on labour demand may thus not translate into higher wages for labourers and rural youth, but rather only into a higher number of economic and employment opportunities. Yet, more decent working conditions are also an important pathway towards rural poverty reduction and livelihoods development (Ayenew et al., 2016). Thus, besides this aforementioned positive generation of labour opportunities for rural youth, broader welfare effects of high-value supply chains *via* casual on-farm labour demand generation, better working conditions, employment stability and higher wages for rural youth in comparison to wage

labour and other labour opportunities may also be an interesting topic to assess in future research, in a rural development and poverty reduction perspective, in particular targeting rural youth.

References

African Development Bank, Organisation for Economic Cooperation and Development, United Nations Development Programme, United Nations Economic Commission for Africa, 2012. *African Economic Outlook 2012: Promoting Youth Development.* OECD: Paris.

African Union, 2006. *African Youth Charter.* African Union: Banjul.

Andersson, C. I., Chege, C. G., Rao, E. J., Qaim, M., 2015. Following up on smallholder farmers and supermarkets in Kenya. *Am. J. Agr. Econ.* **97**(4), 1247–1266.

Ayenew, H. Y., Estruch, E., Sauer, J., Abate-Kassa, G., Schikramm, L., Wobst, P., 2016. Decent rural employment, productivity effects and poverty reduction in sub-Saharan Africa. Rural transformations - Technical Papers Series (5). Food and Agriculture Organization of the United Nations: Rome.

Barrett, C., Reardon, T., Webb, P., 2001. Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food Pol.* **26**(4), 315–331.

Barrett, C. B., Bachke, M. E., Bellemare, M. F., Michelson, H. C., Narayanan, S., Walker, T. F., 2012. Smallholder participation in contract farming: Comparative evidence from five countries. *World Dev.* **40**(4), 715–730.

Bellemare, M. F., 2012. As you sow, so shall you reap: The welfare impacts of contract farming. *World Dev.* **40**(7), 1418–1434.

Belotti, F., Deb, P., Manning, W. G., Norton, E. C., 2015. twopm: Two-part models. *Stata J.* **15**(1), 3–20.

Bezu, S., Holden, S., 2014. Are rural youth in Ethiopia abandoning agriculture? *World Dev.* **64**, 259–272.

Blundell, R. W., Ham, J., Meghir, C., 1987. Unemployment and Female Labour Supply. *Econ. J.* (97), 44–64.

Chege, C. G., 2015. *Impacts and impact dynamics of smallholder participation in high-value markets in Kenya: PhD Dissertation.* Georg-August-University Göttingen: Göttingen.

Cragg, J. G., 1971. Some statistical models for limited dependent variables with application to the demand for durable goods. *Econometrica* **39**(5), 829–844.

Deb, P., Manning, W. G., Norton, E. C., 2013. Modeling Health Care Costs and Counts. iHEA World Congress in Sydney: Australia.

Dillon, B., Barrett, C. B., 2014. *Agricultural factor markets in Sub-Saharan Africa: An updated view with formal tests for market failure.* World bank: Washington, D.C.

Dow, W. H., Norton, E. C., 2003. Choosing between and interpreting the Heckit and Two-Part Models for corner solutions. *Health Serv. Outcomes Res. Methodol.* **4**, 5–18.

Duan, N., 1983. Smearing estimate: A nonparametric retransformation method. *J. Am. Stat. Assoc.* **78**(383), 605–610.

Duan, N., Manning, W. G., Morris, C. N., Newhouse, J. P., 1983. A comparison of alternative models for the demand for medical care. *J. Bus. Econ. Stat.* **1**(2), 115–126.

Ellis, F., Mdoe, N., 2003. Livelihoods and rural poverty reduction in Tanzania. *World Dev.* **31**(8), 1367–1384.

Food and Agriculture Organization of the United Nations, Technical Centre for Agricultural and Rural Cooperation, International Fund for Agricultural Development, 2014. *Youth and agriculture: Key challenges and concrete solutions.* Food and Agriculture Organization of the United Nations (FAO), Technical Centre for Agricultural and Rural Cooperation (CTA) and the International Fund for Agricultural Development (IFAD): Rome.

Henning, C. H., Henningsen, A., 2007. Modeling farm households' price responses in the presence of transaction costs and heterogeneity in labor markets. *Am. J. Agr. Econ.* **89**(3), 665–681.

Hernández, R., Reardon, T., Berdegué, J., 2007. Supermarkets, wholesalers, and tomato growers in Guatemala. *Agric. Econ.* **36**(3), 281–290.

Horticultural Development Council of Tanzania, 2010. Tanzania Horticultural Development Strategy (2012-2021). Horticultural Development Council of Tanzania (HODECT).

Huang, J., Wu, Y., Rozelle, S., 2009. Moving off the farm and intensifying agricultural production in Shandong: a case study of rural labor market linkages in China. *Agric. Econ.* **40**(2), 203–218.

Humphrey, J., McCulloch, N., Ota, M., 2004. The impact of European market changes on employment in the Kenyan horticulture sector. *J. Int. Dev.* **16**(1), 63–80.

International Labour Organization, 2017. ILOSTAT Database. International Labour Organization (ILO): Geneva. Accessed February 2017.

Jolliffe, D., 2004. The impact of education in rural Ghana: Examining household labor allocation and returns on and off the farm. *J. Dev. Econ.* **73**(1), 287–314.

Kimhi, A., Rapaport, E., 2004. Time allocation between farm and off-farm activities in Israeli farm households. *Am. J. Agr. Econ.* **86**(3), 716–721.

Le, K. T., 2010. Separation hypothesis tests in the agricultural household model. *Am. J. Agr. Econ.* **92**(5), 1420–1431.

Lopez, R. E., 1986. Structural Models of the Farm Household That Allow for Interdependent Utility and Profit-Maximization Decision, in I. Singh, L. Squire and J. Strauss, eds. *Agricultural household models: Extensions, applications, and policy.* Johns Hopkins University Press, Baltimore., pp. 306–326.

Lovo, S., 2012. Market imperfections, liquidity, and farm household labor allocation: The case of rural South Africa. *Agric. Econ.* **43**(4), 417–428.

Madden, D., 2008. Sample selection versus two-part models revisited: the case of female smoking and drinking. *J. Health Econ.* **27**(2), 300–307.

Maertens, M., 2009. Horticulture exports, agro-industrialization, and farm-nonfarm linkages with the smallholder farm sector: evidence from Senegal. *Agric. Econ.* **40**(2), 219–229.

