



Linking small-scale farmers to the durum wheat value chain in Ethiopia: Assessing the effects on production and wellbeing

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ABSTRACT

Food security and agricultural-led industrialisation are pivotal development objectives in Ethiopia. One of the main challenges this country faces is increasing agricultural productivity by integrating smallholder farmers into a high-value agricultural commodity supply chain. This paper examines an integrated project—the Agricultural Value Chains Project in Oromia (AVCPO)—that aims to improve the livelihoods of smallholders in the Bale Zone by involving them in the production of high-quality durum wheat and linking them to the pasta industry via farmers' cooperatives. Using primary data collected in 2014 and retrospective information, this paper investigates the AVCPO's effects on the quantity of cereal production, the share of cereals that have been sold through cooperatives, food security, and education. In order to account for potential violations of the exclusion restriction assumption, an instrumental variable approach is applied, together with three additional estimation strategies.

The results suggest that the project has had a large and positive effect on gross and net values of cereal production per hectare, as well as on the share of production sold to pasta makers through cooperatives. These benefits accrue equally to land-rich and land-poor farmers. Furthermore, our analysis suggests that the AVCPO has improved educational outcomes and reduced food insecurity, without affecting crop rotation practices. Overall, our findings point to the effectiveness of the project. Before replicating or scaling up this intervention, however, it is necessary to understand how to better involve poorer farmers and which adjustments are needed if the areas selected have a lower potential than Bale Zone.

1. Introduction

Ethiopia is the leading producer of wheat in Sub-Saharan Africa (SSA) (FAOSTAT, 2015) as well as the only country where smallholders have a majority share in its production (Spielman et al., 2010; Shiferaw et al., 2014). As in many other SSA countries, a growing population, urbanisation and rising incomes are driving a continuous increase in food demand, especially of processed and convenience-oriented foods such as pasta (Jayne et al., 2013; Mason et al., 2015; Donley, 2016). Wheat consumption in Ethiopia has risen faster than any other major food grain, especially for pasta and bread consumption, and is expected to continue to rise rapidly in the future (Minot et al., 2015). While the rising demand for pasta in Ethiopia is largely satisfied by the domestic pasta industry (Shiferaw et al., 2014; Chiari, 2015), the growing demand for durum wheat that results is largely met through imports. Ethiopia's increasing reliance on food imports from volatile global markets has raised concerns over national food security, as has the

possibility that imports may negatively affect the livelihoods of small-scale farmers (Gebreselassie et al., 2017).

It is not an easy task to generate systematic linkages between and among smallholder cooperatives, pasta manufacturers and consumers in a relatively nascent value chain (VC). Efforts to address this situation require attention to wheat production quality, input and output market failures and coordination problems facing smallholder farmers and other actors in the value chain. This implies, in particular, identifying institutional arrangements for linking farmers with each other and to marketing channels as well as bringing together public and private stakeholders (e.g. research, extension, and banking institutions) (Dorward et al., 2004; Jayne et al., 2010; Spielman et al., 2010). Two institutional arrangements that are often debated with reference to Ethiopia and indeed elsewhere are contract farming and farmer cooperatives, which have been the object of investigation from a theoretical and empirical perspective (Biénabe and Sautier, 2005; Holloway et al., 2000; Abebaw and Haile, 2013).

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Contract farming is an important element in the Ethiopian Government's Growth and Transformation Plan II to link small-scale farmers to sustainable market outlets and promote agricultural development. Contract farming is a commercial relationship between farmers and traders or processors over the production and sale of certain agricultural products, often at pre-agreed quality, quantity and price (Eaton and Shepherd, 2001). Smallholders might benefit from access to high-value output market and from the – often included – provisions for access to credit, technical advisory services and inputs (Jayne et al., 2004; Barrett et al., 2012; Abate et al., 2014). It may also help reduce marketing risks by guaranteeing more reliable prices than in the open market (Kaganzi et al., 2009). As a result, it might lead to increasing prices for producers and/or marketed quantity, and thereby to higher incomes.

At the same time, there are concerns about a potential rise in local inequality as access to contract farming opportunities is potentially limited to better-off farmers who have the necessary resources and skills (Barrett et al., 2012). Negative effects may also arise due to increased exposure to production and marketing risk as well as potential power imbalances (Sivramkrishna and Jyotishi, 2008). A number of studies have recently explored these potential effects of contract farming (e.g. Warning and Key, 2002; Simmons et al., 2005; Rao and Qaim, 2011; Bellemare, 2012; Narayanan, 2014; Herrmann, 2017). In an early study, Warning and Key (2002) find substantial income improvements for peanut farmers producing under contract in Senegal. Rao and Qaim (2011) find that selling under contracts to supermarkets in Kenya has positive income effects for vegetable farmers. Bellemare (2012), using an extensive dataset covering a number of crops, firms and regions of Madagascar, concludes that contract farming participation leads to significant income improvements. In Ethiopia, two existing studies on contract farming, one on castor beans by Negash and Swinnen (2013) and one on organic honey by Girma and Gardebroek (2015) find positive effects on food security and incomes, respectively.

A recent systematic review of 26 contract farming arrangements in 13 developing countries by Ton et al. (2017) confirms these positive income effects, estimating an overall pooled income effect of 38%. Yet, while only two of the reviewed studies report negative income effects in some of the contract farming cases (Simmons et al., 2005; Narayanan, 2014), Ton et al. (2017) find large differences depending on type of contract, crops and the institutional environment. In another recent study, Ragasa et al. (2018) also show that maize contract farming in Ghana, while leading to technology adoption and higher yields, did not increase farm profits. Ton et al. (2017) emphasise that such negative or insignificant effects are likely to be systematically underrepresented due to publication and other biases, requiring further rigorous evaluations. They find, for example, that in the majority of cases contract farmers were better off in terms of land or other wealth categories than average farmers in the regions.

Farmer cooperatives play a central role in the Ethiopian Government's strategy for increasing agricultural productivity, and could play an even more strategic role in linking farmers to markets (Bernard and Spielman, 2009; Bernard et al., 2010; Gebreselassie et al., 2017). Marketing cooperatives may help small-scale producers in overcoming minimum quantity, quality and frequency of supply constraints to participating in higher-value markets and contract farming schemes (Kaganzi et al., 2009). Collective action, in general, may enable farmers to aggregate produce, reducing transaction costs and diseconomies of scale (Biénabe and Sautier, 2005). It can also enhance groups' bargaining power and access to information and help establish contracts with buyers who require large volumes (Best et al., 2005; Kwapong and Korugyendo, 2010). Yet, cooperatives can also be instruments to reinforce rural elites and the established order, as they might serve to concentrate market power (Francesconi and Heerink, 2010).

A number of empirical studies find positive effects of cooperatives on technology adoption (Shiferaw et al., 2008; Abebaw and Haile,

2013), prices (Wollni and Zeller, 2007; Bernard et al., 2008; Shiferaw et al., 2009), commercialisation (Francesconi and Heerink, 2010) and farm incomes (Fischer and Qaim, 2012; Ito et al., 2012; Vandeplass et al., 2013), while others come to more mixed results (e.g. Mujawamariya et al., 2013; Verhofstadt and Maertens, 2014). While there is little research in Ethiopia on income effects of cooperatives, some studies have analysed grain marketing performance, but come to mixed conclusions. Bernard et al. (2008) do not find effects of grain cooperatives on agricultural commercialisation on average as well as for poorer farmers, but find effects on prices, implying some positive effects on bargaining power. Likewise, Bernard and Spielman (2009) find that the poorest farmers tend to be excluded from grain marketing cooperatives, although they might benefit through spillover effects, such as through higher prices. Francesconi and Heerink (2010) find higher commercialisation among cooperative members, yet only for marketing cooperatives, which is consistent with Bernard and Taffesse (2012) who find declining success in providing marketing services once a cooperative adopts additional non-marketing-related activities.

This study contributes to the literature on the involvement of smallholders in agricultural value chains by analysing the impacts on production and wellbeing brought about by the Agricultural Value Chains Project in Oromia (AVCPO) in the Bale Zone of Ethiopia. The AVCPO is a durum wheat VC development project that uses cooperatives and contract farming arrangements to improve the productivity and welfare of smallholders cultivating durum wheat. The project was implemented by the Ethiopian government in collaboration with the Italian Development Cooperation between 2011 and 2016.

Its aim was to improve the production and marketing of durum wheat among smallholders by improving the quality and quantity of their crops, strengthening cooperatives and establishing direct links between cooperatives and Ethiopian pasta makers in Addis Ababa through contract farming agreements. Later on, the Bale Zone was identified as a durum wheat commercialisation cluster (MAECI, 2016).

This paper has three objectives. The first objective is to investigate the project's impact on cereals production. The second objective is to assess the capacity of the programme to strengthen the role of cooperatives in marketing durum wheat. The third objective is to explore the impact the project has had on the wellbeing of farming households, paying special attention to education and nutrition.

Our evaluation is based on data that was collected in 2014 via a large-scale household survey. As is common in the evaluation of large agricultural value chain programmes, we had to rely on cross-sectional data and retrospective information. In order to assess the AVCPO's impacts, we applied an instrumental variable (IV) approach. To test the robustness of the results, due to the possible violation of the exclusion restriction assumption, three additional – recently developed – estimation strategies were implemented: a sensitivity analysis approach, an IV estimation on a sub-sample determined by propensity score matching (PSM) without replacement and a non-parametric approach.

The remaining paper is structured as follows: Section 2 briefly introduces the food policies concerning wheat in Ethiopia. Section 3 explains the AVCPO project and the theory of change that frames our evaluation. Section 4 discusses the data and methodology. Section 5 presents the results while Section 6 features our concluding remarks and the policy implications of our findings.

