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ORIGINAL PAPER

Revitalising smallholder agriculture: the impact of technical training in rural Lebanon

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Abstract

This paper provides new evidence about the impact of an agricultural development initiative focused on the cherry sector and implemented in rural areas of the Bekaa Valley (Lebanon). The initiative aims to enhance economic opportunities of smallholder farmers by strengthening technical skills, fostering sustainable productions and developing market linkages. Using original micro data from a sample of 118 smallholder cherry farmers, we explore, through a Difference-in-Differences approach, whether the development initiative, based on the provision of extension services and accompaniment through technical training, impacts on a broad set of alternative agricultural outcomes—namely, total cherry production, average market price, management competency and the adoption of improved agricultural practices. The results show that beneficiary small-scale farmers achieve better performances in three outcomes out of the four considered, with the adoption of improved and sustainable agricultural practices as the most remarkable result. Conversely, the management of the agricultural economic activity does not experience any statistically significant variation connected to the initiative implementation. The analysis of a limited source of treatment heterogeneity discloses the primary role of technical training, rather than other kinds of material support, to explain the main results.

Keywords Smallholder farmers · Agriculture · Extension services · Difference-in-Differences · Impact evaluation · Lebanon

JEL Classification O13 · Q01 · Q10

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1 Introduction

Worldwide, agriculture is facing unprecedented challenges due to growing pressures on natural resources (including land) and climate change (e.g. more erratic rainfall patterns and more frequent extreme weather events), both of which undermine the sustainability of food systems at large (FAO, 2021). Their combined effects tremendously enlarge the problems generated by the constraints that often characterize farming systems in developing countries, such as small land size, lack of resources, and increasing degradation of soil quality (Deininger & Byerlee, 2012; Hall et al., 2017).

Within this framework, smallholder farmers are those showing the highest level of vulnerability. In fact, limited technical endowments and know-how make their productivity largely dependent on the environmental services provided by healthy ecosystems. In addition to that, the increasing fragmentation of landholdings has gone hand in hand with reduced investments and marginalization of small farms in economic and development policy, placing smallholder agriculture at the forefront of a crisis (Walpole et al., 2013). The vulnerability of smallholder farmers is no trivial matter, as globally they are the most populous farm size group: strengthening their productivity and resilience towards external shocks can have a big impact on agricultural growth and food security (Hazell, 2020).

A well-known strategy aimed at supporting the development of small farmers skills is the provision of extension and advisory services, promoted either at the national level through government programs or at the local level through the initiative of development organizations (see for example, Oakley & Garforth, 1985). Although the term is open to a wide variety of interpretations, the core meaning can be traced back to the development of knowledge and skills, the provision of technical advice and information to enable farmers to take action (e.g. information about prices and markets), the support to set up, structure and develop organizations of local farmers, and the promotion of motivation and self-confidence.

Several studies discuss the efficacy of extension and advisory services to foster agricultural outcomes and, thus, to close the gap between actual smallholders' yields and those achievable, promoting an efficient and sustainable use of inputs and natural resources (see for example Yang et al. 2020 and Fu & Akter 2016). However, two main reasons significantly limit the possibility of generalizing the findings. On the one hand, smallholder farmers are a diverse group in terms of incomes, knowledge, perceptions and farming practices across agricultural sub-sectors and countries. As a consequence, the inner structure of the initiatives promoting extension and advisory services ends up being highly context-specific and related to diversified-knowledge demands. On the other hand, available studies adopt multiple methodologies of analysis, and most of them are descriptive case-studies. Thus, we argue that further scientific evidence based on rigorous analyses appears useful especially when focused on still largely under-investigated geographical areas.

Making use of original micro-data, this research work provides a novel contribution to the literature by empirically exploring the impact of a development initiative which fosters agriculture revitalization of smallholders in rural Lebanon.

Some distinctive features of the initiative make it interesting for research purposes and policy implications. First, the inner nature of planned activities, based on a mix of extension services and accompaniment as the backbone of the whole initiative. Whilst the former provides knowledge transfer and foster technical skills, the latter promotes awareness about issues the smallholder farmers are not aware of, and it supports them in identifying their problems and gaining hindsight about their technical choices. The expected goal is to nurture smallholder farmers' competencies as well as agency and, therefore, empower them. The second feature is the framework of action. The intervention under investigation is inspired to an agroecological approach which gives priority to sustainable agricultural practices—in order to improve farmer and ecosystem resilience—and to knowledge co-creation and relations between peers—in order to facilitate cooperative behaviour and spread results through emulation. Third feature is the area of implementation. The Bekaa Valley in Lebanon is an area essentially devoted to agricultural activities, although today environmentally fragile and subject to the pervasive effects of a changing climate. Whilst strengthening the agricultural sector and reducing smallholder farmer vulnerability is a priority issue in the country development strategy (Lebanese Ministry of Agriculture, 2020), evidence about targeted interventions is still limited and mainly descriptive.

Based on a quasi-experimental approach, our findings provide support to the idea that technical training positively impacts on agricultural outcomes, in terms of total production, quality of yields and adoption of improved agricultural practices, whereas we did not find evidence of significant improvements of management competency.

The paper is organized as follows: Sect. 2 describes the relevant literature about smallholder agriculture and the role of extension and advisory services in a development perspective; Sect. 3 illustrates the context of intervention; Sect. 4 explains the research design and the estimation strategy; Sect. 5 reports the results of the descriptive analysis of the outcome variables; and Sect. 6 discusses the main empirical results. Finally, Sect. 7 draws conclusions regarding our research and points out some policy implications.

2 Related literature

Smallholder agriculture significantly contributes to poverty reduction and food security by serving as a valuable source of income in a large part of the developing world (Walpole et al., 2013). Recent FAO estimates report that farms of less than two hectares account for 84% of all farms worldwide, however they operate only around 12% of all agricultural land (Lowder et al., 2021). Worldwide, the concentration of farmland among large farms and the marginalization of small ones is increasingly evident.[1] The relevance of smallholder farming at the global level is well-acknowledged and it represents a key component in transiting to more sustainable forms of

[1] See, for example, data recorded in the FAO Smallholders Data Portrait, available at: https://www.fao.org/family-farming/data-sources/dataportrait/farm-size/en/.

agriculture. In this regard, empirical evidence suggests that improving farmers' participation to sustainable agricultural supply chains can lead to substantial benefits, such as poverty reduction, gender equity and a healthier environment (FAO, 2021).

Despite a renewed centrality in the current development debate, a harmonized and operational definition of the concept does not yet exist (Khalil et al., 2017), and the exact meaning of the adjective "small" varies according to specific historical, institutional and eco-systemic characteristics of the context of reference. From a general point of view, we can define smallholders those farmers operating under structural constraints such as access to sub-optimal amounts of resources, technology and markets (Dixon et al., 2014). When it comes to Low and Middle Income Countries (LMICs), a common measure applied by empirical studies is operating two hectares or less of farmland (UNCTAD, 2015).

The existence of such constraints, coupled with inner characteristics of small-size farming, poses several challenges to households whose livelihood strategy relies on this type of economic activity. In addition to a lack of education and limited access to infrastructure, markets and technologies, smallholders have also become increasingly vulnerable to a wide range of emerging climatic, health and financial risks (Fan & Rue, 2020). Among them, more frequent and extreme climatic events, reduction of biodiversity, natural resource degradation and commodity price volatility are increasingly impacting on small-size agriculture (Shukla et al., 2019). In a long-run perspective, the unrelieved exposure to these stress factors tends to make smallholders more risk-averse and to pursue more subsistence-oriented activities, contributing to the persistence of smallholder poverty (Clarke & Dercon, 2015). In addition to that, other sources of distress are also at play. Changing market structures, growing competition over land and water, rising fuel and fertilizer prices represent intersecting challenges—often originating at the global level—which create significant barriers for smallholder farmers to maintain steady agricultural outcomes and, possibly, a market position (UNCTAD, 2015). Furthermore, their high dependency on ecosystem services implies a lower capacity to adapt to a changing climate, compared with larger and more resource-endowed farmers. Their vulnerability therefore tends to be high (Cohn et al., 2017). It is worth noting that it is an issue of major relevance since smallholder agriculture still dominates the farming system of developing countries, according to recent FAO estimates (Lowder et al., 2021).

From a general standpoint, while these risks and challenges concern any agricultural activity, smallholders bear an additional burden due to the intrinsic greater constraints under which they operate. Moreover, in many countries the growing riskiness of harvests—mainly due to climate change effects and declining soil fertility (Madembo et al., 2020)—increasingly leads to the decision to abandon agricultural activity because it is perceived as unprofitable and too precarious. The excessive switch of small (family) farmers to off-farm activities is a critical issue deeply intertwined with the abandon of agricultural land (Al Dirani et al., 2021), the reduction of biodiversity which is traditionally maintained on-farm (Cheng et al., 2020), the loss of cultural heritage (Britwum & Demont, 2022), and it is likely to reinforce rural–urban migration processes.