Maertens, M., Minten, B., Swinnen, J., 2012. Modern Food Supply Chains and Development: Evidence from Horticulture Export Sectors in Sub-Saharan Africa. *Development Policy Review* **30**(4), 473–497.

Maertens, M., Swinnen, J. F., 2009. Trade, standards, and poverty: Evidence from Senegal. *World Dev.* **37**(1), 161–178.

Mathenge, M. K., Tschirley, D. L., 2015. Off-farm labor market decisions and agricultural shocks among rural households in Kenya. *Agric. Econ.* **46**(5), 603–616.

Matshe, I., Young, T., 2004. Off-farm labour allocation decisions in small-scale rural households in Zimbabwe. *Agric. Econ.* **30**(3), 175–186.

Mduma, J. K., Wobst, P., 2005. Determinants of Rural Labor Market Participation in Tanzania. *African Studies Quarterly* **8**(2), 32–47.

Mullahy, J., 1998. Much ado about two: Reconsidering retransformation and the two-part model in health econometrics. *J. Health Econ.* **17**(3), 247–281.

Neven, D., Odera, M. M., Reardon, T., Wang, H., 2009. Kenyan supermarkets, emerging middle-Class horticultural farmers, and employment impacts on the rural poor. *World Dev.* **37**(11), 1802–1811.

Rao, E. J., Qaim, M., 2011. Supermarkets, farm household income, and poverty: Insights from Kenya. *World Dev.* **39**(5), 784–796.

Rao, E. J., Qaim, M., 2013. Supermarkets and agricultural labor demand in Kenya: A gendered perspective. *Food Pol.* **38**, 165–176.

Reardon, T., 1997. Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. *World Dev.* **25**(5), 735–747.

Reardon, T., Barrett, C. B., 2000. Agroindustrialization, globalization, and international development: An overview of issues, patterns, and determinants. *Agric. Econ.* **23**(3), 195–205.

Ricker-Gilbert, J., Jayne, T. S., Chirwa, E., 2011. Subsidies and crowding out: A double-hurdle model of fertilizer demand in Malawi. *Am. J. Agr. Econ.* **93**(1), 26–42.

Rivers, D., Vuong, Q. H., 1988. Limited information estimators and exogeneity tests for simultaneous probit models. *J. Econom.* **39**, 347–366.

Rosenzweig, M. R., 1980. Neoclassical Theory and the Optimizing Peasant: An Econometric Analysis of Market. *Q. J. Econ.* **94**(1), pp. 31-55.

Sadoulet, E., de Janvry, A., 1995. *Quantitative development policy analysis.* Johns Hopkins University Press: Baltimore, London.

Sadoulet, E., de Janvry, A., Benjamin, C., 1998. Household behavior with imperfect labor markets. *Ind. Relat.* **37**(1), 85–108.

Salmon, C., Tanguy, J., 2016. Rural electrification and household labor supply: Evidence from Nigeria. *World Dev.* **82**, 48–68.

Singh, I., Squire, L., Strauss, J., 1986. *Agricultural household models: Extensions, applications, and policy.* Johns Hopkins University Press: Baltimore.

Smith, R. J., Blundell, R. W., 1986. An exogeneity test for a simultaneous equation Tobit model with an application to labor supply. *Econometrica* **54**(3), 679–685.

Taylor, J. E., Adelman, I., 2003. Agricultural household models: Genesis, evolution, and extensions. *Rev. Econ. Househ.* **1**, 33–58.

Terza, J. V., Basu, A., Rathouz, P. J., 2008. Two-stage residual inclusion estimation: addressing endogeneity in health econometric modeling. *J. Health Econ.* **27**(3), 531–543.

The World Bank, 2008. The Living Standards Measurement Study: Household Questionnaire for Tanzania. The World Bank: Washington, D.C.

Wang, X., Herzfeld, T., Glauben, T., 2007. Labor allocation in transition: Evidence from Chinese rural households. *China Econ. Rev.* **18**(3), 287–308.

Weatherspoon, D. D., Reardon, T., 2003. The rise of supermarkets in Africa: Implications for agrifood systems and the rural poor. *Dev. Policy Rev.*

Weinberger, K., Lumpkin, T. A., 2007. Diversification into Horticulture and Poverty Reduction: A Research Agenda. *World Dev.* **35**(8), 1464–1480.

White, B., 2012. Agriculture and the generation problem: Rural youth, employment and the future of farming. *IDS Bulletin* **43**(6), 9–19.

Wooldridge, J. M., 2002. *Econometric analysis of cross section and panel data.* MIT Press: Cambridge, Mass.

Yen, S. T., 2005. A Multivariate Sample-Selection Model: Estimating cigarette and alcohol demands with zero observations. *Am. J. Agr. Econ.* **87**(2), 453–466.

Yen, S. T., Rosinski, J., 2008. On the marginal effects of variables in the log-transformed sample selection models. *Econ. Lett.* **100**(1), 4–8.

Zampelli, E. M., Yen, S. T., 2017. The impact of tax price changes on charitable contributions to the needy. *Contemp. Econ. Policy.* **35**(1), 113–124.

Tables

Table 1. Descriptive statistics

	Traditional markets (N=257)	Export markets (N=87)	Complete sample (N=344)
Household characteristics			
Household size	4.296 (1.425)	4.494 (1.320)	4.346 (1.400)
Household head age (in years)	47.33 (11.43)	47.94 (11.53)	47.48 (11.44)
Household head male (dummy)	0.934 (0.249)	0.920 (0.274)	0.930 (0.255)
Household head education (in years)	7.424 (2.233)	7.690 (1.826)	7.491 (2.138)
Household head farming experience (in years)	22.43 (10.93)	22.72 (11.37)	22.50 (11.03)
Access to electricity (dummy)	0.412 (0.493)	0.713 (0.455)	0.488 (0.501)***
Access to tarmac road (in kilometers)	11.27 (10.24)	10.69 (8.596)	11.13 (9.842)***
Distance to public transportation system (in kilometers)	1.744 (2.407)	1.298 (2.930)	1.631 (2.553)
Use of credit (dummy)	0.226 (0.419)	0.391 (0.491)	0.267 (0.443)
Share of off-farm income (in percent)	17.56 (28.26)	16.44 (26.21)	17.28 (27.72)
Labour status of the household head			
On-farm work (dummy)	0.914 (0.280)	0.908 (0.291)	0.913 (0.283)
Paid employment (dummy)	0.0311 (0.174)	0.0460 (0.211)	0.0349 (0.184)
Self-employment (dummy)	0.0389 (0.194)	0.0345 (0.184)	0.0378 (0.191)
Farm characteristics			
Farm cultivated area (in acres)	2.863 (2.674)	2.282 (2.168)	2.716 (2.565)
Share of vegetable area (in percent)	38.64 (26.34)	64.26 (25.89)	45.12 (28.47)***
Access to irrigation (dummy)	0.946 (0.227)	0.989 (0.107)	0.956 (0.205)*
Share of irrigated area (in percent)	79.10 (35.22)	87.65 (26.75)	81.27 (33.44)**
Use modern irrigation techniques (dummy)	0.0623 (0.242)	0.0115 (0.107)	0.0494 (0.217)*
Distance to agricultural input markets (in kilometers)	4.535 (6.519)	2.959 (6.173)	4.133 (6.461)***
Access to agricultural extension services (dummy)	0.553 (0.498)	0.690 (0.465)	0.587 (0.493)**
Livestock ownership (dummy)	0.922 (0.268)	0.931 (0.255)	0.924 (0.265)
Observations	344		