2. Background: the durum wheat sector in Ethiopia

In Ethiopia, wheat and wheat products, including bread and pasta, have become staple foods over the years. A nationally representative survey cited in Minot et al. (2015), for example, finds that most urban households in Ethiopia now consume wheat (nearly 90%). However, the survey also finds that only around 50% in rural areas consume wheat products, indicating that purchases increase with urbanisation and incomes. Since the 1990s, wheat consumption has increased by 4.2% annually, well above the population growth rate (Minot et al.,

2015). Its share in overall cereals consumption is around 20%, second only to maize and significantly above most SSA countries (FAOSTAT, 2015).

Ethiopia has been producing wheat for centuries, and is known worldwide for the genetic diversity of its wheat.¹ Wheat cultivation is concentrated in the central and southern highlands due to favourable growing conditions (Hailu, 1991; White et al., 2001; Shiferaw et al., 2014; Minot et al., 2015). In contrast to other SSA countries, wheat is mainly cultivated through small-scale, rain-fed agriculture. Ethiopia has an estimated 4.7 to five million wheat farmers, more than 90% of whom are small-scale farmers who cultivate on less than half a hectare (Gabre-Madhin, 2001; Minot et al., 2015). Most small-scale farmers are linked to an agricultural cooperative system (Gabre-Madhin, 2001; Bernard et al., 2010).

Along with rising demand, wheat farming has more than doubled in acreage and more than quadrupled in terms of production in the last two decades, making wheat one of the four major cereals produced in the country, alongside teff, maize and sorghum (FAOSTAT, 2015). However, domestic wheat production has been insufficient in recent years, leading to growing reliance on imports, to an extent not seen in other agricultural sub-sectors (FAOSTAT, 2015). Imports increased significantly during the food crisis of 2008–2009, when the government began providing wheat to large-scale flourmills in order to encourage the production of subsidised bread (Shiferaw et al., 2014; Minot et al., 2015; Gebreselassie et al., 2017).² Increasing pasta consumption has also led to growing dependency on wheat imports. Indeed, demand for pasta has grown faster than demand for other wheat-based bread products (Minot et al., 2015). Due to the low quantity and quality of durum wheat – most wheat produced in Ethiopia is bread wheat with a homogenous protein content – the pasta industry almost completely relies on imports to meet their production goals. As a result, durum wheat imports have accounted for around 50–80% of total wheat imports (Benson et al., 2014).³

According to some researchers (Shiferaw et al., 2011a, 2011b; Shiferaw et al., 2014), a few areas of Ethiopia have a comparative advantage in producing wheat. However, low yields and weak market systems result in insufficient overall domestic supply response. In 2012–2013, wheat yields were estimated to be 2.4 tons per hectare, which is low compared to other major producers, such as Egypt (6.7 tons), South Africa (3.4 tons) and Kenya (3.0 tons) (Demeke and Di Marcantonio, 2013; Minot et al., 2015). Underlying reasons are limited use of modern inputs and improved varieties – in particular, poor grain quality –⁴ and high implicit taxation, including overvalued exchange rates, export bans, subsidised imported wheat and underdeveloped market structures (Gabre-Madhin, 2001; Bernard et al., 2010; Demeke and Di Marcantonio, 2013; Shiferaw et al., 2014; Yirga et al., 2016). Moreover, seed varieties and quality is a problem that affects how wheat production among smallholders is marketed. Due to weak price incentives, non-integrated and incomplete markets, and low productivity, less than 30% of Ethiopian wheat is sold through the market (Demeke and Di Marcantonio, 2013; Minot et al., 2015). In addition to low marketed volume – due to lack of market information, shortage of working capital, and price instability – local wheat is mostly marketed

through overly complicated systems (Gabre-Madhin, 2001), with many private traders aggregating the quantity of wheat without considering quality and timing (Gebreselassie et al., 2017), both of which are important to the country's pasta producers (Chiari, 2015).⁵ At the same time, there have been substantial investments in large-scale flour mills, suggesting that the potential is there to improve grain markets (Benson et al., 2014).

Historically, increasing the production of wheat and other cereals has been an important policy objective of the Ethiopian government (Spielman et al., 2010). The National Wheat Research Program (NWRP), for instance, was enacted in order to generate basic scientific information and applied technology that could increase and sustain wheat production in Ethiopia (Hailu, 1991).⁶ The grain market was liberalised in March 1990. Restrictions on private inter-regional trade were removed, official pricing and quotas were abolished and the marketing board's monopoly status was eliminated. However, according to Gabre-Madhin (2001), the market remained “efficient but poor” because market development was relatively limited.

The production of wheat and other cereals has also become an important part of several development strategies in Ethiopia, including the Growth and Transformation Plan (GTP) and the Agriculture Development-Led Industrialization (ALDI) policy, both of which were created to foster industrial development and food security through agriculture. Smallholder commercialisation is recognised as a major source of agricultural growth and transformation, which requires establishing appropriate marketing systems and VCs, while also strengthening both cooperatives and the private sector (Growth and Transformation Program, 2013–15).

The Agricultural Transformation Agency (ATA) has been established by the Ethiopian government to strengthen the wheat VC as a strategic sub-sector that can help promote food security and agricultural growth. Likewise, the multi-stakeholder Agricultural Growth Program (AGP) aims at supporting farmer cooperative unions and agribusinesses, raising the production and productivity of wheat and wheat VCs, and increasing the domestic supply. Meanwhile, agricultural cooperatives have been playing an important role in the sector's attempt to increase productivity, and have become increasingly involved in the commercialisation of cereals (Bernard et al., 2008; Wanyama et al., 2009; Bernard et al., 2010; Francesconi and Heerink, 2010; Abebaw and Haile, 2013).

3. The Agricultural Value Chains Project in Oromia (AVCPO)

The AVCPO was presided over by several Ethiopian stakeholders as part of the Ethiopian-Italian cooperation framework between 2011 and 2016.⁷ It was based on a pre-existing large-scale Ethiopian-Italian development project in the region, specifically the Arsi-Bale Rural Development Project⁸ and involved a variety of different local actors – most notably cooperatives, local public research centres and government actors from the state and local levels.

The project is located in the wheat production area of the Bale Zone. Despite being part of one of the main wheat-producing areas of Ethiopia – the Federal State of Oromia – the Bale Zone has in the past been classified as a minor wheat-producing area (Hailu, 1991). Bernard et al. (2010) claim that it has low market access. Most wheat is grown

¹ <http://wheatatlas.org/country/varieties/ETH/0>.

² Ethiopia has been the largest recipient of foreign food aid in SSA, most of which consists of wheat from the United States (Demeke & Di Marcantonio, 2013).

³ Durum wheat is considered indigenous in Ethiopia, but has been increasingly replaced by bread wheat (Benson et al., 2014). This is due to durum wheat's relatively low yields, low producer prices and weak tools for linking farmers to markets (Benson et al., 2014).

⁴ Though modern technologies are being embraced more and more – an estimated 73% of wheat areas in Ethiopia are fertilized – improved crop varieties are not being used to a great extent (Yirga et al., 2016), tractor use is rare and poor crop management is common (Demeke & Di Marcantonio, 2013; Minot et al., 2015). However, rental services for ploughing wheat are becoming more common in commercial wheat growing areas, including the Bale Zone (Minot et al., 2015).

⁵ Cooperatives play a minor role in marketing wheat (Minot et al., 2015; Gebreselassie et al., 2017). They are most active in the distribution of fertiliser.

⁶ The programme had four main dimensions: a zonal dimension (six major wheat-producing regions were selected, including the Bale Zone and Sinana, the latter of which served as a research centre); a disciplinary dimension (with a focus on vertical breeding, genetics research, wheat pathology, entomology and research-extension); a client dimension and a resource dimension (Hailu, 1991).

⁷ The AVCPO was financed by the Italian Development Corporation and received technical assistance from the Overseas Agronomic Institute.

⁸ The Arsi-Bali project was a rural development initiative that was overseen by the Italian Development Corporation from 1996 to 2004.

Table 1

Major bottlenecks addressed by AVCPO regarding the durum wheat VC.

Source: Adapted by authors from (Biggeri et al., 2017).

Bottleneck	Actions	Actors involved
Small size of farms (and small per-farm production)	<ul style="list-style-type: none"> – Strengthening cooperatives – Creation of cooperative's unions – Construction of new storage facilities at cooperative/kebele level 	<ul style="list-style-type: none"> – Cooperatives – Unions – Farmers – Regional and Zonal Institutions
High risk aversion of farmers	<ul style="list-style-type: none"> – Creation of contract farming schemes to link farmers and processing industries – Quality premium in price setting – Peer learning 	<ul style="list-style-type: none"> – Cooperatives & Unions – Pasta producers – Sinana Agricultural Research Centre (quality lab checks) – Regional and Zonal Institutions
Low quality of production (i.e. low protein content)	<ul style="list-style-type: none"> – Training of farmers (fertilisation, appropriate farming practices, etc.) – Selecting new adapted (patented by research institutions) varieties of durum wheat seeds – Creating a seed value chain involving seed multiplier cooperatives and agricultural research centres – Providing seed grading machines to cooperatives (still not operational at the time of evaluation) – Training on appropriate nitrogen fertilisation 	<ul style="list-style-type: none"> – Farmers – Sinana Agricultural Research Centre – Selected farmers devoted to the cycle of seed production – The AVCO programme directly via cooperatives – Oromia Agriculture Research Centre (OARI)
Insufficient coordination among actors along the VC	<ul style="list-style-type: none"> – Strengthening and involving local institutions in the value chain – Capacity building of cooperatives by strengthening technical and managerial skills – Sharing experience and creating awareness among farmers and cooperative managers 	<ul style="list-style-type: none"> – Regional and Zonal Institutions – International consultants – Cooperatives & Unions – Pasta producers

between 1800 and 2500 m above sea level. The project area is flat and located at an (average) elevation of 2000 m above sea level. It has relatively homogeneous socio-economic conditions, agro-climatic conditions (e.g. soil types), rainfall levels and moisture types (BDoFED, 2004).