Overcoming small farmers' limitations such as inadequate access to input and output markets, lack of capital, technology and knowledge (IFAD, 2016) is a key

strategy to improve their livelihoods and capacity for generating income. In this respect, facilitating market linkages and including smallholders in sustainable supply chains (Paglietti & Sabrie, 2013) appear crucial. Further, developing high-value agricultural products and strengthening rural infrastructures to enhance market connections are not only effective strategies (see for example, Cramb et al. 2017, Nedumaran et al. 2020), but they can also induce rural populations to consider farming as a profitable, and therefore a viable, livelihood choice. Reliable market access, in fact, can boost productivity, increase incomes and strengthen food security (FAO et al., 2021).

Based on this broad consensus, the creation of commercialization opportunities for smallholder producers has gained primacy on the development agenda of many developing countries. Nevertheless, most of smallholders remain consistently less productive than commercial farmers and continue to be deficient in market-attitude and capabilities (Hemming et al., 2018). Among the major obstacles they face, we can list the low-quality of productions, the difficulty of reaching the marketplace (for example due to remote location or high transportation costs), the lack of managerial skills and limited operational size which restrains market opportunities.

Agricultural extension and advisory services are often adopted to reduce the lag in commercialization while promoting sustainable agricultural productions (Otsuka & Larson, 2012). This technical approach facilitates technology transfer and farmers' knowledge (Birkhaeuser et al., 1991), and supports their participation in adopting recommendations, both in terms of business management and sustainable agricultural practices (Anang et al., 2020; Aker, 2011). In this respect, it is argued that productivity differentials can be reduced by providing inputs and knowledge able to enhance human capital (Dercon et al., 2009). Overall, empirical evidence suggests that agricultural extension and advisory services positively contribute to productivity and technical efficiency, income level and poverty reduction (Rahman & Connor, 2022) in the face of the effects of climate change (Verner et al., 2018).

Over time, however, a wide range of different options have been adopted (e.g. Training and Visit or Farmer Field School), making an overall evaluation difficult (Ogundari, 2022). A further source of complexity is represented by the fact that empirical studies attempting to measure the impact of agricultural extension and advisory services are found to use different research design (experimental; quasi-experimental; mixed methods) and different outcomes of interest (e.g. production/productivity; income; adoption of improved practices). As a result, empirical evidence is not uniquely clear despite the existence of a large number of studies. In a literature review based on 48 studies, Birkhaeuser et al. (1991) found that 75% of them report some positive impacts. A close percentage (71%) was found by Taye (2013) analysing 21 empirical studies. More recently, a meta-analysis covering 45 studies (and 244 effect sizes) discloses a positive and significant average effect of agricultural extension and advisory services, even if controlling for selection bias and diverse outcomes (Ogundari, 2022).

Thus, making cost-effectiveness comparisons between different experiences is a tough task. In addition, experiences are deeply context-based and irredeemably connected with specific agricultural productions and local conditions (for example, the

geo-climatic characteristics of production areas, or the institutional settings characterizing land access).

This rich and diversified literature essentially focuses on experiences implemented in Sub-Saharan Africa and Asia, given that in these areas small-scale agriculture is particularly relevant, associated with subsistence farming systems and characterized by high poverty rates. On the contrary, few studies have devoted their attention to Middle East countries, where smallholder farmers are not necessarily poor, although highly vulnerable. Recently, the undeniable urgency of revitalizing the agricultural sector in the region is attracting scholars' attention to development strategies, including agriculture extension systems (see for example recent contributions as Dhehibi et al. 2017, Diab et al. 2020, Al Dirani et al. 2021), although most studies remain descriptive in nature.

Overall, the impact of technical training on production and the adoption of improved agricultural and managerial practices has received little attention in the region. This research work contributes innovatively to filling this gap by exploring to what extent a development initiative based on extension and advisory services and implemented in rural Lebanon (Bekaa Valley) impacts on a different set of agricultural outcomes. To the best of our knowledge, this is the first attempt to empirically measure the impact of this kind of intervention in the region.

3 The intervention background

3.1 Agriculture in Lebanon

Agriculture represents a small portion of Lebanon's economy, contributing about 5 percent of GDP, but remains a major source of livelihoods, with 25 percent of the labour force engaged in this sector on a full-time or part-time basis, including seasonal family labour. However, in the poorest regions of the country—such as the Northern Bekaa—agriculture related activities account for up to 80 percent of the local GDP.[2] Farm households usually engage in agriculture as well as in non-agricultural economic activities, although poorer rural households tend to rely more heavily on agriculture. Nevertheless, most food needs are satisfied through imports.

The agriculture sector is currently facing multiple challenges, including changing trade patterns, also due to the on-going Syrian conflict. As a matter of fact, Lebanon remains at the forefront of one of the worst humanitarian crises of recent times. As of July 2021, Lebanon hosts one of the higher per capita refugee population in the world (totally representing more than 20% of its population).[3] The World Bank's Economic and Social Impact Assessment (2013) placed the disruption of agricultural trade routes among the most significant economic shocks experienced by Lebanon, later reinforced by the effects of the Covid-19 pandemic and the subsequent socio-economic crisis. The disruption caused by the pandemic leveraged on

[2] Government of Lebanon. Ministry of Agriculture Strategy (2015–2019).

[3] UNHCR data, available at https://data2.unhcr.org/en/situations/syria.

structural weaknesses of the economic system and massively enlarged pre-existing inequalities, leading to a multifaceted crisis, mass protests and high social instability.

This threatening situation was further aggravated by a devastating explosion that occurred in the port of Beirut on August 2020,[4] which destroyed entire areas of the port and neighbourhoods, causing extensive material damages, and jeopardizing the functioning of many productive areas of the city. The effects of the explosion added to the multidimensional crisis that Lebanon was already facing, exacerbating social and economic conditions, and deeply impacting on unemployment and poverty rate (World Bank, 2022). According to official statistics, annual inflation (measured by the consumers price index) was 84.9% in 2020, compared to just 2.9% a year earlier, and food prices soared as much as 400% within the same period.[5]

Beyond external factors, Lebanon's agricultural value chain shows its own weaknesses; in particular, it is highly fragmented: smallholder farmers are not well connected to local markets and lack legal and financial support to be able to overcome such limitations. Logistical barriers and transportation costs remain very high.

Nevertheless, it is generally argued that there is substantial room for improvement. The last National Agriculture Strategy 2020–2025 (NAS)[6] states that the agri-food sector can contribute to absorb the crises-induced economic shocks and identifies some key areas of intervention: i) restoring the livelihoods and productive capacities of farmers and producers: ii) increasing agricultural production and productivity; iii) enhancing efficiency and competitiveness of agri-food value chains; iv) improving climate change adaptation and sustainable management of agri-food systems and natural resources; v) strengthening the enabling institutional environment (Lebanese Ministry of Agriculture, 2020).

3.1.1 Cherry production

The development initiative under investigation refers to the cherry sector and targets smallholder farmers operating in the Bekaa Valley. This area is a fertile valley located in eastern Lebanon along the Syrian border and it has been the country's most important agricultural region since ancient times. With an average altitude of 1000 m above sea level, the climate of the valley is very suitable for the cultivation of vines and other fruit trees. According to FAO data (2021), today the valley makes up 40% of Lebanon's arable land.

Cherry is the most cultivated stone fruit in Lebanon, covering almost 4800 hectares of national territory, in particular in the Bekaa Valley. Total cherry production ranks Lebanon at the 18th place among world producers in 2020.[7] The cherry value chain is dominated by smallholder production, with less than 0.2 ha per farmer, on

[4] The explosion left around 200 dead and over 6,000 injured, according to initial estimates see for example: https://www.bbc.com/news/topics/c88p951myv0t.

[5] All data are gathered from World Bank Development Indicators.

[6] Available at http://www.agriculture.gov.lb/getattachment/Ministry/Ministry-Strategy/strategy-2020-2025/NAS-web-Eng-7Sep2020.pdf?lang=ar-LB.

[7] Data are gathered from FAOSTAT Crops and Livestock database, Item code (CPC): 01344.02, available at https://www.fao.org/faostat/en.

average. These individually owned orchards are typically parcels of previous larger properties, divided as the land was passed through generations by inheritance, or sold (USAID, 2014). Cherries are mostly cultivated in rain-fed extensive cropping systems and irrigated orchards located on the mountain slopes, where the abundance of water springs enables the cultivation on agricultural terraces.

The cherry agricultural sector is characterized by a long-lasting stagnation, lacking targeted investments and incentives to drive the traditional cultivation towards a more competitive and market-oriented production (Lebanese Ministry of Agriculture, 2020).