Mean coefficients.
Standard deviations in parentheses.
* p < 0.10, ** p < 0.05, *** p < 0.01.

Table 2. Descriptive statistics - On-farm hired labour

	Traditional markets (N=257)	Export markets (N=87)	Complete sample (N=344)
Total hired labour use – All hired labourers (in person-days)	55.57 (99.23)	96.96 (192.9)	66.04 (130.4)**
Hired labour use – 15-34 age cohort (in person-days)	41.48 (82.61)	71.23 (159.6)	49.00 (107.9)**
Hired labour use – 35 and over age cohort (in person-days)	14.09 (47.67)	25.73 (80.84)	17.03 (57.97)
Observations	344		

Mean coefficients.
Standard deviations in parentheses.
* p < 0.10, ** p < 0.05, *** p < 0.01.

Table 3. Descriptive statistics - Off-farm labour supply

	Traditional markets (N=256)	Export markets (N=87)	Complete sample (N=343)
Total off-farm labour supply (in person-days)	52.50 (104.6)	85.16 (144.3)	60.78 (116.6)**
Off-farm labour supply – 15-34 age cohort (in person-days)	17.10 (55.06)	29.55 (83.57)	20.26 (63.60)
Off-farm labour supply – 35 and over age cohort (in person-days)	35.40 (92.31)	55.60 (115.8)	40.52 (99.02)
Observations	343		

Mean coefficients.
Standard deviations in parentheses.
* p < 0.10, ** p < 0.05, *** p < 0.01.

Table 4. Distribution of the households based on their labour regime

	Traditional markets (N=257)	Export markets (N =87)	Complete Sample (N =344)
Autarkic household	32	5	37
Hiring-in labour only	125	45	170
Hiring-in and selling out labour	79	32	111
Selling out labour only	21	5	26

Table 5. First stage probit of the control function approach

	Hired labour		Off-farm labour	
	Participation in export markets		Participation in export markets	
Distance to the closest collection center	-0.137**	(0.065)	-0.136*	(0.070)
Household head age	-0.047	(0.056)	-0.033	(0.057)
Household head age (square)	0.000	(0.001)	0.000	(0.001)
Household head education	0.052	(0.068)	0.042	(0.065)
Household head male	-0.082	(0.392)	-0.131	(0.402)
Numbers of individuals aged under 15	0.049	(0.126)	0.084	(0.128)
Number of individuals aged 15-34	0.254**	(0.128)	0.254*	(0.133)
Number of individuals aged 35 and over	0.221	(0.227)	0.202	(0.219)
Share of primary school graduates	0.008	(0.007)	0.008	(0.007)
Share of lower secondary school graduates	-0.002	(0.008)	-0.002	(0.009)
Share of upper secondary school graduates	-0.038**	(0.015)	-0.033**	(0.015)
Farm cultivated area	-0.096	(0.066)	-0.093	(0.068)
Irrigated area	0.045	(0.069)	0.050	(0.069)
Access to credit	0.537**	(0.215)	0.499**	(0.224)
Hired labour wage	0.208	(0.151)		
Off-farm wage			0.029	(0.055)
Access to extension services	0.249	(0.168)		
Access to electricity	0.672***	(0.240)	0.694***	(0.215)
Distance to public transportation system	-0.027	(0.062)	-0.027	(0.058)
Division Kingo'ri [a]	-1.012*	(0.537)	-1.259**	(0.527)
Division Mbuguni [a]	-0.026	(0.583)	-0.153	(0.588)
Division Moshono [a]	0.025	(0.452)	-0.082	(0.447)
Constant	-1.321	(1.632)	-1.227	(1.587)
Log-likelihood	-157.633		-159.148	
Observations	338		338	

[a] Reference division is Poli.
Bootstrapped standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 6. P-values of the residuals and exogeneity tests of participation in export supply chains

	All age cohorts	**15-34 age cohort**	**35+ age cohort**
Hired labour demand		*p-value*	
Selection equation	0.265	0.940	0.193
Level equation	0.142	0.410	0.960
Off-farm labour supply		*p-value*	
Selection equation	0.469	0.230	0.177
Level equation	0.423	0.419	0.952

Table 7. Conditional and unconditional average marginal effects on hired labour demand (lognormal double-hurdle model)