3.1. Objectives and main features

The AVCPO's general aim is to raise domestic production of durum wheat and facilitate greater access to value added markets. At the core of its strategy is an attempt to enable smallholders to produce large amounts of high-quality durum wheat that will meet the demands of the domestic pasta industry and increase the bargaining power of smallholders. The project identified a number of production and coordination problems that prevented farmers from achieving satisfactory results in terms of the quantity, quality and timing of production (see Table 1).

In 2011, the AVCPO launched a series of interlinked actions addressing two main areas: The first is focused on technical aspects of production, including the proliferation of appropriate agronomic practices, the introduction of adapted durum wheat varieties and the provision of key assets at the cooperative level. The second area concerned the overall institutional architecture of the VC – paying special attention to capacity-building among cooperatives, establishing links between cooperatives and public agricultural research centres and using cooperatives to establish contract farming arrangements, not practiced previously in the region. These arrangements involved establishing contracts between cooperatives and pasta makers as well as between cooperatives and the farmers (Chiari, 2015). Incentives aimed at ensuring that cooperatives and farmers adhere to their contracts include significant price increases that are based on verified quality parameters (namely, the protein content of durum wheat).

The AVCPO was expected to induce a change in the power relations within the VC. Farmers in local markets are often negatively affected by the greater bargaining power of traders, intermediaries and lenders (Biggeri et al., 2017; Sultan, 2016). The ability of cooperatives to act as a link between farmers and the pasta industry was expected to result in a redistribution of bargaining power in favour of the farmers.

According to the data collected by the Sinana Agricultural Research Centre in the AVCPO area – where about 140,000 ha are cultivated with

bread wheat every year – the project worked with 15 cooperatives and second-level associations (e.g. unions). According to internal monitoring data, durum wheat production in the project area increased thirtyfold between 2012 and 2015 (Chiari, 2015).

3.2. Rationale and impact framework

The AVCPO has implemented a two-pronged approach to upgrading small-scale cereals production, emphasising, in particular, technical improvements and improvements to the VC's institutional architecture. The effectiveness of the AVCPO depends on how these approaches interact with each other, as farm-level impacts are only achievable as long as action is taken collectively. For instance, the use of improved seeds is only sustainable if farmers, cooperatives and public agricultural research centres are connected in a sound durum wheat seed production cycle. Moreover, since the quality of durum wheat is measured at the cooperative/area level, individual farmers are only incentivised to invest in qualitative activities – such as better training, higher quality seeds and more fertiliser – if other members of the cooperative do likewise.

Direct access to national markets, especially through cooperatives, is expected to increase the bargaining power of farmers. Moreover, the alternative marketing channels that are made available through cooperatives may induce competition, as other intermediaries might be compelled to offer competitive prices. Perhaps more importantly, the transformations associated with having better access to national markets might allow smallholders to produce higher value crops, which will in turn allow farmers to retain a greater share of the added value. These induced changes in the production and market system are expected to increase farmers' wheat revenues by increasing the prices and/or quantity that is produced and sold. Household income may rise as long as additional costs are lower than the revenue increases. Through an increase in household income, the project might then improve other dimensions of farmers' wellbeing, such as food security, education and health (see Fig. 1).

Regardless, the transformations brought about by the AVCPO may potentially introduce undesired effects. For instance, more profitable crops might encourage less sustainable forms of land use (e.g. reduced crop rotation) or crowd out traditional crops (e.g. emmer wheat, teff or barley). Another point worth mentioning is the possibility that factors beyond the AVCPO's control may influence its effectiveness,

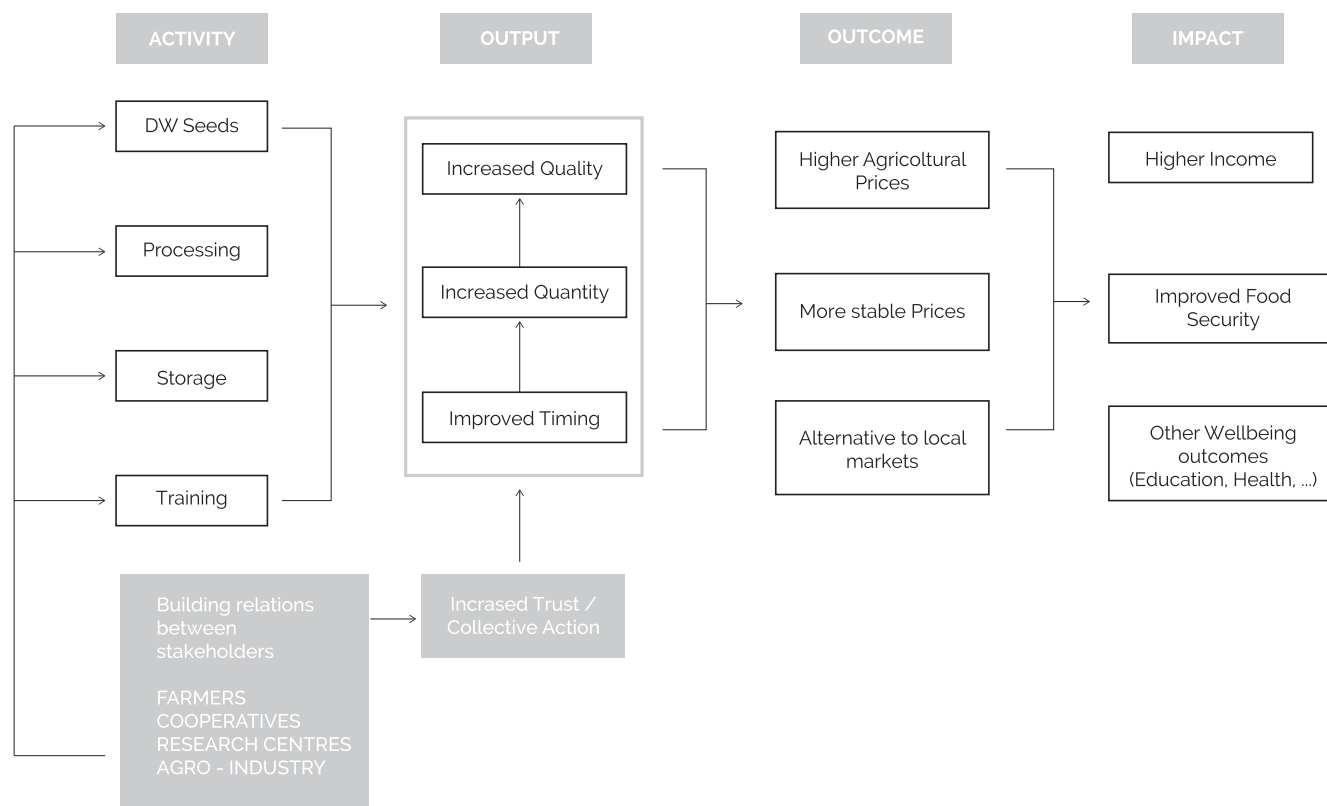


Fig. 1. AVCPO impact framework.

Source: Authors.

particularly natural disasters such as drought or floods. The political stability of the area and ethnic tensions might also undermine the AVCPO's efforts to establish a positive business climate and forge sound cross-level interactions between stakeholders. Price instability in the international and national grain markets could also hinder the AVCPO's efforts, as Ethiopia is still heavily reliant on foreign imports of both grain and fertilisers.

4. Methodology

In order to evaluate the project's effects, a large-scale household survey was conducted in 2014.⁹ The data was then analysed using several different econometric techniques. The information gathered from in-depth interviews with key stakeholders, including AVCPO staff and researchers from the Sina Agricultural Research Center (SARC),¹⁰ were used to formulate the questionnaire, to identify participating cooperatives and farmers (the treatment) as well as to develop the sample design.

4.1. Sample design and data collection

Among all the cooperatives interested in introducing durum wheat in their area, the AVCPO selected those that were previously involved in the Arsi-Bale Rural Development Project. The latter was implemented in a specific sub-area of the Bale Zone, characterised by homogenous socio-economic and agro-ecological conditions (mostly flat land and with two rainy seasons). The other cooperatives operating in this sub-area, including those that were eventually selected as part of the control

⁹ A small pilot survey involving 20 smallholders was carried out to test the questionnaire and to verify the goodness of retrospective information gathered.

¹⁰ SARC is the regional state-owned research institution that serves as a branch office of the OARI in the Bale Zone. The OARI's role in the AVCPO was to develop and release improved durum wheat varieties and supervise all value chain activities.

group for this study, were permitted to join the AVCPO in 2015, when the scaling-up phase of the project began.

The sample design therefore included two stages: selection of treated and non-treated cooperatives followed by a random sampling of smallholders based on the list of farmers provided by the AVCPO. Based on a power analysis, the farmers' sample consisted of 752 households, with households in the control group oversampled.¹¹

Ten out of the fifteen AVCPO cooperatives were selected in our sample (five had already left the programme by the time of the survey).¹² The non-treated cooperatives were selected according to a set of criteria established a priori:

- these cooperatives were supposed to have been part of the previous Arsi-Bale Rural Development Project;
- they were located far enough from the treated cooperatives to avoid spillover effects;
- they were located in areas comparable to the treated ones in terms of agro-ecological characteristics;
- they did not experience extreme climate shock during the reference cropping season.