The majority of Lebanese cherries are consumed domestically, despite the fact that wholesale prices in nearby Middle-East and Northern Africa (MENA) markets are significantly higher than domestic wholesale prices. Since 2015 Lebanese cherry exports have been characterized by large fluctuations mainly due to changing demand patterns, unstable quality of harvests (which is directly reflected in market prices) and exogenous shocks.[8]

Overall, cherry production in Lebanon is challenged by several factors. Traditional cultivation methods (deeply connected to cultural heritage) and small-scale productions that do not often achieve high quality standards and have low-productivity rates. Lack of connection to local markets and farmers' high aversion to risk smother investments in agriculture and result in underachieving productions and low income generation. Further, climate-related events—in particular, water shortages and droughts episodes—have an increasing impact on current and future productions, as well as on cherry quality.

3.2 The initiative

This research work takes advantage of the implementation of a development initiative promoted by the Italian non-governmental organization Fondazione Giovanni Paolo II (hereafter, FGPII) and financed by the Italian Agency for Development Cooperation[9]. The initiative aims at revitalizing the local agricultural sector by helping cherry farmers improve their agriculture practices (both technical and managerial) and facilitating market opportunities. The overall objective is twofold: enhancement of the economic and environmental sustainability of cherry production, and improvement of economic opportunities by strengthening technical skills and developing market linkages among small-scale producers towards local markets.[10]

[8] Information gathered from the Trade Map platform, joint initiative of the European Union, the United Nations Conference on Trade and Development and the World Trade Organization, which covers 220 countries and territories and 5300 products of the Harmonized System. Data are available at https://www.trademap.org/Index.aspx.

[9] The complete name of the initiative is *International network for sustainable development and production, managerial and commercial innovation of small producers in the agribusiness cherry chain in Lebanon* Project AID 010933. Started in 2017, the initiative ended in 2021.

[10] The initiative intends also removing bottlenecks and promoting market linkages to international markets through the development of competitive local cooperatives, able to overcome small-size farming shortfalls. However, this component experienced a significant delay due to the socio-economic crisis that

To a large extent, the initiative embraces an agroecological approach by integrating ecological, economic and social principles in the transition of smallholder farming systems, towards greater resilience. Considering the principles listed by the High Level Panel of Experts on Food Security and Nutrition (HLPE, 2019), the initiative is particularly focused on enhancing soil health and functioning; diversifying on-farm incomes so that smallholder farmers have greater financial independence and value addition opportunities; strengthening land and natural resource governance; and fostering the co-creation and sharing of knowledge, including farmer-to-farmer exchange. Overall, these components contribute to an incremental transition by narrowing the use of costly, scarce or environmentally damaging inputs, and supporting the adoption of agroecological practices (Gliessman, 2016).

The initiative gives great relevance to extension and advisory services aimed at fostering technology transfer, human capital development (especially technical and management skills), and social capital building (farmers organized into producer groups) towards the application of sustainable practices and quality management systems. Generally speaking, agricultural extension is expected to bring about changes in farmers attitude and skills, prioritizing the experience, the co-creation of knowledge and agroecosystem sustainability (Sulaiman et al., 2018). We recognized this component as a personalized accompanying process and it constitutes the most distinctive feature of the initiative.

In terms of geographical scope, the initiative targets the Bekaa Valley, the most important agricultural area for cherry production in the country, and it is implemented in different productive zones, as shown by Fig. A1 in the Appendix.

As for the structure of the intervention, beneficiary farmers are required to participate in an initial individual needs assessment, to focus on the specific constraints each farmer faces. Then, the project staff[11] provides regular visits at the farmer's premises throughout the implementation of the initiative (at least two visits per year). In addition, a series of collective training are provided in each area of production. According to FGPII's notes, the organization of these meetings is perfectly homogeneous across the areas. This agricultural training covers a variety of topics, for example, the sessions may refer to the correct set-up of a sustainable fertilization program, environmental-friendly pests management, pruning techniques, and the efficient use of water in the orchard.

On the business management side, FGPII organized other technical training sessions on different topics, such as the use of a dedicated register for keeping farm accounts and recording costs and operative details of agricultural practices; basic administrative alphabetization, and the organization of a quality management system.

Footnote 10 (continued)

impacted the country since 2019 (see 3.1). New cooperatives started operating after the conclusion of the initiative, and the first export took place in the harvest season subsequent to the follow-up data collection (namely, May-July 2021). This component of the initiative is therefore not measured by this study.

[11] We interchangeably use the term "initiative" and "project" to indicate the development intervention under investigation.

The collective nature of this training is reinforced by targeted focus-groups on the same topics aimed at promoting the interchange and co-creation of knowledge between farmers. It also helps to connect smallholder farmers, used to working in a fiercely independent way and being suspicious of other peers.

This research work therefore explores whether the mix of collective technical training and personalized accompaniment is able to generate tangible effects in terms of increasing the production of high-quality and environmentally sustainable crops (namely, cherries) and fostering the adoption of improved agricultural practices and management systems.

4 Research design

4.1 Sample and timeline description

The reference population of this study on sustainable agricultural development is composed of smallholder cherry farmers living in the Bekaa Valley. Among this population, a number of farmers benefited from the development initiative promoted by FGPII, inspired to an agro-ecological approach and aimed to improve the scale and quality of harvests, market access, and sustainability of agricultural practices.

Organizing a longitudinal study in a complex environment—due to a very unstable socio-political situation and security issues—with geographically dispersed population implies major challenges.

Further, the definition of the research protocol had to comply with objective constraints. First, the total reference population was numerically unknown and local authorities did not hold a comprehensive list of active (cherry) farmers; second, the development initiative, whose effects are explored in this study, totally envisages 350 small-scale cherry farmers as direct beneficiaries, however reaching this number was planned on a rolling basis throughout the implementation period; third, financial constraints forced us to hypothesize the feasibility of only two data collections (namely, one baseline and one follow-up), to be carried out in a pre-established time frame.

These obstacles were managed by working in close connection with FGPII from the beginning of the initiative.

In detail, we used an exploratory survey carried out in 2014 under the Lebanon Industry Value Chain Development project promoted by USAID[12] and preliminary data collected by FGPII during local meetings to identify the reference population for this study. These meetings were publicly advertised at the local level and made known by the project's local partners through their communication channels. Furthermore, FGPII managed spreading word in key-areas—such as the main local agricultural market—to get in contact with cherry farmers and make them aware of the possibility of accessing the initiative. During these meetings, the staff explained the importance of adopting improved agricultural techniques to increase the quality

[12] The acronym stands for United States Agency for International Development. That exploratory survey was administered in some productive areas also targeted by the initiative, such as Ainata.

and quantity of cherry production, and described how the promoted development initiative could help small-scale cherry farmers to enhance their skills. A list was then created containing the names, contact and basic information of the farmers who presented themselves in these preliminary meetings or who made contact with the local staff of the initiative. At the time, the list totally included 314 smallholder cherry farmers (November 2017).

Farmers interested in the initiative's activities were therefore invited to attend subsequent meetings and to show their willingness to participate. It is worth noting that no fees were required to attend the meetings, and no financial compensation was provided for participating in the subsequent technical training. The adhesion to the initiative constitutes the element used for the identification of the intervention beneficiaries (for the purposes of this study, the treatment group), and, conversely, those farmers who did not show interest in being involved were listed among the population for the selection of the control group.

Financial constraints imposed a selection on the total number of farmers to be interviewed, thus we performed some power calculations in order to identify a sample size suitable for the analysis. The USAID exploratory survey contains individual information about the average market price (as per 2014) obtained by 68 cherry farmers. Since one specific objective of the FGPII initiative is increasing this parameter by 30% for beneficiary farmers, we took advantage of the recorded information to calculate a sample size consistent with the expected target. In detail, we assumed discrete increases from 20% up to 30% to calculate the sample size. It is worth mentioning that, given the multiple crises affecting the country, the price levels deriving from these calculations are today inappropriate to describe local market functioning, since prices soared tremendously in the meantime due to uncommon high inflation levels. We precautionary decided to set the total sample size at 210 individuals—corresponding to a price increase of almost 20%, that is a lower variation than the expected—as the more rigorous and efficient solution. More details are provided in Table A2 in the Appendix.

Thus, from the original list including 314 farmers, we randomly selected 210 individuals, corresponding to the 67% of the reference population.[13] We adopted a stratification selection procedure to maintain the original proportions of geographical distribution across different productive areas. The resulting sample is therefore composed of 105 beneficiaries (Treatment group, T) and 105 non-beneficiaries (Control group, C).

Overall, the implementation of the initiative spans over three growing seasons (namely, 2018–2020). The timeline of the study is structured as follows.