	All age cohorts			15-34 age cohort			Over 35 age cohort		
	Conditional		Unconditional	Conditional		Unconditional	Conditional		Unconditional
	Decision	Labour days	Both stages	Decision	Labour days	Both stages	Decision	Labour days	Both stages
Participation in export markets	0.103**	38.131**	46.045***	0.121**	17.297	25.639**	0.133**	25.998	43.058
	(0.041)	(16.828)	(15.117)	(0.054)	(11.797)	(12.971)	(0.061)	(23.799)	(46.732)
Household head age	-0.003	0.156	0.023	-0.005	0.151	-0.151	0.003	0.144	0.323
	(0.003)	(0.781)	(0.769)	(0.003)	(0.726)	(0.663)	(0.003)	(0.631)	(3.759)
Household head education	-0.009	4.087	3.493	0.002	3.474	3.547	-0.009	0.086	-0.563
	(0.011)	(2.612)	(3.035)	(0.013)	(2.420)	(2.817)	(0.012)	(2.608)	(7.989)
Household head male	0.229**	16.386	27.899*	0.154	17.026	23.282*	-0.060	11.706	9.870
	(0.099)	(19.146)	(15.842)	(0.104)	(17.162)	(13.103)	(0.097)	(10.899)	(35.348)
Numbers of individuals aged under 15	0.001	-13.669**	-13.527**	0.029	-8.937	-7.090	-0.003	-8.014	-8.571
	(0.024)	(6.895)	(6.415)	(0.029)	(5.555)	(4.813)	(0.028)	(9.056)	(22.146)
Number of individuals aged 15-34	-0.026	-11.687	-13.170*	-0.032	-7.640	-9.468	-0.009	-2.704	-3.473
	(0.022)	(7.452)	(7.610)	(0.027)	(5.272)	(5.937)	(0.026)	(5.964)	(13.073)
Number of individuals aged 35 and over	-0.013	-20.374*	-21.055*	-0.018	-11.929	-12.830	-0.045	-1.290	-4.582
	(0.040)	(12.208)	(11.111)	(0.050)	(9.314)	(9.223)	(0.049)	(9.708)	(32.004)
Share of primary school graduates	-0.001	-0.256	-0.324	-0.001	-0.112	-0.148	0.001	-0.449	-0.403
	(0.001)	(0.378)	(0.338)	(0.001)	(0.283)	(0.266)	(0.001)	(0.389)	(1.739)
Share of lower secondary school graduates	0.002	-0.629	-0.496	0.001	-0.697*	-0.650*	0.005**	-0.388	-0.074
	(0.002)	(0.512)	(0.459)	(0.002)	(0.401)	(0.371)	(0.002)	(0.423)	(0.635)
Share of upper secondary school graduates	-0.000	0.269	0.246	0.004	-0.254	0.007	0.003	0.341	0.582
	(0.004)	(0.782)	(0.846)	(0.005)	(0.766)	(0.779)	(0.004)	(0.786)	(5.389)
Farm cultivated area	0.023	1.615	2.986	0.010	-0.366	0.229	0.019	0.689	2.098
	(0.015)	(4.422)	(4.451)	(0.015)	(3.679)	(4.648)	(0.013)	(2.799)	(4.649)
Irrigated area	0.037*	6.430	8.632*	0.042**	4.677	7.090	0.018	-0.369	0.882
	(0.020)	(5.020)	(4.960)	(0.020)	(4.232)	(5.187)	(0.016)	(3.357)	(16.705)
Access to credit	0.069	-1.010	3.172	0.089	-3.754	1.410	-0.061	-0.429	-4.846
	(0.044)	(12.765)	(12.227)	(0.055)	(10.417)	(10.464)	(0.052)	(12.260)	(20.450)
Hired labour wage	0.008	-20.788**	-20.173*	0.066	-14.598	-10.458	-0.050	-6.052	-9.853
	(0.042)	(9.755)	(10.339)	(0.050)	(9.303)	(9.310)	(0.046)	(8.201)	(12.098)
Access to extension services	0.091**	20.409*	25.697**	0.055	14.639	17.533*	0.098**	-16.900	-8.343
	(0.043)	(11.380)	(10.676)	(0.051)	(9.458)	(9.125)	(0.048)	(15.080)	(35.645)
Access to electricity	-0.026		-1.598	0.006		0.354	-0.011		-0.774
	(0.043)		(2.741)	(0.052)		(3.474)	(0.051)		(14.855)
Distance to public transportation system	-0.010	4.105	3.448	-0.005	3.069	2.742	-0.015	0.638	-0.375
	(0.008)	(3.119)	(2.704)	(0.009)	(2.921)	(2.089)	(0.012)	(2.775)	(17.936)

Division Kingo´ri [a]	0.055	-16.664	-13.587	0.025	-16.660	-15.240	0.235*	8.912	32.616
	(0.077)	(26.934)	(27.882)	(0.112)	(21.689)	(20.516)	(0.129)	(36.552)	(173.135)
Division Mbuguni [a]	0.137**	2.173	11.213	0.051	-6.999	-3.970	0.033	27.725	30.160
	(0.058)	(26.621)	(28.570)	(0.100)	(23.482)	(22.690)	(0.100)	(50.115)	(50.352)
Division Moshono [a]	0.079	-47.105*	-40.836	0.068	-39.893	-34.433	-0.096	4.564	-2.320
	(0.075)	(28.065)	(27.229)	(0.095)	(28.736)	(25.978)	(0.094)	(26.780)	(64.147)
Observations	341	280	341	341	240	341	341	97	341

[a] Reference division is Poli.

Robust standard errors in parentheses for the marginal effects of the first stage. Bootstrapped standard errors (150 replications) in parenthesis for the conditional marginal effects for the second stage and unconditional marginal effects.

Marginal conditional effects for the second stage and unconditional marginal effects were transformed using Duan´s smearing estimate (Duan, 1983).

*** p<0.01, ** p<0.05, * p<0.1.

Table 8. Conditional and unconditional average marginal effects on off-farm labour supply (lognormal double-hurdle model)