A potential group of 32 control cooperatives was initially identified. A total number of 12 non-treated cooperatives were then selected on the basis of the

¹¹ Two variables, taken from the statistics of SARC, were chosen to calculate the power analysis ex-ante: the percentage of smallholder farmers cultivating cereals in the area (95.2%) and the percentage of smallholder farmers who did not deliver their cereals to the cooperative (96.5%). According to these two statistics, the number of households that needed to be interviewed were 752 and 556 with 1% error (188 and 138 with 2% error). A total of 751 farming households completed the interview. The validity of the power analysis was confirmed ex-post on these and other relevant variables used in the analysis.

¹² Two cooperatives were excluded at an early stage because they were unable to carry out various activities, while three cooperatives dropped out due to adverse natural conditions.

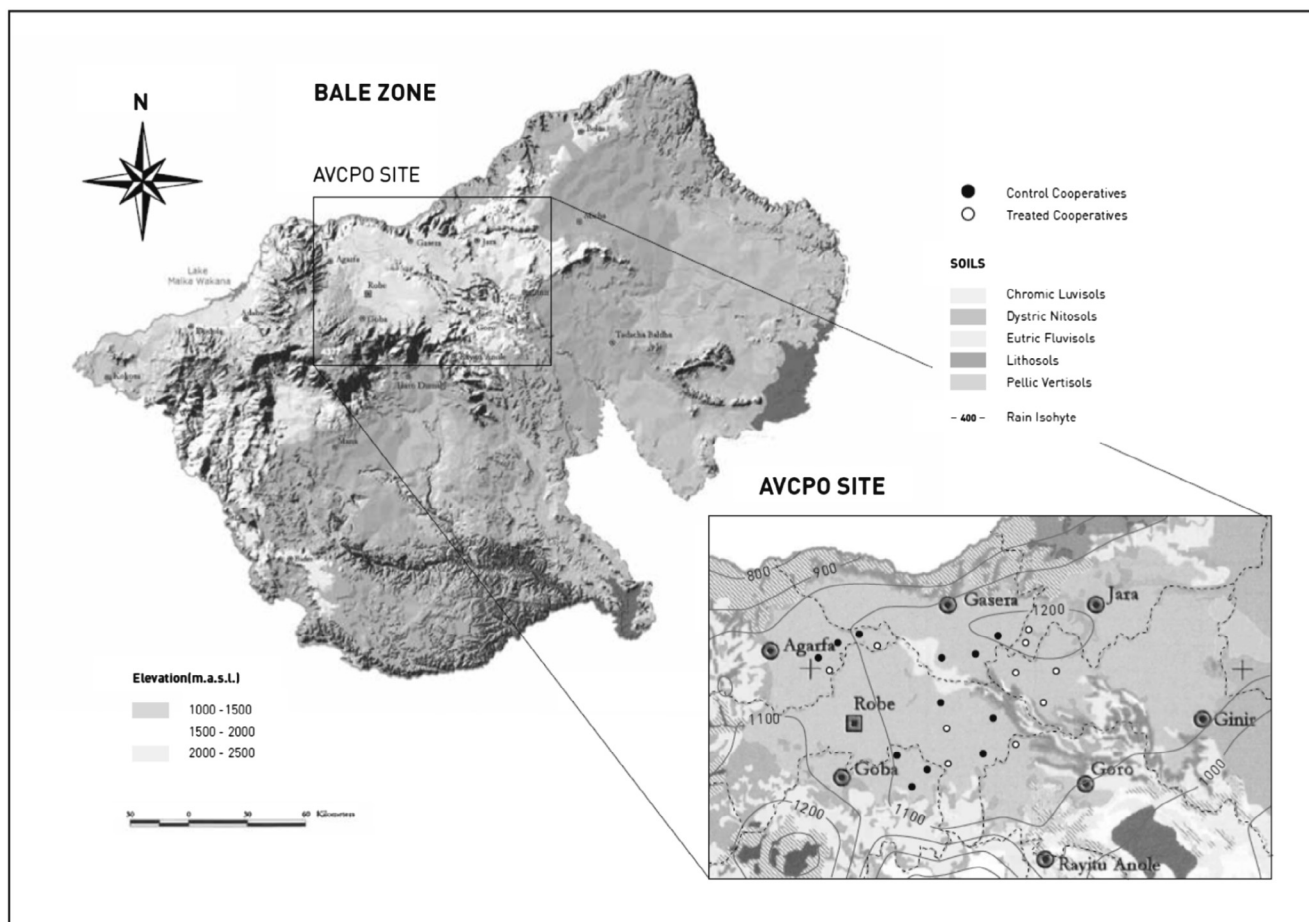


Fig. 2. Location, soils, average rainfall and elevation of Bale Zone and cooperatives surveyed.
Source: BDoFED (2004).

above-mentioned criteria. In each cooperative, 30–40 farmers were randomly selected from a complete list of farmers. The map of the area and the location of the cooperatives are presented in Fig. 2. According to research conducted in 2004, these cooperatives are located in an area with similar average annual amounts of rainfall (1000–1200 mm), elevation, soil quality, moisture, humidity, crop cultivation typologies and socio-economic characteristics (BDoFED, 2004). These factors are also explained in Fig. 2 and Table 2.

In ten AVCPO cooperatives, both farmers participating in the AVCPO (Groups F-a and F-b in Fig. 2) and non-participating farmers of the same cooperatives (Group D) were randomly selected (30–40 farmers in each cooperative).

Fig. 3 presents the structure of participation in the AVCPO within the treated woredas (districts), identifying different groups of treated and non-treated farmers based on their role in the evaluation. Among the treated farmers, two groups can be identified. Group F-a are treated farmers who agreed to sell their harvest directly to pasta producing factories by delivering their production to cooperatives. Their relative prevalence varies from one cooperative and woreda to another (i.e. it is close to 100% in Golocha, but lower in other woredas).

Group F-b is composed of farmers who are part of the project, but sold their durum wheat through channels other than the cooperative.¹³

¹³ The reason that pushed many farmers to sell via other channels is the sudden and sharp rise in durum wheat prices that occurred during the 2013 harvest season. The rise in the durum wheat price was chiefly due to reduced imports from Ukraine (as a result of political instability) and to the volatility of international markets (Ukrstat, 2011–2014; UNCTAD, 2011–2014). Therefore, the prevailing local market price at harvest time was higher than the price stated by the factories a few months before. Ethiopian government interventions such as cereals acquisition and storage were central to reducing the pressure on prices for staple foods.

These farmers are also considered part of the treated group (according to our definition), since the project cannot exclude that local middlemen may have decided to offer higher prices as a reaction to the new system created by the AVCPO.

Among the non-treated farmers, only 2 of the 6 potential groups were used in the analysis.¹⁴ Group B is composed of farmers who are members of a non-treated cooperative (i.e. living in a non-treated kebele – the lowest administrative unit in Ethiopia – as each kebele has only one cooperative). This group can be used as a control group if three conditions are met: (i) The kebele is comparable to treated kebeles in terms of agro-ecological, socioeconomic and demographic conditions; (ii) the kebele is willing to join the programme in the near future¹⁵ and (iii) there is no evidence of spillover resulting from the treatment to this kebele. Insofar as the last point is concerned, SARC researchers have found that many non-treated kebeles – especially Sinaana Woreda – can be used as a control group because they are far enough from the treatment area that the risk of spillover is almost zero. Finally, Group D is composed of farmers who are members of one of the

¹⁴ Group A is composed of farmers who are not officially members of cooperatives, but live in a treated kebele. This group cannot be used as a control group as these farmers cannot be easily identified and they are structurally different from treated farmers in that they are not involved in any form of collective action. Group C is composed of farmers who are not members of cooperatives living in a non-treated kebele: This makes them unsuitable to act as a control group. Group E is composed of farmers who are members of a non-treated cooperative in a treated kebele. Only in a few kebeles are there more than one cooperative. However, the risk of trickle-down and spillover of the treatment is extremely high and this group was therefore excluded from the control group.

¹⁵ Based on information obtained in 2018 from the Italian Development Cooperation Agency branch office in Addis Ababa, 10 out of the 12 cooperatives (83.3%) included as the control group have actually joined AVCPO since 2014.

Table 2
Characteristics of the areas where surveyed cooperatives are located.
Source: BDoFED (2004).

Woreda	Cooperative	AVCPO	Relief elevation (m.a.s.l)	Mean annual rainfall (m.m.)	Soil type quality	Crop production system zone	Number of members	Thermal zone C°	Length of growing period (days)	Geology
Agarfa	Agarfa1T	Yes	2000–2500	1000–1100	Pellic vertisoils	Barley, wheat, pulses	551	15–20	300–365	Quaternary Undifferentiated, Ginir Formation Q.U.G.F
	Agarfa2T	Yes					509			
	Agarfa1C	No					416			
	Agarfa2C	No					329			
	Agarfa3C	No					547			
Sinana	Sinana3T	Yes	2000–2500	1000–1100	Pellic vertisoils	Barley, wheat, teff, pulses	638	15–20	300–365	Q.U.G.F
	Sinana4T	Yes					963			
	Sinana4C	No					1168			
	Sinana5C	No					649			
	Sinana6C	No					785			
	Goro	Goro5T					Yes			
Ginir	Ginir6T	Yes	1800–2200	1000–1200	Pellic vertisoils	Barley, wheat, teff, pulses	494	15–20	240–300	Q.U.G.F
	Ginir7T	Yes					653			
	Ginir8T	Yes					684			
Gololcha (Jara)	Jara9T	Yes	1900–2500	1000–1200	Pellic vertisoils	Barley, wheat, teff, pulses	673	15–20	240–300	Q.U.G.F
	Jara10T	Yes					486			
Goba	Goba7C	No	2000–2500	1000–1100	Pellic vertisoils	Barley, wheat, teff, pulses	212	12–18	300–365	Oligocene Miocene, Arsi Bale Basalts
	Goba8C	No					285			
	Goba9C	No					373			
Gassera	Gassera10C	No	2000–2500	1000–1200	Pellic vertisoils	Barley, wheat, teff, pulses	541	15–20	240–365	Q.U.G.F
	Gassera11C	No					557			
	Gassera 12C	No					658			

Note: All cooperatives are part of the hydrographic system of Weyberr, Tectonics based on Mesozoic tertiary cover of plateau, Tertiary mainly lower tertiary volcanic basalts, The Climatic classification: vegetation warm temperate humid.

cooperatives involved in the AVCPO, but did not agree to join the project. The size of this group is dependent on the size of the area. They can help identify the factors that systematically influence the programme's uptake.