The baseline was administered in the last quarter of 2017, after the cherry harvest season which occurs yearly between May and July. Despite all efforts applied to cover the whole sample, we had a quite relevant non-respondent rate (around 36%)

[13] As mentioned, the total number of beneficiaries was reached through an open process of enrollment. It was initially thought of using such enrollment time windows to define distinct treatment groups and empirically exploit the discontinuity. Unfortunately, the strict lockdown imposed by the break-out of the COVID-19 pandemic and the worsening of security conditions prevented additional data collection from being possible.

mainly due to temporary displacement to other locations and, to a minor extent, unwillingness to participate in the survey. As a mater of fact, the under-paying and sluggish Lebanese agricultural sector as well as the unstable socio-political and economic context push many smallholder farmers to move to the capital or even abroad in search of economic opportunities in different sectors rather than agriculture. According to information collected on the field from relatives and neighbours, about 90% of non-respondent cases can be explained by this dynamic, indeed. Unfortunately, budget and timing constraints did not allow the adoption of a substitution strategy and, as a consequence, data collected at the baseline totally refer to 134 cherry farmers (T + C farmers).

The follow-up survey was administered between February and April 2021, making reference to the last available growing season (2020) as far as regards cherry production. As described in Sect. 3.1, since 2019 a series of multiple and intertwined crises impacted the country, making the questionnaire administration burdensome due to strict movement limitations in the territory, but also to the absence of many people who had moved away from their own properties. In this challenging environment, the enumerators' team was able to interview 118 cherry farmers (namely, 70 farmers in the Treatment group and 48 farmers in the Control group), with a drop-out rate of about 12% respect to the baseline.

Table 1 describes the composition of the final longitudinal sample included in the analysis.

Despite the limited number of cherry farmers interviewed in respect to what had been planned, the final sample population still appears balanced, and sufficiently large to achieve statistical significance according to the preliminary sample size calculations[14]. As evident from the data reported in Table 1, the drop-out rate is low and well distributed among farmers enrolled in the Project (n = 7) and belonging to the Control group (n = 9). The difference between drop-out rates in the two groups does not reach a significant level (z-value>0.1), thus we did not notice any serious risk of attrition bias.

With reference to the final sample (n = 118), Table 2 summarizes the areas of production where the smallholder farmers included in the analysis are located.

4.2 Background characteristics of the sample population

To account for possible differences in the environment where farmers live and carry out their agricultural activity, we collected a set of information about their background socio-economic characteristics. As these characteristics play a role in determining different outcomes (for example, in terms of both scale and quality of production), we checked possible unbalances between T and C farmers.[15]

In particular, we consider the following features:

[14] See Table A2 in the Appendix for details.

[15] Balance tests for background characteristics refer to baseline data only, since it is assumed that differences in such elements could determine diversified outcomes at the end of initiative's implementation. See Table 3.

Table 1 Structure of the sample, by data collection

	Project (T)	Control (C)	Total	Drop-out (%)
Baseline (2017)	77	57	134	–
Follow-up (2021)	70	48	118	11.9

Table 2 Structure of the final longitudinal sample, by area of production

	Project (T)	Control (C)	Total
Farmers by area of production			
1- Baskenta	2	2	4
2- Aynata	13	6	19
3- Rachaya	10	9	19
4- Koussaya	5	4	9
5- Kaa el Reem	16	8	24
6- Ferzol/Niha	10	12	22
7- Wadi el Aarayech	14	7	21
Total observations	70	48	118

1. *Age*: it is reasonable to expect that enhancing technical know-how and introducing a more market-oriented approach might be more likely welcomed by younger farmers, given the strong traditional connotation of this agricultural activity and the high average age of farmers in the Bekaa Valley.
2. *Education*: in the same line of reasoning, a higher level of education (which is associated to younger generations in our sample) is likely to reduce risk-aversion of people engaged in small-scale farming and increase the likelihood of adopting improved agricultural practices.
3. *Donum*[16] *under cherry cultivation*: larger properties may be associated to different levels of productivity, market size and sets of economic incentives for the adoption of management systems.
4. *Technical equipment*: owning specific tools and equipment is positively correlated to a more efficient (and possibly, a better quality) production. We calculated an additive index—normalized to the (0–1) range—including the availability of the following items: motorized tractor; manual tractor; weed chopper; electrical pruning shears; mixing tank for fertigation; drip irrigation pipes. According to the project staff these elements represent key endowments for (cherry) production in the region.
5. *Other fruit trees*: it is reasonable to expect that having other agricultural productions (such as apples, almonds and grapes) might modify the interest of adopting new practices or shared mechanism for commercial sale, since economy of scope are likely to emerge.

[16] A *donum* is a traditional land measure used in Middle East countries and corresponding to 0.1 hectares.

Table 3 Summary statistics of background characteristics, by treatment group

	Project (T)		Control (C)		Difference		
	Mean	SD	Mean	SD	Diff	T-stat	Chi-sq
Age	57.04	14.16	58.75	13.14	1.71	(0.67)	
Education:							
Some primary	0.27	0.45	0.21	0.41	−0.06	(−0.79)	(0.61)
Primary	0.26	0.44	0.29	0.46	0.03	(0.41)	(0.17)
Some secondary	0.10	0.30	0.02	0.14	−0.08*	(−1.90)	(2.82)*
Secondary	0.09	0.28	0.17	0.38	0.08	(1.27)	(1.78)
Vocational training	0.06	0.23	0.10	0.31	0.05	(0.89)	(0.89)
Some University	0.04	0.20	0.10	0.31	0.06	(1.21)	(1.69)
University	0.19	0.39	0.10	0.31	−0.08	(−1.26)	(1.46)
Other endowments:							
Cherry donum	8.95	10.96	12.24	13.43	3.29	(1.41)	
Equipment index	0.25	0.25	0.23	0.24	−0.02	(−0.37)	
Other fruit trees	0.76	0.43	0.83	0.38	0.08	(1.02)	(0.98)
Perm. Employment	0.19	0.39	0.29	0.46	0.11	(1.31)	(1.81)
Seas. Employment	0.77	0.42	0.83	0.38	0.06	(0.83)	(0.67)
Observations	70		48		118		

T-statistics refer to difference between means by group. Pearson Chi-Sq. is reported for binary and categorical variables. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6. *Permanent employment*: cherry production is essentially carried out as family-run activity. The possibility to hire permanent workers is an indirect indicator of economic performance, and it signals a more formal organization and higher disposable income to be invested in the agricultural activity.
7. *Seasonal employment*: similarly, hiring seasonal workers signals a vital economic activity, whose dimension exceeds the family "endowment" in terms of participating members.

Table 3 provides summary statistics by treatment group, as well as the outcome of a t-test to assess the pre-treatment balancing of our sample. The results clearly show that the sample is almost perfectly balanced, and almost none of the variables considered show any significant difference between treated and control farmers, at the baseline. Having partially attended a secondary school program represent the only socio-economic characteristic achieving a statistically significant level (p-value<0.10). Although this characteristic refers to a limited number of farmers in the sample, we address this source of unbalance by controlling for the education level in all our model specifications.

While the sample is well balanced for almost all background characteristics, it deserves to be noted that T farmers are endowed with smaller cultivated areas, lower

presence of other fruit trees and lower employment of both permanent and seasonal workers. In other words, T farmers appear initially more vulnerable than farmers belonging to the control group.

Finally, it is worth noting that only 2 farmers are women (perfectly split between T and C groups), and this feature does not allow any comparison based on gender, whereas it signals a huge gender disparity (confirmed by national data) in agricultural activities. In fact, recent FAO estimates (2021) report that women, although accounting for up to 43 percent of the agricultural work force in Lebanon, usually spend long hours performing labor-intensive and time-consuming manual agricultural tasks (such as sowing, weeding, harvesting and processing) and they rarely are the head of family-run agricultural activities.

4.3 Outcome variables

The analysis aims at measuring changes in the capabilities of smallholder farmers in production output levels and quality (so as to enhance income generation and market size), as well as in management skills and technical expertise (so as to reduce their vulnerability to external shocks). Within this perspective, we defined four different outcome variables to possibly capture the treatment effect, namely:

1. *Total production*: total amount of fresh cherries produced by each farmer in each growing season. It is expressed in number of kilos.[17]
2. *Average price*: average seasonal price obtained by the farmer. It is an indirect measure of production quality, since high quality cherries arrive at higher prices within the same sale period and cherry variety. This analytical strategy is based on the local market's functioning, empirically observed by FGPII and confirmed by the local Lebanese Chamber of Commerce, interviewed at the time of the baseline. The variable is expressed in nominal Lebanese Lira (LBP).
3. *Management index*: weighted composite index which includes multiple items describing the formal profile of the economic activity and the organization of the managerial process. It is based on information about: i) how financial records are kept (in descending order of value: "well organized, written records"; "not well organized but written records"; "combination of memory and written records"; "mostly by memory"); ii) the existence of a specific bank account where the income generated by agricultural activities is credited; iii) the adoption of registers where the implementation of agricultural practices (e.g. fertilization), the purchase of production inputs (e.g. typology and costs of fertilizers) and their use (e.g. frequency and modalities of their use) are recorded. It is a continuous variable, normalized to (0–1) range, with higher values expressing a more advanced business management.