	All age cohorts			15-34 age cohort			Over 35 age cohort		
	Conditional		Unconditional	Conditional		Unconditional	Conditional		Unconditional
	Decision	Labour days	Both stages	Decision	Labour days	Both stages	Decision	Labour days	Both stages
Participation in export markets	0.010	18.806	20.294	0.023	9.610	13.267	0.033	8.086	13.986
	(0.060)	(17.777)	(19.308)	(0.048)	(23.094)	(82,293.231)	(0.054)	(14.698)	(1,926.968)
Household head age	-0.011***	-0.658	-2.260*	-0.003	-0.179	-0.505	-0.009***	0.356	-1.089
	(0.004)	(1.255)	(1.308)	(0.003)	(1.056)	(86,449.094)	(0.003)	(0.666)	(139.623)
Household head education	0.029**	3.835	8.195**	-0.008	0.887	-0.140	0.026**	2.645	6.999
	(0.013)	(2.702)	(4.070)	(0.010)	(3.222)	(101,958.635)	(0.011)	(2.270)	(944.474)
Household head male	-0.009	33.498	32.479*	-0.059	7.165	1.623	0.109	27.250	36.152
	(0.100)	(22.674)	(18.059)	(0.089)	(24.477)	(37632866.971)	(0.080)	(49.624)	(84.591)
Numbers of individuals aged under 15	-0.046	-9.213	-16.169*	0.000	-3.503	-3.479	-0.028	0.080	-4.514
	(0.030)	(7.676)	(8.283)	(0.024)	(7.962)	(288,445.743)	(0.025)	(6.591)	(264.879)
Numbers of individuals aged under 15-34	0.116***	7.594	25.260***	0.071***	8.983	18.331	0.052**	4.622	13.297
	(0.028)	(8.363)	(9.015)	(0.021)	(8.156)	(1153826.604)	(0.024)	(5.738)	(2,085.339)
Numbers of individuals aged 35 and over	0.161***	16.957	41.515***	-0.045	6.021	0.146	0.224***	11.323	48.496
	(0.052)	(16.601)	(14.798)	(0.042)	(12.587)	(633,589.966)	(0.043)	(11.054)	(4,942.840)
Share of primary school graduates	-0.004***	-0.729	-1.332**	-0.000	-0.583	-0.625	-0.003**	-0.003	-0.557
	(0.002)	(0.444)	(0.564)	(0.001)	(0.437)	(8,863.082)	(0.001)	(0.282)	(79.499)
Share of lower secondary school graduates	-0.002	-0.577	-0.852	0.002	-0.478	-0.178	-0.004**	-0.158	-0.786
	(0.002)	(0.510)	(0.610)	(0.002)	(0.521)	(10,895.920)	(0.002)	(0.372)	(115.988)
Share of upper secondary school graduates	-0.002	0.251	-0.032	0.000	-0.316	-0.275	-0.001	1.581*	1.382
	(0.005)	(1.315)	(1.952)	(0.004)	(1.008)	(58,041.619)	(0.004)	(0.949)	(211.173)
Farm cultivated area	-0.008	2.851	1.522	-0.014	-1.732	-3.555	-0.002	5.565	5.299
	(0.016)	(6.797)	(8.778)	(0.017)	(10.050)	(291,283.743)	(0.014)	(5.368)	(1,008.272)
Irrigated area	0.007	-2.524	-1.398	0.022	4.013	6.911	-0.007	-9.566	-10.925
	(0.019)	(7.565)	(9.248)	(0.018)	(10.168)	(26,419.187)	(0.017)	(6.216)	(1,422.627)
Access to credit	-0.031	22.646	16.957	-0.047	-1.802	-7.806	0.059	17.763	29.644
	(0.058)	(18.669)	(21.263)	(0.043)	(16.881)	(403,484.135)	(0.054)	(14.587)	(5,568.405)
Off-farm wage	0.043**	-6.894***	-0.207	0.003	-3.096	-2.725	0.019**	-4.381***	-1.253
	(0.017)	(1.985)	(3.124)	(0.007)	(3.103)	(14,855.420)	(0.009)	(1.685)	(429.790)
Access to electricity	-0.002		-0.328	0.024		3.147	-0.016		-2.576
	(0.055)		(8.518)	(0.043)		(419,697.799)	(0.048)		(1,347.229)
Distance to public transportation system	-0.020*	-4.411	-7.442	-0.007	0.426	-0.473	-0.016	-5.343	-8.015
	(0.011)	(5.513)	(5.298)	(0.009)	(3.105)	(121,039.846)	(0.011)	(4.430)	(1,503.919)

Division Kingo´ri [a]	-0.037	8.335	1.917	-0.045	18.413	8.872	0.124	-27.816	-17.376
	(0.117)	(61.890)	(48.990)	(0.072)	(108.105)	(96,481.032)	(0.121)	(17.406)	(6,086.963)
Division Mbuguni [a]	-0.184**	9.392	-21.591	-0.167***	3.950	-18.504	0.051	-14.699	-7.816
	(0.090)	(45.846)	(31.235)	(0.048)	(127.988)	(452,489.012)	(0.103)	(23.055)	(4,806.577)
Division Moshono [a]	-0.112	42.646	25.150	-0.156**	25.398	6.203	0.079	-11.086	2.396
	(0.098)	(44.668)	(38.279)	(0.071)	(44.717)	(413,572.873)	(0.084)	(25.448)	(1,668.609)
Observations	341	134	341	341	60	341	341	86	341

[a] Reference division is Poli.

Robust standard errors in parentheses for the marginal effects of the first stage. Bootstrapped standard errors (150 replications) in parenthesis for the conditional marginal effects for the second stage and unconditional marginal effects.

Marginal conditional effects for the second stage and unconditional marginal effects were transformed using Duan´s smearing estimate (Duan, 1983).

*** p<0.01, ** p<0.05, * p<0.1.

Appendix

Table A1. Results of Le´s Generalized Separability Test (following Le, 2010)

	Log(pQ/L)		
	OLS	LAD	IV [c]
	(1)	(2)	(3)
Off-farm hour labour wage (log)	-0.119	0.103	2.305*
	(0.230)	(0.203)	(1.348)
Number of male non-dependents	-0.263	-0.293	-0.0916
	(0.237)	(0.215)	(0.345)
Number of female non-dependents	-0.290	0.0911	-0.694
	(0.292)	(0.251)	(0.464)
Number of dependents	0.0742	-0.0251	0.0413
	(0.189)	(0.171)	(0.266)
Export vegetables as main crops [a]	-0.886	0.0969	-0.684
	(0.561)	(0.504)	(0.796)
Local vegetables as main crops [a]	-0.500	-0.523	-0.390
	(0.517)	(0.456)	(0.728)
Division Kingo´ri [b]	-1.676*	-1.049	-2.525*
	(0.848)	(0.752)	(1.276)
Division Mbuguni [b]	0.753	0.559	-0.468
	(0.803)	(0.702)	(1.306)
Division Moshono [b]	-0.240	-0.423	-0.645
	(0.721)	(0.623)	(1.035)
Constant	9.418***	7.113***	-8.307
	(1.965)	(1.705)	(9.955)
F-Test: Coefficients of household characteristics are simultaneously zero and coefficient of wage is equal to one F(1,115)	6.86***	5.18***	0.72
Observations	124	124	124
R-squared	0.130		

[a] Reference crops are the non-vegetable crops.
[b] Reference division is Poli.
[c] Off-farm wage is instrumented with the household head education and the commune wage (Le, 2010).
Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table A2. Maximum Likelihood Estimates of the Multivariate Sample-Selection Model (All age cohorts)