For the purposes of this evaluation, we considered farmers that met the following requirements as “treated”: (i) they were members of an AVCPO cooperative;¹⁶ (ii) they had participated in at least one AVCPO activity¹⁷ and (iii) they had agreed to grow durum wheat.¹⁸ As shown in Table 3, the degree of overlap between the treatment definitions is quite high. Indeed, only 27 out of 293 durum wheat growers did not take part in at least one AVCPO activity, and only 41 farmers who were involved with the AVCPO decided not to grow durum wheat.

4.2. Outcome variables

The questionnaire used in the survey includes several modules, related to agricultural activities and socio-economic outcomes. Questions concerning inputs and outputs of the production process as well as asset ownership and social capital were collected for 2013 and, retrospectively, for 2010 (just before the beginning of the programme).

Three outcome variables were selected to measure the effects of AVCPO on agricultural activities: two related to the production side and one related to the delivery of cereals production to the cooperative (Table 4). The first one is the increase in gross value of cereals production per hectare between 2010 and 2013 (using 2013 constant prices) – this outcome is used to measure the success of the project in

terms of production.¹⁹ The second outcome is the net value of the cereals production per hectare per family labour unit (FLU),²⁰ which is taken as a proxy for household income. This is justified by the fact that all the interviewees identified agriculture as their main source of income and that the data clearly indicates that cereals production is the main component of agricultural activities: based on the descriptive statistics in Table 4, 82–84% of land was used for cereals before the intervention. To convey an idea of the relative contribution of agriculture, the average annual net household income from cereals production is 44,000 Ethiopian Birr (ETB) while the income from livestock is about 3700 ETB. The third variable is the share of cereals production value sold through the cooperatives.²¹ This outcome allows identifying the AVCPO's effectiveness in the creation of a viable alternative to local markets and middlemen/intermediaries.²²

Moreover, this paper provides an analysis of the AVCPO's effects on two important wellbeing outcomes: food security and access to education. Food security is measured through two different variables. The

¹⁹ This is the only dependent variable calculated using retrospective information. While, in general, some caution is needed when retrospective information is used, we noticed that interviewees had no difficulties in recalling 2010 data, especially about their key livelihood, agriculture. A similar approach was used by several other authors in this field (e.g. Maertens and Swinnen, 2009; Ito et al., 2012; Herrmann, 2017).

²⁰ The net value is computed as the gross value – non-labour input cost – hired labour cost. The family labour unit (FLU) was calculated taking into consideration family members involved in agricultural activities adjusted for their effort. The effort was estimated by enquiring the average number of hours worked per week during the 2013 main cropping season.

²¹ The share of cereals value was preferred to the share of cereals quantity to have a more homogeneous unit of measure (as cereals prices may be quite different). As a robustness check, all the empirical analyses were also implemented to the quantity of production, revealing very similar results.

²² Given the legally binding nature of the contract between cooperatives and the pasta company, it is very likely that nearly all of the produce of these cooperatives has been sold to the company. Observations during the qualitative interviews support this argument.

¹⁶ Note that this condition is a pre-condition for participating in AVCPO activities.

¹⁷ At the farmer level, the AVCPO consisted of several proposed activities (training, storage facilities and purchase of high-quality durum wheat seeds) and farmers could choose to join one or more of these activities.

¹⁸ It is worth remembering that durum wheat cultivation, although quite widespread in the past, was almost absent before the AVCPO began.

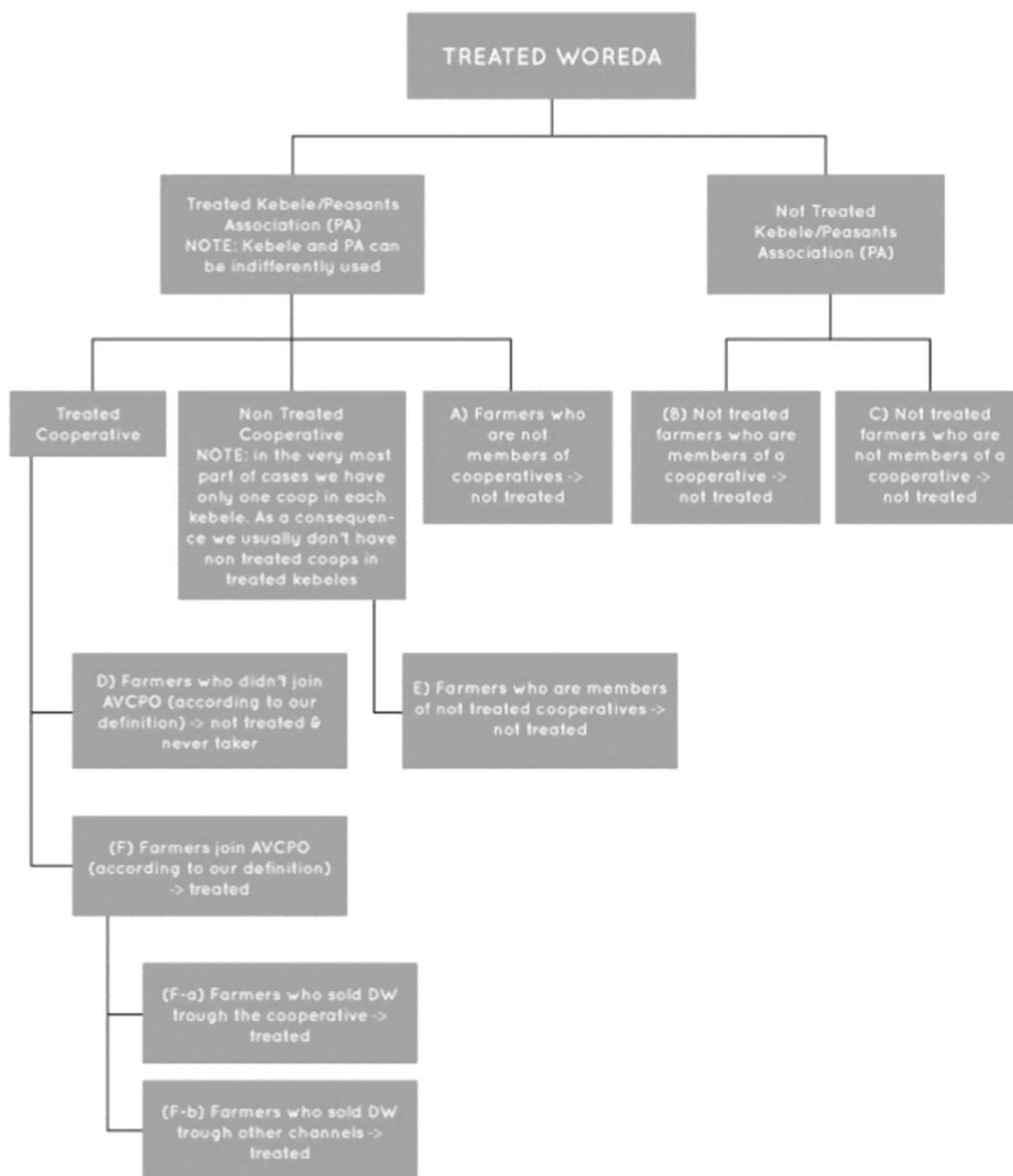


Fig. 3. Structure of participation/non-participation in the AVCPO. Source: Authors.

Table 3
Overlap and differences according to different definitions of treatment. Source: Authors.

At least 1 small plot for durum wheat	Participation in at least 1 AVCPO activity		
	Non-treated	Treated	Total
Non-treated	417 (55.53%)	41 (5.46%)	458 (60.99%)
Treated	27 (3.60%)	266 (35.42%)	293 (39.01%)
Total	444 (59.12%)	307 (40.88%)	751 (100.00%)

first is the household dietary diversity score, which is calculated as the number of different food groups that the household has consumed the day before the interview (Swindale and Bilinsky, 2006). It can potentially range from 0 (no food group consumed) to 16 (all food groups

consumed). The second indicator is calculated in line with the Household Food Insecurity Access Scale (HFIAS), but is based on a smaller set of questions as compared to the original one (Coates et al., 2007). This indicator is calculated by aggregating self-reported information on people’s frequency of use of coping strategies ranging from the moderate (eating a smaller meal) to the extreme (experiencing lack of food of any type). Extreme forms of food insecurity are not present among the sampled households, as nearly 94% of them never had to resort to any of these coping strategies. We also analyse the project’s effects on farmers’ frequency of relying on two of these coping strategies (the other two have no variability): these variables take value 0, 1 or 2 depending on whether farmers experienced that event never, sometimes or often, respectively.

Concerning education, the selected outcome is the share of family members aged 6–18 who are currently attending some kind of formal education. This variable is further disaggregated by gender.

Finally, this paper takes into consideration possible crowding-out effects of durum wheat production expansion. In the Bale Zone, the

Table 4
Outcome variables: descriptive statistics (2013).
Source: Authors.