[17] It was not possible to calculate a productivity measure—often applied in this kind of studies—since many farmers do not know exactly the number of cherry trees they possess, and the number per planted area (for example, a donum) varies in a significant way across farmers, moreover not excluding other fruit trees from being cultivated in the same area.

4. *Agricultural techniques index*: weighted index which includes multiple items describing the adoption of improved agricultural techniques compliant with sustainable practices and resource use, in particular: i) using sustainable pesticides; ii) checking soil fertility; iii) adopting fertilization programs; iv) using organic amendments; v) adopting foliar fertilization programs; vi) pruning trees; and vii) applying weed control.

   Values are attributed on the basis of the frequency of use/adoption of each practice (possible options: "Regularly"; "Sometimes"; "Rarely"; "Never"). It is a continuous variable, normalized to (0–1) range, with higher values expressing higher adherence to the adoption of improved agricultural techniques.

Some final considerations on the identification of the outcome variables should be provided.

First, we preferred to apply two separate outcome variables (namely, total production and average price) instead of a general measure of total revenue. This operative choice is based on two main reasons: on the one hand, while seasonal average price is clearly remembered by farmers,[18] the calculation of total revenue based on intra-seasonal price swings appear inconsistent and incomplete; on the other hand, the use of diverse outcome variables allowed us to disentangle a quantity and a quality effect, both being specific dimensions targeted by the initiative.

Second, possible variations in average market price are measured in nominal terms, despite the tremendous inflationary process that hit the Lebanese economy during the implementation of the initiative. It is worth noting that at the local level, fresh cherries are sold to the same marketplace (i.e., the Ferzol fruits and vegetables wholesale market, in Zahle), and that empirical observation—along with qualitative information collected during the follow up survey—confirms that all farmers were equally affected by the inflationary process (e.g. transportation costs, workers' wage level, loss of purchasing power due to the domestic currency depreciation). We therefore argue that the socio-economic crisis that is gripping Lebanon should be considered an exogenous shock impacting on smallholder cherry farmers in a homogeneous way, regardless of their being enrolled in the initiative. Since the effect is generalized across groups (farmers under Treatment and those belonging to the Control group), the estimation strategy applied in this study will be able to control for the common trend and properly assess any changes in the outcome variable due to the initiative implementation (see Sect. 4.4).

4.4 Estimation strategy

The definition of the estimation strategy takes into consideration the characteristics of the intervention, the modalities of implementation, and the nature of the data.

More specifically, since the treatment (the agricultural development initiative promoted by FGPII) was not randomized at the pre-treatment stage of the outcomes of

[18] Qualitative inspection of data confirms the absence of outliers and the high consistency between reported average prices of individual cherry varieties across farmers.

interest, the analysis was designed on a Difference-in-Differences (DID) approach, which compares the changes in outcomes over time between a population that is enrolled in the initiative (the treatment group) and a population that is not (the control group). DID is a quasi-experimental design that makes use of longitudinal data to estimate a causal effect. It is often used in observational settings and it allows for controlling time-invariant unobserved confounding factors.

The most general specification model applied in this study is:

$$Outcome_{jit} = \alpha + \beta Treat_{it} + \gamma Time_{it} + \rho(Treat \times Time)_{it} + \delta X_i + \epsilon_{it}$$

being *Outcome* the performance of farmer i at time t in one of the four alternative outcomes j (i.e. *Total Production*; *Average Price*; *Management Index*; *Agricultural Techniques Index*). Other terms are explained as follows: α represents the constant term; *Time* is the time dummy which takes the value 1 for observations recorded at the follow-up survey (i.e., 2021) and 0 for observations recorded at the baseline (i.e., 2017)[19]; *Project* is the treatment dummy, identifying farmers who are enrolled in the initiative activities; X represents a set of individual characteristics (either referring to the farmer or to his agricultural activity) such as education level, the area under cherry cultivation, the availability of technical equipment, the cultivation of other fruit trees). We did not control for those other individual characteristics which, besides being perfectly balanced at the pre-treatment stage do not change over time (see Table 3). Further, the empirical analysis controls for the permanence of farmers within the initiative as active beneficiaries. While there are no farmers who have voluntarily dropped out from the project, some farmers (n = 23) who were initially included in the control group, changed their status by joining the project activities during the first year of implementation (namely, 2018). In other words, these *Transfer* farmers attended technical training and focus groups before the second growing season under the initiative time span. A reduced exposure to the treatment might lead to different outcomes, and for this reason we controlled those farmers by changing their enrollment status. The impact generated by the agricultural development initiative (the Average Treatment effect on the Treated: ATT) is estimated by the coefficient ρ. Finally, ϵ is the error term.

The research design also envisages the possibility that unobserved geographical characteristics might influence the outcomes (such as different altitude or soil characteristics), and for this reason we included a set of fixed effects to explicitly account for areas of production (see Appendix A1 for further details).

A potential issue in our analysis is the selection bias arising from the endogenous choice of being enrolled in the treatment. In development practice, quite often interventions are structured on the voluntary enrollment of targeted populations within the planned activities and, consequently, self-selection bias may occur. We cannot exclude the possibility that farmers who voluntarily participated in the project share some common (unobservable) characteristics—for example, attitude towards innovation—which distinguish them from the reference population. These

[19] As follow-up data collection was administered in the first quarter of 2021, that is before the yearly harvest, the data recorded for *Total Production* and *Average price* refer to the the latest available growing season, namely 2020. As a matter of fact, three harvest seasons are covered by the analysis: 2018–2020.

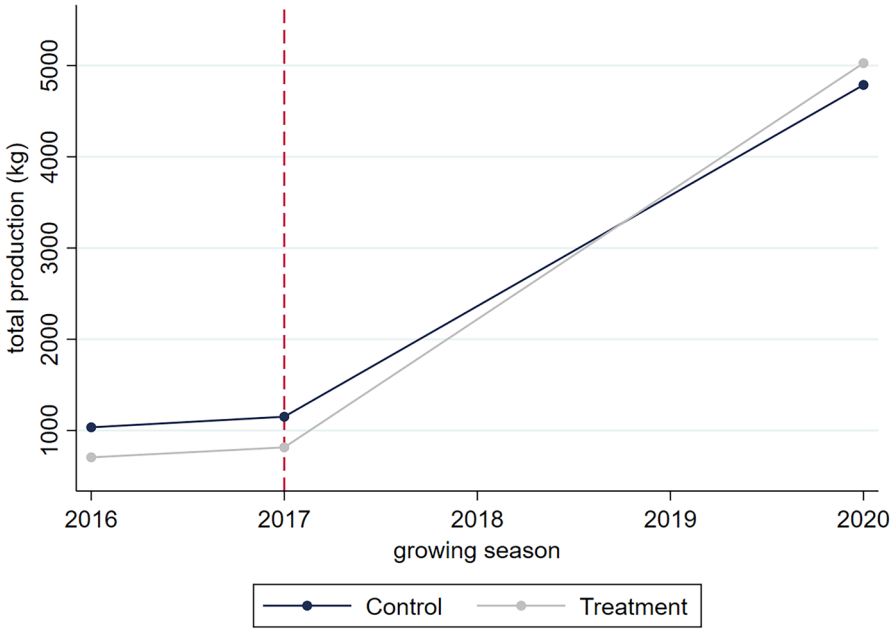

Fig. 1 Graphical inspection of pre-trend assumption. Values refer to average production per farmer. The vertical line indicates the baseline, administered at beginning of the initiative implementation

characteristics, as latent variables, may influence the magnitude of impact. Correcting self-selection bias is difficult, nevertheless this study adopts multiple precautions to mitigate possible effects on outcome variables.

First, we checked the validity of the pre-trend assumption. During the baseline data collection (2017), cherry farmers were requested to also provide information about the total production achieved the previous year (namely, 2016 harvest season). During that season, C farmers produced 1.04 tons on average while T farmers produced 0.706 tons, leading to a differential of 0.329 tons of fresh cherries per farmer. The following year (2017 harvest season, being the baseline), the average differential increased reaching the value of 0.337 tons. A graphical inspection of the pre-trend assumption (Fig. 1) confirms the validity of the approach and it reduces concerns about possible effects deriving from a self-selection bias in the treatment group. The qualitative analysis of the information collected through open questions included in the survey reveals that the majority of cherry farmers (88% overall) consider the two seasons (namely, 2016 and 2017) particularly unfavorable due to very adverse weather conditions, that greatly reduced the average annual yields. Such perception was further confirmed by officers of the Lebanese Chamber of Commerce (Zahle branch) in an interview carried out during the baseline. In addition, it should also be considered that 11% of farmers in the sample reported having very young cherry trees at the time, not yet productive (in details, 7 farmers in the treatment group and 6 farmers in the control group). As expected, during the subsequent growing seasons, yields greatly increased for both T farmers and C farmers.