	Decision to hire labour (1)		Quantity of hired labour (log) (2)		Decision to supply labour off-farm (3)		Quantity of labour supplied off-farm (log) (4)	
Participation in export markets	0.528**	(0.248)	0.502**	(0.196)	-0.002	(0.183)	0.286	(0.214)
Household head age	0.039	(0.067)	0.054	(0.059)	-0.132**	(0.061)	-0.039	(0.076)
Household head age (square)	-0.001	(0.001)	-0.001	(0.001)	0.001*	(0.001)	0.000	(0.001)
Household head education	-0.041	(0.050)	0.060	(0.037)	0.089**	(0.041)	0.084**	(0.038)
Household head male	0.870**	(0.342)	0.247	(0.369)	0.001	(0.306)	0.683*	(0.386)
Numbers of individuals aged under 15	0.003	(0.114)	-0.198**	(0.088)	-0.147	(0.094)	-0.176*	(0.104)
Number of individuals aged 15-34	-0.120	(0.106)	-0.172*	(0.094)	0.358***	(0.092)	0.191	(0.124)
Number of individuals aged 35 and over	-0.075	(0.193)	-0.288*	(0.158)	0.472***	(0.164)	0.388*	(0.201)
Share of primary school graduates	-0.005	(0.006)	-0.004	(0.005)	-0.012**	(0.005)	-0.015**	(0.006)
Share of lower secondary school graduates	0.010	(0.008)	-0.009	(0.006)	-0.006	(0.006)	-0.011	(0.007)
Share of upper secondary school graduates	-0.002	(0.018)	0.004	(0.014)	-0.008	(0.015)	0.001	(0.014)
Farm cultivated area	0.106	(0.072)	0.023	(0.048)	-0.028	(0.050)	0.037	(0.088)
Irrigated area	0.174*	(0.098)	0.094*	(0.054)	0.022	(0.059)	-0.032	(0.093)
Access to credit	0.341	(0.242)	-0.024	(0.184)	-0.107	(0.180)	0.265	(0.218)
Hired labour wage	0.044	(0.195)	-0.304**	(0.130)				
Off-farm wage					0.157***	(0.054)	-0.088***	(0.026)
Access to extension services	0.410**	(0.193)	0.305*	(0.173)				
Access to electricity	-0.114	(0.221)			-0.008	(0.163)		
Distance to public transportation system	-0.048	(0.036)	0.061*	(0.036)	-0.061*	(0.035)	-0.108**	(0.053)
Division Kingo´ri	0.274	(0.426)	-0.233	(0.381)	-0.220	(0.385)	0.141	(0.351)
Division Mbuguni	0.754*	(0.414)	0.062	(0.369)	-0.692**	(0.352)	-0.045	(0.350)
Division Moshono	0.349	(0.339)	-0.679**	(0.326)	-0.409	(0.311)	0.579*	(0.301)
Constant	-0.887	(1.705)	2.940*	(1.584)	2.678*	(1.522)	4.362**	(1.764)
Ln Sigma2	0.192***	(0.042)						
Ln Sigma4	-0.004	(0.107)						
ρ_12	-0.021	(0.508)						
ρ_13	-0.027	(0.115)						
ρ_14	0.079	(0.124)						
ρ_23	-0.007	(0.087)						
ρ_24	0.161	(0.100)						
ρ_34	0.455	(0.353)						
Log Likelihood	-959.184***							
Chi-Squared	239.70							
Observations	341		341		341		341	

[a] Reference division is Poli.
Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table A3. Maximum Likelihood Estimates of the Multivariate Sample-Selection Model (15-34 age cohort)

	Decision to hire labour (1)		Quantity of hired labour (log) (2)		Decision to supply labour off-farm (3)		Quantity of labour supplied off-farm (log) (4)	
Participation in export markets	0.404**	(0.200)	0.423**	(0.211)	0.073	(0.219)	0.259	(0.354)
Household head age	-0.046	(0.061)	0.044	(0.063)	-0.114	(0.070)	-0.063	(0.140)
Household head age (square)	0.000	(0.001)	-0.001	(0.001)	0.001	(0.001)	0.001	(0.001)
Household head education	0.012	(0.043)	0.075*	(0.040)	-0.036	(0.048)	0.069	(0.069)
Household head male	0.489	(0.306)	0.525	(0.374)	-0.245	(0.354)	0.621	(0.556)
Numbers of individuals aged under 15	0.088	(0.097)	-0.167*	(0.101)	-0.002	(0.112)	-0.253	(0.210)
Number of individuals aged 15-34	-0.132	(0.092)	-0.170	(0.107)	0.331***	(0.104)	0.331	(0.256)
Number of individuals aged 35 and over	-0.034	(0.166)	-0.241	(0.177)	-0.213	(0.197)	0.180	(0.358)
Share of primary school graduates	-0.003	(0.005)	-0.002	(0.005)	-0.001	(0.006)	-0.027***	(0.010)
Share of lower secondary school graduates	0.001	(0.007)	-0.014**	(0.007)	0.011	(0.008)	-0.020	(0.014)
Share of upper secondary school graduates	0.011	(0.018)	-0.002	(0.016)	0.001	(0.017)	-0.008	(0.022)
Farm cultivated area	0.031	(0.051)	-0.003	(0.052)	-0.067	(0.078)	-0.111	(0.192)
Irrigated area	0.136**	(0.065)	0.123**	(0.062)	0.105	(0.083)	0.202	(0.193)
Access to credit	0.334*	(0.194)	0.001	(0.202)	-0.234	(0.220)	-0.137	(0.360)
Hired labour wage	0.253	(0.169)	-0.227	(0.149)				
Off-farm wage					0.016	(0.034)	-0.119**	(0.050)
Access to extension services	0.205	(0.165)	0.404**	(0.182)				
Access to electricity	0.023	(0.165)			0.157	(0.215)		
Distance to public transportation system	-0.013	(0.030)	0.061	(0.038)	-0.033	(0.041)	-0.057	(0.072)
Division Kingo´ri [a]	0.096	(0.389)	-0.330	(0.431)	-0.232	(0.391)	0.603	(0.479)
Division Mbuguni [a]	0.167	(0.353)	-0.071	(0.370)	-0.993***	(0.369)	0.087	(0.633)
Division Moshono [a]	0.230	(0.318)	-0.720**	(0.344)	-0.700**	(0.308)	0.918*	(0.482)
Constant	0.675	(1.530)	2.292	(1.594)	2.644	(1.775)	5.096	(3.452)
Ln Sigma2	0.254***	(0.074)						
Ln Sigma4	-0.028	(0.188)						
ρ_12	0.450	(0.343)						
ρ_13	0.073	(0.119)						
ρ_14	0.396*	(0.205)						
ρ_23	0.012	(0.107)						
ρ_24	0.367*	(0.211)						
ρ_34	0.350	(0.663)						
Log Likelihood	-782.989***							
Chi-Squared	179.51							
Observations	341		341		341		341	

[a] Reference division is Poli.
Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table A4. Maximum Likelihood Estimates of the Multivariate Sample-Selection Model (Over 35 age cohort)