Variables	Total		Treated		Control	
	Mean	s.d.	Mean	s.d.	Mean	s.d.
Outcomes related to Production						
Cereal production growth (2010–2013) (10,000 ETB/ha)	0.62	1.25	1.24	1.24	0.28	1.12
Net value cereal production (10,000 ETB/ha/FLU)	1.21	1.29	1.81	1.44	0.87	1.06
Share of cereal production sold through cooperative	0.09	0.20	0.19	0.21	0.04	0.18
Outcomes related to Land Use						
= 1 practice crop rotation	0.56	0.50	0.55	0.50	0.57	0.50
Share of cereals on total agricultural land	0.90	0.14	0.91	0.11	0.89	0.15
Share of bread wheat on total cereal area	0.57	0.31	0.36	0.28	0.69	0.27
Share of other cereals on total cereal area	0.16	0.19	0.09	0.11	0.19	0.21
Outcomes related to Education						
Share of HH members aged 6–18 in education	0.87	0.01	0.89	0.02	0.87	0.01
Share of male HH members aged 6–18 in education	0.85	0.01	0.87	0.03	0.84	0.02
Share of female HH members aged 6–18 in education	0.91	0.1	0.94	0.02	0.89	0.02
Outcomes related to Food Security						
Household food insecurity access scale (HFIAS)	0.12	0.53	0.02	0.21	0.17	0.64
Frequency of “eating smaller meals” (never \ sometimes \ often)	0.07	0.31	0.01	0.11	0.11	0.37
Frequency of “eating fewer meals” (never \ sometimes \ often)	0.04	0.25	0.01	0.11	0.06	0.29
Household dietary diversity score	9.55	1.73	9.73	1.77	9.46	1.71

Note: ETB stands for Ethiopian Birr (the national currency). Based on the 2014 exchange rate, 10,000 ETB correspond to approximately 384.6 Euro.

availability of new land for cultivation is close to zero. That means that it is not possible to expand the area for durum wheat cultivation without having effects on other uses. Three potential substitution effects were examined. First, durum wheat area expansion could have caused a reduction in crop rotation, and in particular rotation from cereals to grazing/fallow and from cereals to pulses (i.e. a practice to maintain and restore soil fertility). Second, it could have crowded out horticulture and other non-cereal crops. Finally, durum wheat could have replaced bread wheat (cash crop vs. cash crop) or other minor cereals (cash crop vs. food crop).

4.3. Econometric strategy

Given that treatment assignment was based on the willingness of individual farmers to join AVCPO activities, in principle, we cannot exclude the possibility that individual or household characteristics influenced the probability of joining the AVCPO. Moreover, it may be the case that at least some of these relevant characteristics are unobservable. For instance, farmers who are more entrepreneurial, less risk-averse, more skilled or more confident in their abilities are probably more likely to accept the treatment than others.²³ The use of propensity score matching techniques could therefore lead to a biased measurement of the impact due to selection of unobservables, a common problem when specific units (e.g. farmers) are free to accept (or refuse) an innovation (Barrett et al., 2012). An IV approach has often been used as a remedy to assess the impact of interventions encompassing contract farming schemes (e.g. Bellemare, 2012), smallholders' involvement in agro-industrial activities (Maertens and Swinnen, 2009) or their adoption of improved varieties (Sanglestasawai et al., 2014; Yirga et al., 2016).

Against this background, it is worth exploring the reasoning for the implementation of an IV procedure to assess the impact of the AVCPO.

²³ One part of our questionnaire focused on risk. People were asked to choose between two different options in a hypothetical situation: one option involved greater risk than the other. Depending on how they answered previous questions, participants may be asked to answer up to five questions. Our analysis shows that AVCPO participants are significantly less risk-averse than non-participants. However, this information should be taken with a grain of salt, as it refers to the post-intervention period rather than the pre-intervention period. For this reason, we decided to exclude this variable from the econometric estimates.

The IV setting is as follows:

$$Y = D\beta + X\gamma + \varepsilon \quad (1a)$$

$$D = Z\pi + v \quad (2a)$$

where Y is our outcome variable, D is the treatment variable (correlated with other unobservable variables and, hence, endogenous) and X is a matrix of other covariates. Z is the instrument(s) that is correlated to the endogenous treatment but not directly to outcome Y. According to Angrist and Imbens (1995), a two-stage least squares procedure can be used to obtain an unbiased estimate of β , as long as the instrument (Z) is strong/relevant (i.e. correlated to D) and valid (i.e. no direct effect of Z on Y or exclusion restriction). Through IV and a local average treatment effect (LATE), only the impact for those units whose treatment status would change D in case of an exogenous change in the value of the instrument Z is estimated.

Given this framework, membership of an AVCPO cooperative is a plausible candidate for an IV. Given that the compliance rate is 66.7%, the strength of the instrument should not be a problem: This is also confirmed by the results of the Anderson-Rubin test, reported in the Appendix (online). The validity (exogeneity) assumption is non-testable. Despite the existence of partial tests, such as the Sargan test, the validity of the instrument must be supported by the description of the evaluation setting.

In this evaluation setting, all members of AVCPO cooperatives were exposed to the possibility of joining the treatment, while members of non-AVCPO cooperatives were not. There is one single cooperative for each kebele. In other words, living or not living in an AVCPO kebele (and, consequently being or not being a member of an AVCPO cooperative) is chiefly determined by the place of birth (more than 98% of interviewees still live in the same kebele in which they were born).²⁴ Consequently, from an individual point of view, the assignment of the intention to treat can be considered random. However, as the first three columns of Table 5 show, there are statistically significant differences between farmers that were part of AVCPO cooperatives and those that were part of non-AVCPO cooperatives in the pre-project phase (2010). The former were, on average, slightly better endowed in terms of land

²⁴ It is possible to exclude that farmers moved to AVCPO kebeles to join the project: Given Ethiopian land property rights, land belongs to the state and farmers have the formal right to use and to bequeath it, but not to sell or buy it.

Table 5
Pre- and post-matching differences between farmers from AVCPO and non-AVCPO cooperatives.
Source: Authors.

Variable (pre-AVCPO)	Pre-Matching Means			Post Matching Means		
	(a) AVCPO Coop	(b) Non-AVCPO Coop	(a)–(b)	(c) AVCPO Coop	(d) Non-AVCPO Coop	(c)–(d)
Household asset						
Value of owned livestock (BIRR)	55,267	56,092	–825	54,791	53,573	1218
Value of agricultural assets (BIRR)	2829	2656	173	3113	2950	163 *
Value of HH productive plants (BIRR)	4957	3241	1716 **	3341	3901	–560
Farm size (ha)	3.95	3.5	0.45 **	3.75	3.61	0.14
= 1 HH owned a horse kart	0.13	0.15	–0.02	0.15	0.14	0.01
= 1 HH owned at least 1 mobile	0.33	0.32	0.01	0.33	0.33	0
= 1 HH owned at least 1 radio	0.41	0.41	0	0.42	0.4	0.02
= 1 the dwelling has a roof in iron	0.75	0.63	0.12 ***	0.67	0.69	–0.02
= 1 HH has access to piped water	0.40	0.34	0.06 *	0.4	0.4	0
Agro-ecological characteristics						
= 1 the farm experienced flood	0.30	0.43	–0.13 ***	0.4	0.4	0.01
= 1 the farm experienced a drought	0.06	0.07	–0.01	0.06	0.06	0
= 1 the farm experienced frost	0.08	0.13	–0.05 **	0.1	0.1	0
Bread wheat yields (q/ha)	28.87	26.43	2.44 *	25.61	25.38	0.23
Share of land cropped with cereal	0.84	0.82	0.02	0.83	0.85	–0.01
Household characteristics						
Number of adults equivalent	5.85	5.39	0.46 **	5.5	5.65	–0.15
= 1 HH head is Muslim	0.64	0.45	0.19 **	0.54	0.57	–0.02
= 1 HH head is a man	0.96	0.95	0.01	0.96	0.96	0
Age of HH head	41.79	44.16	–2.37 *	42.96	42.89	0.07
Year of education of HH head	5.56	5.32	0.24	5.4	5.42	–0.02
Social participation						
Participation in coops (score 1–4)	3	2.95	0.05	2.95	2.94	0.01
Trust toward coops (score 1–4)	2.91	2.96	–0.05	2.93	2.93	0
Social participation (score 0–7)	1.96	1.82	0.14 *	1.83	1.88	–0.05
Infrastructure						
Dist. from coop office (in min)	13.52	14.5	–0.98 *	14.24	13.9	0.34
Dist. from mobile network (in min)	3.42	4.7	–1.28	4.07	3.97	0.1
Dist. from health service (in min)	24.67	21.52	3.15 *	22.07	22.37	–0.3

* = 10% confidence level; ** = 5% confidence level; *** = 1% confidence level.

and productive assets, characterised by a higher pre-AVCPO soil productivity, and less exposed to natural hazards, such as flood and frost. This means that the instrument could influence the outcomes through channels other than participation in the AVCPO, therefore violating the exclusion restriction assumption.

Given this framework, the instrument is unlikely to be exogenous. Consequently, we employed three different strategies to relax the restriction assumption. First, we conducted a sensitivity analysis following the procedure proposed by Conley et al. (2012) and operationalised by Clarke and Matta (2017).²⁵ In brief, the effect of the violation of the restriction assumption can be modelled by specifying different ranges of values for the ϑ coefficient (i.e. specifying ϑ_{max} and ϑ_{min}).²⁶ This way we can obtain confidence intervals for β , the impact coefficient.

$$Y = D\beta + X\gamma + Z\vartheta + \varepsilon \tag{1b}$$

$$D = Z\pi + v \tag{2b}$$

The second strategy consists of a two-step procedure. First, we used pre-treatment variables in order to perform a PSM estimation using a calliper (neighbour matching without replacement) on the intention to treat (i.e. Z in Eq. (1)) as treatment variable. The rationale for this first step is to manage pre-project unbalances of key variables. A calliper equal to 0.025 has been used to calibrate the matching and obtain a more than sufficient reduction of the pre-matching bias.