Second, since the non-random assignment of treatment originate in unobserved variables at the group level, we decided to adopt a DID approach which captures these unobserved variables by a group level fixed effect. In fact, the DID estimator is an effective strategy for dealing with unobservable characteristics that may motivate participation and that are related to potential outcomes (Wooldridge, 2015), and for this reason it is often applied in the evaluation of policies in quasi-experimental settings in a variety of domains, such as education, health and social programs (Gertler et al., 2016). Taking this feature into consideration and the numerical composition of the final sample, we preferred the DID estimation strategy instead of a propensity score matching approach.

Finally, our research design envisages the possibility that unobserved neighbouring effects might influence agricultural performances. Farmers located in the same productive area are likely to be relatives, share informal moments of exchange and attend meetings in farmers' associations or cooperatives. Further, according to the Lebanese law, producers' organizations should be tied to a specific administrative area: for example, members of the Ainata cooperative must be residents in the same administrative unit. For this reason we included productive areas fixed effects to explicitly account for possible neighbouring effects and reducing potential selection bias arising from operating in a specific productive area over another.

In addition to the precautions adopted, it is worth remembering that the initiative does not provide any kind of prize or reward to incentivize farmers to participate, and that there are no limits to access.

5 Overview of the outcome variables

According to the main objectives of the initiative, we defined four alternative outcome variables to measure the impact on beneficiary farmers. A first set of variables refers to the scale and quality of cherry production (namely: *Total Production* and *Average Price*), whereas a second set of variables refers to the management of the agricultural activity and to the frequency of use of improved agricultural techniques (namely: *Management Index* and *Agricultural Techniques Index*). This section provides descriptive insights about the performances achieved by Project farmers (T) and Control farmers (C).

5.1 Cherry production and average market price

As expected, given the exceptionally low level of production recorded at the baseline, descriptive results report a huge increase in cherry production over time for both groups of farmers.

Despite such a generalized increase, it deserves to be noted that Project farmers obtained a higher performance. Left-hand panel of Fig. 2 illustrates this trend: the columns describe mean values recorded at the baseline (2017 harvest season) and at the follow-up (2020 harvest season), distinguishing between Project farmers (under treatment) and Control farmers.

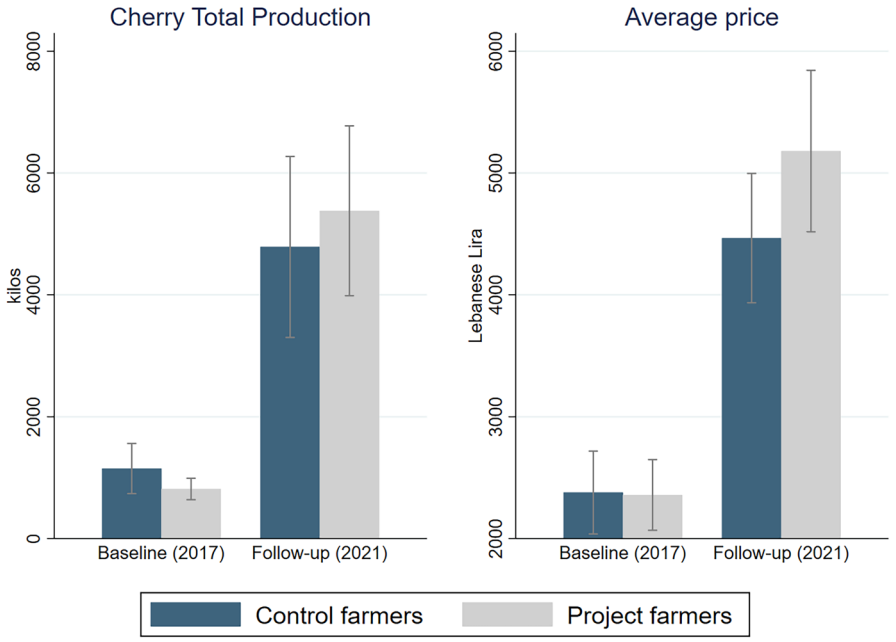

Fig. 2 Overview of quantity and quality outcomes: mean values, by treatment group. Last harvest season included in the analysis: May–July 2020. Whiskers represent error bars

The total production of Project beneficiaries increased almost seven times achieving the average per capita level of 5378 kilos, whereas Control group farmers reached a lower level corresponding to 4787 kilos per capita, on average.

Right-hand panel illustrates the average market price obtained by farmers. As previously presented, persistent socio-economic crises are deeply affecting the general price level in Lebanon which is steadily increasing and supporting a massive inflationary process in the country. However, as explained in Sect. 4.3, such an increase has simultaneously impacted both Project farmers and Control farmers in the same way. Thus, the estimation technique applied in this study will be able to "clean up" this background dynamic and to capture the true impact of the initiative in terms of market price. This indicator is particularly relevant for the purpose of the analysis, since it is conceived as an indirect measure of cherry quality. In this perspective, data suggest that Project beneficiaries achieved a better market positioning respect to other cherry producers, reaching a price differential of + 714.68 nominal LBP/kilo. It must be reminded that during the initiative's time span, all farmers in the sample confirmed that they had sold cherries in the local wholesale market only, thus facing the same price structure.

Thus, both quantity (total production) and quality (market average price) of cherry production appear to be positively impacted by the initiative.

5.2 Management and agricultural techniques

As in any other economic activity, the use of basic management and administrative tools improves the overall organizational structure making it more accountable and effective. Looking at the sample, data disclose a very weak management capacity: for example, we found that only 20.7% of smallholder farmers keep written records regarding the farming activity (e.g. whether a fertilization routine is implemented), and 61.5% affirm to not keep any written financial record, but make use of only memorized information to inform decisions (e.g. the cost of a fertilization routine) and manage economic activities. Further, more than 80% of cherry farmers do not use a specific bank account to credit the income generated from agricultural activities, with a preference for holding cash and the consequent difficulty in properly monitoring cash flow.

Overall, we recorded a general increase of the management index score for both Treatment and Control groups. While absolute values remain quite low, it deserves to be noted that at the baseline the management capacity of Project farmers was even more limited than the level shown by Control farmers; however, within the initiative time span, the gap is completely filled and the difference reversed. Left-hand panel of Fig. 3 illustrates such variations.

The agricultural techniques index provides information about the adoption and the frequency of use of key practices to support a productive and sustainable cherry cultivation. The promotion of these practices (e.g. adequate fertilization, reduction of chemicals, use of environmental-friendly traps for pests) is a core element of the extension

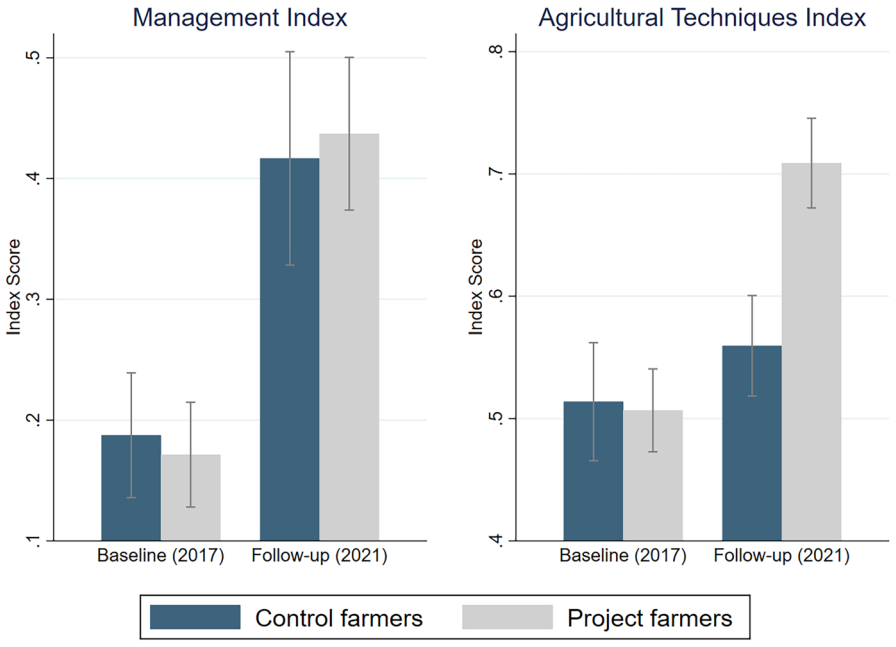

Fig. 3 Overview of managerial and technical outcomes: mean values, by treatment group. Both indexes are in a (0–1) range, with 1 denoting the highest value. Whiskers represent error bars

activities carried out within the initiative. The intervention envisages the improvement of technical skills and the adoption of sustainable agricultural practices as primary tools to enhance cherry quality and, thus, the likelihood of entering in highly remunerative markets. This is the dimension where the impact appears most remarkable. Adherence to the regular application of such procedures impressively rose for Project farmers (+ 20%), outclassing the performance achieved by farmers belonging to the Control group (+ 4%). Right-hand panel of Fig. 3 describes this effect.