	Decision to hire labour (1)		Quantity of hired labour (log) (2)		Decision to supply labour off-farm (3)		Quantity of labour supplied off-farm (log) (4)	
Participation in export markets	0.410**	(0.198)	0.670	(0.539)	0.136	(0.199)	0.206	(0.239)
Household head age	0.087	(0.065)	0.074	(0.162)	-0.053	(0.068)	0.158	(0.099)
Household head age (square)	-0.001	(0.001)	-0.001	(0.002)	0.000	(0.001)	-0.001	(0.001)
Household head education	-0.030	(0.042)	-0.007	(0.075)	0.104**	(0.045)	0.044	(0.050)
Household head male	-0.202	(0.309)	0.857	(0.608)	0.456	(0.415)	0.895	(0.668)
Numbers of individuals aged under 15	-0.014	(0.095)	-0.360*	(0.208)	-0.097	(0.097)	0.039	(0.121)
Number of individuals aged 15-34	-0.030	(0.088)	-0.082	(0.167)	0.196**	(0.095)	0.055	(0.129)
Number of individuals aged 35 and over	-0.156	(0.168)	0.066	(0.389)	0.888***	(0.187)	0.089	(0.327)
Share of primary school graduates	0.003	(0.005)	-0.020*	(0.011)	-0.013**	(0.005)	0.003	(0.007)
Share of lower secondary school graduates	0.016**	(0.006)	-0.022	(0.019)	-0.015**	(0.007)	0.000	(0.009)
Share of upper secondary school graduates	0.010	(0.016)	0.023	(0.030)	-0.004	(0.015)	0.039**	(0.018)
Farm cultivated area	0.065	(0.045)	0.027	(0.099)	-0.009	(0.054)	0.137	(0.090)
Irrigated area	0.060	(0.056)	-0.106	(0.104)	-0.021	(0.064)	-0.216**	(0.097)
Access to credit	-0.214	(0.194)	0.206	(0.407)	0.205	(0.194)	0.342	(0.235)
Hired labour wage	-0.166	(0.158)	-0.204	(0.318)				
Off-farm wage					0.066*	(0.035)	-0.119***	(0.031)
Access to extension services	0.338**	(0.171)	-0.813*	(0.459)				
Access to electricity	-0.003	(0.188)			-0.031	(0.183)		
Distance to public transportation system	-0.051	(0.040)	0.022	(0.118)	-0.061	(0.041)	-0.104	(0.064)
Division Kingo´ri [a]	0.789**	(0.393)	0.529	(0.928)	0.437	(0.406)	-0.939**	(0.462)
Division Mbuguni [a]	0.181	(0.344)	1.449**	(0.617)	0.165	(0.380)	-0.352	(0.443)
Division Moshono [a]	-0.258	(0.314)	0.785	(0.630)	0.283	(0.346)	-0.288	(0.402)
Constant	-2.827*	(1.668)	3.072	(4.795)	-0.915	(1.668)	-0.192	(2.620)
Ln Sigma2	0.275	(0.302)						
Ln Sigma4	-0.156	(0.199)						
ρ_12	-0.449	(1.087)						
ρ_13	0.025	(0.112)						
ρ_14	-0.106	(0.166)						
ρ_23	0.006	(0.161)						
ρ_24	0.203	(0.249)						
ρ_34	-0.429	(0.706)						
Log Likelihood	-595.394***							
Chi-Squared	200.28							
Observations	340		340		340		340	

[a] Reference division is Poli.

Standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1.

Table A5. Likelihood ratio tests for the MSSM and nested SSM and DHM

	All age cohorts			15-34 age cohort			35+ age cohort		
	Likelihood Ratio Tests								
	χ2	*p-value*	*Interpretation*	*χ2*	*p-value*	*Interpretation*	*χ2*	*p-value*	*Interpretation*
DHM nested in SSM (*df*=2)	1.23	0.54	DHM preferred	2.44	0.29	DHM preferred	0.77	0.68	DHM preferred
SSM nested in MSSM (*df* =4)	3.35	0.50	SSM preferred	6.12	0.19	SSM preferred	0.90	0.92	SSM preferred
DHM nested in MSSM (*df* =6)	4.58	0.60	DHM preferred	8.57	0.20	DHM preferred	1.68	0.95	DHM preferred

Table A6. Maximum Likelihood Estimates for the hired labour demand (lognormal double-hurdle model)

	All age cohorts				15-34 age cohort				Over 35 age cohort			
	Selection		Log outcome		Selection		Log outcome		Selection		Log outcome	
Participation in export markets	0.530**	(0.224)	0.503***	(0.170)	0.418**	(0.192)	0.336*	(0.192)	0.435**	(0.187)	1.046**	(0.454)
Household head age	0.036	(0.064)	0.056	(0.051)	-0.042	(0.060)	0.055	(0.059)	0.088	(0.058)	0.152	(0.151)
Household head age (square)	-0.000	(0.001)	-0.001	(0.000)	0.000	(0.001)	-0.001	(0.001)	-0.001	(0.001)	-0.001	(0.001)
Household head education	-0.043	(0.041)	0.060*	(0.033)	0.007	(0.038)	0.072*	(0.042)	-0.031	(0.039)	0.004	(0.081)
Household head male	0.866**	(0.366)	0.272	(0.334)	0.474	(0.312)	0.427	(0.429)	-0.197	(0.313)	0.814*	(0.490)
Numbers of individuals aged under 15	0.004	(0.098)	-0.201**	(0.087)	0.095	(0.086)	-0.186**	(0.092)	-0.011	(0.090)	-0.405*	(0.232)
Number of individuals aged 15-34	-0.119	(0.104)	-0.172*	(0.102)	-0.107	(0.085)	-0.159	(0.108)	-0.032	(0.089)	-0.137	(0.189)
Number of individuals aged 35 and over	-0.063	(0.177)	-0.300**	(0.153)	-0.059	(0.157)	-0.249	(0.165)	-0.156	(0.161)	-0.065	(0.340)
Share of primary school graduates	-0.005	(0.005)	-0.004	(0.005)	-0.002	(0.005)	-0.002	(0.005)	0.003	(0.005)	-0.023**	(0.011)
Share of lower secondary school graduates	0.010	(0.007)	-0.009	(0.006)	0.002	(0.006)	-0.015**	(0.007)	0.016**	(0.007)	-0.020	(0.013)
Share of upper secondary school graduates	-0.002	(0.015)	0.004	(0.009)	0.014	(0.014)	-0.005	(0.012)	0.011	(0.014)	0.017	(0.022)
Farm cultivated area	0.105*	(0.058)	0.024	(0.044)	0.033	(0.046)	-0.008	(0.053)	0.066	(0.063)	0.035	(0.091)
Irrigated area	0.171**	(0.084)	0.095*	(0.054)	0.137**	(0.060)	0.098	(0.066)	0.061	(0.070)	-0.019	(0.108)
Access to credit	0.343	(0.212)	-0.015	(0.163)	0.302	(0.189)	-0.079	(0.182)	-0.217	(0.190)	-0.022	(0.421)
Hired labour wage	0.036	(0.117)	-0.306**	(0.140)	0.218	(0.136)	-0.304*	(0.169)	-0.171	(0.158)	-0.306	(0.304)
Access to extension services	0.413**	(0.190)	0.316*	(0.165)	0.180	(0.161)	0.320*	(0.183)	0.340**	(0.171)	-0.730**	(0.345)
Access to electricity	-0.122	(0.192)			0.020	(0.167)			-0.037	(0.175)		
Distance to public transportation system	-0.048	(0.031)	0.060	(0.042)	-0.016	(0.031)	0.064	(0.046)	-0.050	(0.034)	0.032	(0.110)
Division Kingo´ri [a]	0.278	(0.400)	-0.272	(0.453)	0.085	(0.361)	-0.403	(0.482)	0.720*	(0.402)	0.395	(0.747)
Division Mbuguni [a]	0.767*	(0.404)	0.032	(0.389)	0.173	(0.319)	-0.149	(0.432)	0.109	(0.346)	1.058	(0.692)
Division Moshono [a]	0.357	(0.327)	-0.699*	(0.379)	0.223	(0.280)	-0.802*	(0.418)	-0.319	(0.310)	0.221	(0.670)
Constant	-0.767	(1.634)	2.909**	(1.327)	0.620	(1.513)	2.631	(1.601)	-2.734*	(1.488)	0.979	(3.636)
Log pseudolikelihood	-582.982				-574.342				-338.247			
Observations	341		280		341		240		341		97	