Table 5 reports the variables used for matching and clearly shows

²⁵ In order to implement this procedure, we utilised the user-written command *plaussexog* in the statistical software Stata, version 13.

²⁶ An alternative approach starts from the specification of the parameters of the distribution of .

that post-matching mean differences are not significant (see the last three columns of Table 5) and that the matching procedure proved to be able to re-balance pre-matching systematic differences between project and control areas. This is confirmed by the standard matching quality statistics (Table 6). The critical values proposed by Rubin (2001) are respected: post-matching, Rubin’s B is below 25 and Rubin’s R is within the 0.5–2 range.²⁷

Once non-matched observations are dropped, the resulting sub-sample is composed of 603 units: 161 treated and 442 control (including 90 non-compliers living in AVCPO cooperatives). Then, we ran the IV estimation on this sub-sample.

A third strategy for dealing with a strong but potentially endogenous instrument is the one elaborated by Frölich (2007) and operationalised by Frölich and Melly (2010), who proposed a fully non-parametric estimator for estimating LATE with covariates: The instrument is supposed to satisfy the exclusion restriction conditioning only on a set of covariates X.

Let $\bar{\beta}$ be the LATE estimate. Considering the conditional mean functions:

$$m_z(x) = E[Y|X = x; Z = z] \tag{3}$$

$$\mu_z(x) = E[D|X = x; Z = z] \tag{4}$$

the proposed way to get $\bar{\beta}$ (i.e. the ratio between two matching indicators) is:

²⁷ Rubin’s B is the absolute standardised difference of the means of the linear index of the propensity score in the treated and (matched) non-treated group; Rubin’s R is the ratio of treated to (matched) non-treated variances of the propensity score index.

Table 6
Matching quality statistics.
Source: Authors.

Sample	Pseudo R2	LR chi2	Mean stand. bias	Median stand. bias	Rubin's B	Rubin's R	% Variance
Before matching	0.10	101.86	12.4	10.5	77.3	0.92	33
After matching	0.01	6.11	3.3	3.3	22.1	1.18	20

Table 7
Estimates of the impact of AVCPO: sensitivity analysis.
Source: Authors.

ϑ _{min}	ϑ _{max}	Growth of cereal production value			Net value of cereal production			Share of production sold through coops				
		β	β 95% confidence interval		β	β 95% confidence interval		β	β 95% confidence interval			
			β - 1.96se	β + 1.96se		β - 1.96se	β + 1.96se		β - 1.96se	β + 1.96se		
0	0	1.39	1.13	1.64	0.89	0.65	1.13	0.18	0.14	0.21		
0	0.1	1.15	0.98	1.32	0.81	0.63	0.99	0.10	0.06	0.14		
0	0.2	1.08	0.98	1.17	0.73	0.63	0.84	0.03	-0.09	0.14		
0	0.3	1.00	0.98	1.01	0.66	0.63	0.69	-0.05	-0.23	0.14		
0	0.4	0.92	0.86	0.98	0.58	0.54	0.63	-0.12	-0.38	0.14		
0	0.5	0.85	0.71	0.98	0.51	0.38	0.63	-0.19	-0.52	0.14		
0	0.6	0.77	0.56	0.98	0.43	0.23	0.63	-0.26	-0.66	0.14		
0	0.7	0.69	0.40	0.98	0.35	0.08	0.63	-0.33	-0.81	0.14		
0	0.8	0.62	0.25	0.98	0.28	-0.07	0.63	■	-0.40	-0.95	0.14	
0	0.9	0.54	0.10	0.98	0.20	-0.22	0.63	■	-0.48	-1.09	0.14	
0	1.0	0.47	-0.05	0.98	■	0.13	-0.37	0.63	■	-0.55	-1.23	0.14
0	1.1	0.39	-0.20	0.98	■	0.06	-0.51	0.63	■	-0.62	-1.37	0.14
0	1.2	0.32	-0.35	0.98	■	-0.02	-0.66	0.63	■	-0.69	-1.52	0.14

■ = 0 is included in the 95% confidence interval.

$$\bar{\beta} = \frac{\sum_i m_1(X_i) - m_0(X_i)}{\sum_i \mu_1(X_i) - \mu_0(X_i)} \tag{5}$$

We are confident that these different estimation strategies allow the elimination of a substantial part of the potential biases. However, given the use of retrospective information and less-than-perfect identification strategy, we cannot exclude that the results on the project's effects may be upwardly biased.

5. Results

The results of the standard IV estimations and the sensitivity analysis are reported in Table 7, where the values of β for the three outcomes for different values of ϑ are displayed.²⁸ The first row of the table shows the values of β with ϑ = 0, which is the standard IV impact estimate. These initial results indicate that treated farmers experienced a higher growth in the gross production of cereals per hectare in value – around 13,900 ETB higher, in fact. The growth among participating farmers in the period 2010–2013 is nearly five times stronger than in the control group. Moreover, the project has increased the net value of production per FLU by around 8900 ETB per hectare, which corresponds to an increase by about 102%. Finally, AVCPO has contributed to a rise in the share of production sold through the cooperative by 18% (from an average of 2% in the control group to an average of 20% in the treated group). In Table 5 we noticed that, on average, households from project areas are richer, more endowed in land and less hit by climate hazards than households from control areas. This justifies the hypothesis that ϑ ≥ 0 – that is to say that living in an AVCPO area might be positively linked to better outcomes (besides actual participation in AVCPO activities). Starting from this plausible left hand side limit of ϑ, the magnitude of ϑ has been progressively increased to identify the right hand side limit (i.e. the highest value of ϑ for which we can observe

²⁸ The complete tables of the standard IV estimates can be viewed in the Appendix. All the impact coefficients are significant at the 1% level.

Table 8
Estimates of the impact of AVCPO with PSM + IV strategy.
Source: Authors.

Outcome	β	s.e.	P-val	A-R test	P-val	F-Stat	P-val	
Growth of cereal production value	1.24	0.14	0.000	***	80.65	0.000	8.91	0.000
Net value of cereal production	0.90	0.14	0.000	***	39.75	0.000	6.88	0.000
Share of production sold through coops	0.18	0.02	0.000	***	75.7	0.000	4.63	0.000

* = 10% confidence level; ** = 5% confidence level; *** = 1% confidence level.

a significant beta coefficient).

The sensitivity analysis shows that the impact estimate is still significantly different from zero with quite high values of ϑ (comparing ϑ with the baseline value of β). For example, impact estimates about production growth “tolerate” a ϑ_{max} = 0.9 starting from a given baseline β = 1.39 with ϑ_{min} = 0.

As a second strategy, we ran IV estimations on a sub-sample of treated and control farmers, where only observations matching the nearest neighbour method were used. The results of the IV estimation on the sub-sample (see Table 8) are in line with estimates found via the standard IV procedure.

Lastly, Table 9 presents the non-parametric LATE estimates, which were computed by applying the estimator proposed by Frölich (2007).²⁹ The estimates are in line with both the baseline IV estimates and the IV with PSM estimates. These results support evidence showing that the AVCPO has had a positive and significant impact on the three outcome variables. They also suggest that the findings seem to be robust

²⁹ We used the Stata (13) user-written command *nplate* developed by Frölich (2007).

Table 9
Non-parametric LATE estimates of the impact of AVCPO.
Source: Authors.

Outcome	β	s.e.	P-val	
Growth of cereal production value	1.232779	0.126758	0.000	***
Net value of cereal production	0.8768	0.125	0.000	***
Share of production sold through coops	0.176862	0.041762	0.000	***

* = 10% confidence level; ** = 5% confidence level; *** = 1% confidence level.

to a less restrictive specification of the exclusion restriction assumption.

5.1. Heterogeneity analysis

In order to obtain a better understanding of the effectiveness of a project like the AVCPO, it is necessary to examine whether some groups benefit from it more than others. For example, Herrmann (2017) finds that participation in sugarcane out-grower schemes in Tanzania led to greater increases in income among land-rich farmers than among land-poor farmers. By contrast, Rao and Qaim (2011) in Kenya find that land-poor farmers benefit over-proportionally from participation in supermarket channels.

This sub-section explores variations of the AVCPO’s impact according to three levels of farm size: 0–2 ha, 2–4 ha and more than 4 ha (see Table 10).³⁰ Farm size is taken as a proxy for the household’s overall economic status, as well as its productive potential. This heterogeneity analysis was conducted using the IV with PSM and LATE approaches.

As shown in Table 11, the positive and statistically significant effect of the AVCPO is consistent across the three groups and all selected outcomes. As shown in Table 12, the project’s impact does not differ significantly across the categories of farm size.³¹ Therefore, unlike in the studies by Herrmann (2017) and Rao and Qaim (2011), we conclude that the project benefits land-richer and land-poorer farmers equally.

5.2. Analysis of the AVCPO’s effects on land-use outcomes

Table 13 shows that substituting cereal crops for other types of crops is not especially common, while also drawing attention to the fact that crop rotation practices have largely continued unchanged. However, participation in the AVCPO has significantly reduced the amount of land that is used for bread wheat and (to a lesser extent) other cereals. In other words, there seems to be a partial crowding-out of bread wheat, the most common cash crop in the area. Grazing, horticulture, and fallow areas were not affected.³²

5.3. Analysis of the AVCPO’s effects on wellbeing outcomes

While the dependent variables analysed so far could have been

³⁰ The 0–2 ha category was selected because the threshold of 2 ha is adopted by the FAO and hence often used in the academic literature (e.g. Lowder et al., 2016; Graeub et al., 2016) and in official documents (e.g. IFAD, 2013; Singh et al., 2002) to identify smallholders. The remaining two categories were determined in order to have categories of comparable size tertiles, which led to results that are not significantly different from the ones presented in Table 9.