5.3 Descriptive analysis of outcome variables

The ex-ante selection procedure of a pool of small-scale cherry farmers who produce in the same geographical areas and who have similar agricultural surface, efficiently limited possible pre-treatment unbalance of the sample with respect to observable covariates. The four considered outcome variables at the baseline (2017) exhibited a very high balance between Project farmers and Control farmers: as reported in Panel A of Table 4, no statistically significant differences emerge between them. These features support the validity of the parallel trend assumption: in other words, if the initiative had not been implemented, it is reasonable to expect that the two groups of producers would have followed similar trajectories, keeping the original difference in average outcomes constant over time.

The only noticeable, although not statistically significant, difference refers to total production since C farmers are associated with a higher level in respect to Project farmers (difference at the baseline = 336.5 kilos, on average). Considering that the area under cherry cultivation is well-balanced between the groups (as reported in

Table 4 Summary statistics of outcomes variables

	Project (T)		Control (C)		Difference	
	Mean	SD	Mean	SD	Diff	T-stat
Panel A:	*Baseline (2017)*					
Total production	814.71	749.2	1151.2	1447.7	336.5	(1.48)
Average price(*)	2358.2	1176.0	2378.3	1119.3	20.08	(0.08)
Management index	0.171	0.184	0.187	0.181	0.016	(0.46)
Agric. index	0.506	0.143	0.513	0.169	0.007	(0.23)
Observations	70		48		118	
Panel B:	*Follow-up (2021)*					
Total production	5378.4	5925.2	4787.5	5216.8	−590.92	(−0.57)
Average price	5179.6	2815.5	4464.9	1867.7	−714.68*	(−1.65)
Management index	0.437	0.268	0.416	0.311	−0.020	(−0.37)
Agric. index	0.708	0.155	0.559	0.144	−0.149***	(−5.34)
Observations	70		48		118	

*Due to missing data, baseline summary statistics are calculated on 106 observations

For *Total production* and *Average price* outcomes, Follow-up refers to 2020 harvest season, being the latest available data on yields. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3), the descriptive result suggests that beneficiary farmers were probably less productive than C farmers. This feature might explain why they decided to enroll in the initiative and therefore attend the technical training.

The descriptive analysis reported in Panel B of Table 4 refers to the outcome variables measured at the follow-up (2021). Results suggest the existence of a positive treatment effect (that is, the initiative produced an impact on beneficiary farmers). After the last available harvest season, Project farmers (T) achieved a higher performance in all of the four considered outcomes with respect to both baseline and C farmers. In a nutshell: their production level is higher than that achieved by C farmers; there is a relevant difference in average market price; the management dimension is still very close between the two groups with a greater progress shown by Project farmers; the implementation of improved agricultural practices is the dimension where the impact is most noticeable and statistically significant.

In addition, we noticed a higher correlation between the average market price and the agricultural techniques index for farmers under treatment (Pearson's Chi-sq. = 0.31, p-value = 0.01) in respect to farmers not engaged with the initiative (Pearson's Chi-sq. = 0.06, p-value = 0.64) in the follow-up survey. In other words, attendance to technical training seems to have strengthened the relation between the adoption of improved agricultural practices and the quality of agricultural production.

6 Empirical analysis: evidence of the treatment effect

The empirical analysis confirms the existence of a positive treatment effect: cherry farmers involved in the initiative achieved statistically significant higher performances in respect to Control farmers in terms of three outcome variables out of the four considered. In detail, T farmers increase the total volume of production, achieve a higher average market price and show a greater adoption of improved agricultural practices. This last dimension appears as the most prominent result achieved. It should be noted that also the Management Index shows a positive *ATT* coefficient (that is, the Average Treatment effect on the Treated), although it is not statistically significant. Table 5 describes the results of the DID analysis.

In regard to the other results, variable *Time* expresses the time trend in the control group (namely, the gains that occur over time independently of the treatment): the passage of time is significant for C farmers for achieving higher market prices (also reflecting the ongoing inflation process) and better business management (the accumulated experience over time is reasonably associated with a more effective management). The variable $Pre - treat$ measures the pre-treatment difference between the two farmer groups: as already noted, no significant differences are identified in this respect. Thus, results further corroborate the soundness of the research design.

Although balanced between groups, the initial level of agricultural area under cherry cultivation is important in determining the level of production. Thus, we controlled this aspect in the empirical analysis. As expected, larger agricultural areas are positively associated not only with the increase of total production, but also with a higher average market price. It is reasonable to assume that greater size of

Table 5 Treatment Effect on outcome variables

	Outcome variables			
	(1)	(2)	(3)	(4)
	Tot. Prod	Avg. Price	Manag. Index	Agric. Index
ATT	1.694**	0.905*	0.023	0.154***
	(0.799)	(0.475)	(0.060)	(0.029)
Time trend	0.471	1.567***	0.244***	0.034
	(0.725)	(0.332)	(0.054)	(0.027)
Pre-treat	−0.302	0.011	−0.004	−0.020
	(0.430)	(0.261)	(0.038)	(0.027)
Cherry donum	0.262***	0.035**	−0.001	0.001
	(0.060)	(0.018)	(0.002)	(0.000)
Other fruit trees	1.469***	−0.051	−0.037	0.032
	(0.533)	(0.287)	(0.042)	(0.022)
Equipment index	−0.452	−0.349	0.244***	0.096**
	(0.944)	(0.587)	(0.063)	(0.044)
Education level				
Primary	−0.055	−0.065	0.096**	0.019
	(0.507)	(0.342)	(0.044)	(0.027)
Some secondary	0.464	−0.773	0.216***	−0.030
	(0.681)	(0.501)	(0.070)	(0.034)
Secondary	0.680	−0.006	0.140**	−0.033
	(0.711)	(0.355)	(0.057)	(0.040)
Vocational training	0.500	0.497	0.045	−0.031
	(1.121)	(0.486)	(0.073)	(0.039)
Some university	−0.909	−0.091	0.127***	0.071*
	(1.121)	(0.372)	(0.045)	(0.041)
University	0.077	0.389	0.155***	0.027
	(0.772)	(0.412)	(0.053)	(0.029)
Transfer	0.161	−0.563	−0.088**	0.014
	(0.654)	(0.358)	(0.041)	(0.025)
Cooperative	1.755**	0.358	0.025	0.019
	(0.722)	(0.305)	(0.073)	(0.039)
Constant	−0.899	2.373***	0.120	0.454***
	(1.091)	(0.628)	(0.090)	(0.050)
Production area FE	Yes	Yes	Yes	Yes
Adj. R-sq	0.554	0.471	0.327	0.458
Obs	236	224	236	236
AIC	1215.5	893.5	−21.35	−277.30
BIC	1288.2	965.2	51.382	−204.56

The lower number of observations in Model (2) is due to missing data in the baseline data collection. Standard errors clustered at individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

production encourages a more market-oriented attitude and fuels a greater production efficiency which may also possibly be reflected in a higher cherry quality.

Since the background characteristics of some cherry farmers slightly changed over time (namely, the presence of other fruit trees and the equipment index), we decided to control these elements in the DID analysis because they are potentially associated to agricultural activity performance. The cultivation of other fruits (such as apples, almonds and grapes) is associated with the increase of total production, most probably due to existence of economies of scope. Nevertheless, the production of such agricultural commodities appears to be connected only to total production, whereas the other outcome variables result unaffected.

It is rather interesting to note that a greater endowment of agricultural tools and machines does not generate a tangible effect on the scale and the quality of production, but it enhances business management capacity and adoption of improved agricultural practices. This result is quite unexpected. A possible explanation could be that possessing technical endowments is not necessarily reflected in their proper use: for example, having pruning shears at disposal, although undoubtedly useful to speed up and improve the quality of the procedure, does not imply that farmers manage the correct know-how to prune cherry trees. On the other hand, the financial and planning commitment that underlies possessing these endowments can find support for higher focus towards the development of the agricultural activity, which is in turn reflected in the improvement of management capabilities and the adoption of improved agricultural practices. It may take longer to observe effects on the production side.

Given the background characteristics analysis reported in Sect. 4.2, we controlled the level of education achieved, since it is a source of (limited) unbalance between groups. In general terms, each formal education level (thus excluding vocational training) is positively associated to an increase in the management index, whereas it does not appear relevant for any other outcome variable.