[a] Reference division is Poli.
Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table A7. Maximum Likelihood Estimates for the off-farm labour supply (lognormal double-hurdle model)

	All age cohorts				15-34 age cohort				Over 35 age cohort			
	Selection		Log outcome		Selection		Log outcome		Selection		Log outcome	
Participation in export markets	0.030	(0.184)	0.279	(0.220)	0.104	(0.215)	0.389	(0.419)	0.123	(0.198)	0.180	(0.259)
Household head age	-0.146***	(0.056)	0.001	(0.070)	-0.116*	(0.060)	-0.060	(0.132)	-0.047	(0.068)	0.150	(0.111)
Household head age (square)	0.001**	(0.001)	-0.000	(0.001)	0.001**	(0.001)	0.001	(0.001)	0.000	(0.001)	-0.001	(0.001)
Household head education	0.088**	(0.040)	0.059*	(0.032)	-0.037	(0.044)	0.038	(0.089)	0.099**	(0.044)	0.060	(0.042)
Household head male	-0.028	(0.347)	0.702**	(0.353)	-0.251	(0.370)	0.356	(0.457)	0.478	(0.414)	0.955	(0.716)
Numbers of individuals aged under 15	-0.141	(0.087)	-0.143	(0.099)	0.002	(0.097)	-0.151	(0.213)	-0.106	(0.098)	0.002	(0.119)
Number of individuals aged 15-34	0.353***	(0.086)	0.118	(0.092)	0.332***	(0.091)	0.387*	(0.202)	0.199**	(0.095)	0.106	(0.114)
Number of individuals aged 35 and over	0.493***	(0.154)	0.263	(0.179)	-0.212	(0.177)	0.259	(0.397)	0.854***	(0.180)	0.259	(0.213)
Share of primary school graduates	-0.012***	(0.005)	-0.011**	(0.006)	-0.001	(0.005)	-0.025**	(0.011)	-0.013**	(0.005)	-0.000	(0.006)
Share of lower secondary school graduates	-0.006	(0.006)	-0.009	(0.006)	0.011*	(0.006)	-0.021	(0.013)	-0.014**	(0.007)	-0.004	(0.008)
Share of upper secondary school graduates	-0.006	(0.014)	0.004	(0.016)	0.002	(0.014)	-0.014	(0.027)	-0.005	(0.015)	0.036*	(0.019)
Farm cultivated area	-0.025	(0.048)	0.044	(0.096)	-0.065	(0.058)	-0.075	(0.296)	-0.008	(0.054)	0.127	(0.100)
Irrigated area	0.022	(0.056)	-0.039	(0.108)	0.102	(0.065)	0.173	(0.307)	-0.028	(0.064)	-0.219**	(0.108)
Access to credit	-0.096	(0.178)	0.335	(0.213)	-0.230	(0.220)	-0.079	(0.389)	0.219	(0.192)	0.392	(0.251)
Off-farm wage	0.130***	(0.044)	-0.107***	(0.024)	0.014	(0.029)	-0.133**	(0.066)	0.074**	(0.036)	-0.100***	(0.022)
Access to electricity	-0.007	(0.166)			0.113	(0.192)			-0.059	(0.182)		
Distance to public transportation system	-0.062**	(0.029)	-0.068	(0.071)	-0.032	(0.035)	0.018	(0.086)	-0.060	(0.041)	-0.122*	(0.068)
Division Kingo´ri [a]	-0.114	(0.365)	0.123	(0.505)	-0.223	(0.369)	0.612	(0.759)	0.437	(0.401)	-0.864*	(0.486)
Division Mbuguni [a]	-0.607*	(0.336)	0.139	(0.415)	-0.981***	(0.356)	0.159	(0.600)	0.190	(0.371)	-0.359	(0.486)
Division Moshono [a]	-0.338	(0.303)	0.657	(0.466)	-0.687**	(0.308)	1.052	(0.696)	0.307	(0.340)	-0.247	(0.440)
Constant	3.033**	(1.417)	3.703**	(1.768)	2.700*	(1.539)	5.265	(3.641)	-1.023	(1.671)	-0.572	(2.799)
Log pseudolikelihood	-378.825				-211.925				-263.297			
Observations	341		134		341		60		341		86	

[a] Reference division is Poli.

Standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1.

Table A8. Hourly wages received by hired labourers

	Traditional markets (N=257)	Export markets (N=87)	Total (N=344)
Wage received by hired labourers (in Tsh. per hour)	1103.1 (533.2)	1210.4 (587.4)	1130.3 (548.5)
Wage received by hired labourers –15-34 age cohort (in Tsh. per hour)	1169.3 (646.2)	1242.2 (670.7)	1191.5 (653.1)
Wage received by hired labourers – 35 and over age cohort (in Tsh. per hour)	1042.3 (477.7)	1108.0 (455.2)	1064.4 (468.6)
Observations	344		

Mean coefficients.
Standard deviations in parentheses.
* p < 0.10, ** p < 0.05, *** p < 0.01.