³¹ These tests were performed on the PSM + IV estimates.

³² For this set of outcomes, we also conducted the heterogeneity analysis (see Table A9 in the Appendix). The AVCPO’s impacts on the likelihood of practicing crop rotation, the proportion of bread wheat to total agricultural land and the proportion of other cereals to total cereal area are independent of farm size. Where a difference does emerge is for the proportion of cereals to total agricultural land: The project’s effects are significantly stronger for farmers with 0–2 ha and 2–4 ha of land. This is not surprising: Smaller farmers, who want to start growing durum wheat may need to reduce the quantity of land intended for both cereals and other crops.

Table 10
Farm size groups and treatment status.
Source: Authors.

Farm size	Total	Treated	Control
0–2 ha	201	47	154
2–4 ha	282	105	177
4+ ha	255	110	145

Table 11
Estimates according to farm size.
Source: Authors.

Outcome	Farm size	PSM + IV			LATE				
		β	s.e.	P-val	β	s.e.	P-val		
Growth of cereal production value	(a) 0–2 ha	1.55	0.37	0.000	***	1.47	0.26	0.000	***
	(b) 2–4 ha	1.19	0.19	0.000	***	1.16	0.20	0.000	***
	(c) 4+ ha	1.21	0.20	0.000	***	1.22	0.17	0.000	***
Net value of cereal production	(a) 0–2 ha	1.05	0.22	0.000	***	1.09	0.19	0.000	***
	(b) 2–4 ha	0.82	0.21	0.000	***	0.67	0.23	0.000	***
	(c) 4+ ha	0.82	0.23	0.000	***	0.99	0.23	0.000	***
Share of production sold through coops	(a) 0–2 ha	0.25	0.07	0.000	***	0.20	0.08	0.000	***
	(b) 2–4 ha	0.13	0.04	0.000	***	0.13	0.06	0.000	***
	(c) 4+ ha	0.20	0.03	0.000	***	0.19	0.05	0.000	***

* = 10% confidence level; ** = 5% confidence level; *** = 1% confidence level.

Table 12
Tests of differences in project’s impact across farm size categories.
Source: Authors.

Outcome	difference	$\beta_i - \beta_j$	s.e.	p-val
Growth of cereal production value	group(a) - group(b)	0.36	0.42	0.398
	group(a) - group(c)	0.34	0.42	0.375
	group(b) - group(c)	-0.02	0.27	0.939
Net value of cereal production	group(a) - group(b)	0.23	0.30	0.469
	group(a) - group(c)	0.23	0.32	0.425
	group(b) - group(c)	0.00	0.30	0.904
Share of production sold through coops	group(a) - group(b)	0.12	0.08	0.179
	group(a) - group(c)	0.05	0.08	0.516
	group(b) - group(c)	-0.07	0.05	0.256

Table 13
PSM + IV estimates of impact on land-use outcomes.
Source: Authors.

Outcome	β	s.e.	P-val	
= 1 practice crop rotation	-0.03	0.06	0.675	
Share of cereals on total agricultural land	0.06	0.04	0.147	
Share of bread wheat on total cereal area	-0.72	0.17	0.000	***
Share of other cereals on total cereal area	-0.18	0.05	0.000	***

* = 10% confidence level; ** = 5% confidence level; *** = 1% confidence level.

directly affected by the project, and in a relatively short time, this is not the case for other wellbeing outcomes. In particular, an improvement in diet and education could take longer to materialise. Unfortunately, we do not have data on intermediate variables, such as household expenditures on health and education.

Table 14 shows that the project has had a positive and significant

Table 14
PSM + IV estimates of impact on education and food security.
Source: Authors.

Outcome	β	s.e.	P-val
Outcomes on education			
Share of HH members aged 6–18 in education	0.06	0.03	0.092 *
Share of male HH members aged 6–18 in education	0.09	0.05	*
Share of female HH members aged 6–18 in education	0.10	0.06	0.02 **
Outcomes on food security			
HFIAS	−2.34	1.21	0.052 *
Frequency of “eating smaller meals” (never \ sometimes \ often)	−1.41	0.71	0.045 **
Frequency of “eating fewer meals” (never \ sometimes \ often)	−0.77	0.92	0.402
Household dietary diversity score	−0.08	0.12	0.51

effect on education, which was measured as the share of family members aged 6–18 who were enrolled in school. The effect is stronger and more significant among girls than among boys.³³

Treated households score lower on the household food insecurity access scale, even though the coefficient is significant only at the 10% level. Treated households were less likely to eat smaller meals than households in the control group (the coefficient is significant at 5%). They also make less use of the coping strategy “eating fewer meals” than control households; the difference, however, is not statistically significant. Lastly, the effect of the project on dietary diversity is also not statistically significant. The same trend emerges when considering consumption of all the major food groups: protein-rich food items, vegetables, milk and milk derivatives as well as fruit.³⁴

6. Concluding remarks and policy implications

Economic, demographic, and urbanisation trends in many low-income countries are often associated with both increases and shifts in food demand patterns. In some cases, changes in food demand are met by increases in imports. For instance, the growing demand for pasta in Ethiopia is largely met by increasing imports of both durum wheat and pasta products. Durum wheat has been produced in Ethiopia for centuries. The country is a leading wheat producer in SSA, and is the only country where smallholders have a majority share in wheat production (Shiferaw et al., 2014; Minot et al., 2015). Smallholders, however, face bottlenecks and other difficulties in satisfying the growing internal demands of the pasta industry (Gebreselassie et al., 2017). Enhancing both food security and promoting inclusive, agriculture-led industrialisation is at the heart of Ethiopia’s development strategy.

This paper examined a multi-stakeholder VC development project called AVCPO. This project constituted the largest durum wheat VC project in the region, and was implemented by a wide range of public and private sector stakeholders supported by the Italian Development Cooperation. The project aimed at increasing the quantity and quality of durum wheat production, and connecting smallholder farmers to the national pasta industry via cooperatives and contract farming. Although official documents point to a large increase in durum wheat cultivation in the Bale highlands during the project’s duration, there is a need for

³³ Note that those models were estimated on the sub-sample of households with at least one member aged 6–18. In particular, the sample consists of 281 control and 218 treated observations for the female sample, 233 control and 273 treated observations for the male sample, and lastly 308 control and 240 treated observations for the combined group.

³⁴ Based on the heterogeneity analysis (see Table A10 in the Appendix), the project’s effects on overall child education and boys’ education are not significant across any of the categories of farm size. Among girls, on the other hand, the AVCPO’s impacts are significantly more concentrated in the category of farm size 2–4 ha. For food security, there is no heterogeneity in the impacts across farm size categories for the household dietary diversity score and the frequency of eating fewer meals. The impacts on the other two food security outcomes are, instead, triggered by the farmers in the largest farm size category.

empirical evidence on the project’s impact on smallholder agricultural performance and wellbeing.

Based on a large household survey, this paper investigated the effects of the AVCPO on cereals production in combination with the share of production that ended up being sold through cooperatives. It also sought to study the effects on other wellbeing outcomes, namely education and food security. Furthermore, it investigated the project’s impact on land use practices and whether it crowded out other food crops. We employed an IV approach and three additional estimation strategies to account for potential violations of the exclusion restriction assumption. Given that our estimates build on cross-sectional data and retrospective information, some caution is required in establishing firm causal relationships.

Regardless of the method employed, our findings suggest that the AVCPO has had a positive impact on gross and net values of cereal production per hectare. Moreover, our findings point to a positive effect on the share of production sold by farmers to pasta makers through cooperatives. The heterogeneity analysis suggests that the AVCPO’s effects were positive for different categories of farm size, and that land-rich and land-poor farmers benefited equally from the project’s activities.

Interestingly, the changes brought about by the AVCPO do not seem to have occurred at the expense of crop rotation practices that preserve soil fertility. In fact, the expansion of cultivable land for growing durum wheat came mostly at the expense of bread wheat. Other estimates highlight the positive contribution the AVCPO has made to educational outcomes and food security. However, no significant effect has been detected in terms of household diet.

While an evaluation of the longer-term effects would be necessary to understand the sustainability of the AVCPO, the findings of this study already point to its effectiveness and to the potential of such a project to improve agricultural VCs and farmers’ living standards. However, two issues should be analysed further before replicating or scaling up an intervention like this. First, while the results seem to suggest that AVCPO does not benefit land-rich farmers to a proportionally higher degree, the issue of participation in the project remains. Our analysis shows that ownership of land and assets is important in explaining who participates in the project. While this point requires further investigation, we think that large economies of scale are not necessarily required to benefit from this type of project. Our hypothesis is that the innovations introduced by the AVCPO could have particularly attracted less risk-averse and wealthier farmers, who therefore decided to join the project at an early stage. This idea is supported by the fact that younger farmers, who are usually less risk-averse than older farmers, were more likely to sign up. After learning about the widespread positive effects of the project, other farmers may decide to participate. However, more research is required to validate this point.

Second, when attempting to adapt a project like the AVCPO, policy-makers should be aware that the Bale Zone features larger than average size farms and is characterised by agro-ecological conditions that are favourable for growing wheat. Moreover, the infrastructure projects undertaken in Bale improved market accessibility and created a window of opportunity for local producers.

In other words, the growing demand for pasta might offer greater opportunities for small-scale Ethiopian wheat farmers, but increasing the quality and quantity of their harvests and connecting them to the national pasta industry poses a significant policy challenge.

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We confirm that as authors we have no financial relationship with the project we are evaluating. Moreover, we confirm that the research was been conducted in a manner that ensured our independence. We acknowledge that research has been funded by DIE (German Development Institute) through budget from BMZ and confirm that both these institutions are independent from the Italian Development Cooperation Agency and the former Overseas Agronomic Institute.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.foodpol.2018.06.001>.

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