Furthermore, the *Transfer* variable controls for those farmers (n = 23) recorded as Control group members during the initial phase of implementation, but who subsequently moved into project activities. These cherry farmers are located throughout all the production areas, without any clear spatial pattern. A reduced temporal exposure to the project effect seems to be quite irrelevant in terms of final outcomes (in line with the fact that regular field extension and accompaniment activities were carried out starting from the second year of implementation), except for the *Management Index* where these farmers performed worse. In absolute terms, *Transfer* farmers achieved a 0.356 average score level, whereas T farmers who joined the project at the beginning achieved an average score of 0.476 (p-value<0.10). The result suggests that the inception phase of intervention—mainly focused on the assessment of individual needs and capacities, as well as on a targeted sensitization about the importance of equipping farming activities with adequate management tools—plays a role in determining this final outcome.

Finally, the last control refers to being member of a cooperative. Active agricultural cooperatives are rare in Lebanon, even if the limited production of small-scale farmers is a major concern for the agricultural sector and should rather justify their development. The initiative promotes a comprehensive approach to foster the

improvement of the whole cherry value chain at the local level, and it particularly emphasizes the role of cooperatives as collective units able to overcome individual farmer's shortfalls to facing market dynamics. Considering the initiative time span, we found only one pre-existing cooperative—based in Ainata—which received technical assistance to reinforce its internal structure and market competitiveness. The intervention under investigation promoted the establishment of other cooperatives, however their economic activity actually started after the conclusion of the development initiative, therefore potential effects (e.g. market size) are not captured by the follow-up data. Nevertheless, the (long) process of establishment, based on a participatory approach, may have contributed to the adoption of shared management and agricultural practices by individual farmers as facilitators to remove barriers for cooperation. For this reason, we included a binary variable indicating being a member of a cooperative.[20] We found a significant positive effect only on the production outcome variable.

Although not directly comparable in size, our results are in line with the main findings of the empirical literature (see Sect. 2), confirming the existence of positive impact of technical training and accompaniment (intended as the provision of agricultural extension and advisory services) on diverse agricultural outcomes. The novelty of these results lies in the fact that they concern an understudied area (Lebanon) characterized by traditional smallholder farming activities whose abandonment and progressive reduction of productivity is a central issue for the country's rural development.

6.1 Robustness checks

We performed two different robustness checks to corroborate the consistency of the results obtained by the empirical analysis.

First, we performed the analysis on a reduced sample where smallholder farmers who changed their status during the first phase of the implementation were removed. Possibly, such different behaviour conceals characteristics (either material or non-material) which differentiate them from other farmers and which could have driven the overall result. For example, we noticed that *Transfer* farmers hold on average larger areas devoted to cherry production (12.5 donum versus the 7.29 possessed by those who immediately entered into the project activities), and they are better equipped with respect to those who did not change their status. On average, the *Equipment index* reaches the score of 0.311 for those who changed their status, whereas the other farmers in the treatment group do not exceed the 0.23 score. Thus, it is reasonable to affirm that the reduced sample of beneficiaries includes more vulnerable small-scale farmers.

As reported in Table 6, even when we consider the reduced sample, all the main findings are clearly confirmed, providing further evidence about the impact generated by the initiative.

[20] At the baseline, only 16 farmers belonged to this category (all located in Ainata), whereas at the follow-up survey this number increased to 21 (13 beneficiary farmers and 8 control farmers, located in Ainata, Wadi el Aarayech, Kaa El Reem and Rachaya)

Table 6 Treatment effect on outcome variables, reduced sample

	Outcome variables			
	(1.1)	(2.1)	(3.1)	(4.1)
	Tot. prod	Avg. price	Manag. index	Agric. index
ATT	1.844**	1.173*	0.037	0.162***
	(0.835)	(0.667)	(0.067)	(0.032)
Time trend	0.108	1.736***	0.280***	0.042
	(0.766)	(0.401)	(0.058)	(0.029)
Pre-treat	−0.036	−0.214	−0.007	−0.028
	(0.396)	(0.288)	(0.040)	(0.028)
Constant	−0.192	2.500***	0.063	0.438***
	(1.029)	(0.739)	(0.089)	(0.046)
Control variables	Yes	Yes	Yes	Yes
Production area FE	Yes	Yes	Yes	Yes
Adj. R-sq	0.566	0.458	0.308	0.436
Obs	190	178	190	190
AIC	959.63	733.41	−6.361	−214.79
BIC	1024.5	797.05	58.57	−149.84

The lower number of observations in Model (2.1) is due to missing data in the baseline data collection. Standard errors clustered at individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Secondly, we explored whether treatment heterogeneity might lead to different results. According to local staff records, planned activities were carried out in a fairly homogeneous way in all areas of intervention. However, we found a source of (limited) heterogeneity: some farmers received in-kind assistance along with accompaniment and technical training. More precisely, 44 cherry farmers received basic agricultural instruments (e.g. traditional shears) and plant assemblages (e.g. thyme or small almond trees) whose use in the orchard is aimed at maintaining the quality of the soil, biodiversity and related ecosystem services. While the benefits of grass covering and the use of plant assemblages in the orchard was the object of technical training for all T farmers, the material provision of plants concerned only some of them.

Thus, we created two sub-groups of beneficiary farmers, distinguishing them between those who received trainings and continuous technical assistance (n = 26, labelled T1) and those who in addition also received material goods that may have affected the final outcomes (n = 44, labelled T2). We therefore applied the same estimation strategy, but including a single sub-group of beneficiaries at a time and comparing it to control farmers (Table 7).

Controlling for intra-sample variance of treatment produced some interesting findings. On one side, outcomes related to production, management (still not significant) and agricultural practices are all confirmed in both sub-groups of treatment. In other words, training and accompaniment (the core treatment for both sub-groups) stand out as the main drivers explaining the significant increase of

Table 7 Treatment Effect on Outcome variables, intra-sample variance of treatment

	Outcome variables							
	(1.2)		(2.2)		(3.2)		(4.2)	
	Tot. prod.		Avg. price		Manag. index		Agric. index	
	T1	T2	T1	T2	T1	T2	T1	T2
ATT	2.010*	1.591*	0.300	1.246*	−0.046	0.047	0.173***	0.142***
	(1.181)	(0.848)	(0.419)	(0.676)	(0.080)	(0.067)	(0.040)	(0.033)
Time trend	1.297*	0.184	1.758***	1.649***	0.247***	0.273***	0.038	0.040
	(0.689)	(0.780)	(0.315)	(0.400)	(0.058)	(0.058)	(0.029)	(0.029)
Pre-treat	−1.573	0.268	−0.297	0.081	−0.004	0.005	0.022	−0.026
	(0.782)	(0.433)	(0.395)	(0.308)	(0.067)	(0.043)	(0.042)	(0.031)
Constant	−0.535	−0.371	1.933***	2.732***	0.065	0.130	0.442***	0.472***
	(1.059)	(1.008)	(0.534)	(0.810)	(0.114)	(0.093)	(0.047)	(0.055)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Production area FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-sq	0.491	0.564	0.545	0.482	0.301	0.304	0.467	0.384
Obs	148	184	141	173	148	184	148	184
AIC	792.13	929.25	485.51	707.72	3.373	−6.776	−172.17	−200.00
BIC	855.07	996.77	547.44	773.94	66.315	60.738	−109.23	−132.49

The lower number of observations in Model (2.2) is due to missing data in the baseline data collection. Group T1 denotes farmers receiving trainings and technical assistance; whereas group T2 denotes farmers also receiving in-kind assistance in addition to technical training. Standard errors clustered at individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

production and the adoption of improved agricultural practices. Receiving in-kind assistance does not further improve the outcomes in these dimensions. On the other side, a higher intensity of the treatment (namely, receiving additional material support) is associated to a significant increase in average market price respect to control farmers, denoting a higher cherry quality. In this respect, receiving plant assemblages—the predominant source of heterogeneity—along with knowledge transfer on the matter through technical training seems to play a role in terms of average market price. We explain this results as follows: the correct use of grass covering and plant assemblages can actually improve the quality of soil in the orchard in the medium term, leading to higher quality productions; at the same time, this practice represents a profoundly different approach respect to traditional cultivation techniques and it therefore implies conceiving the orchard as an integrated eco-system, leading towards a greater adherence to the adoption of improved agricultural practices. Not surprisingly, the correlation between *Average Price* and *Agricultural Index* outcomes is particularly high (Pearson's Chi-sq. = 0.48, p-value<0.01) for T2 farmers.

7 Conclusions

Despite a renewed attention to agriculture development in terms of food security, environmentally sustainable productions and poverty reduction, agricultural rural areas in most Low and Middle Income Countries are still suffering from under-investment, lack of knowledge and inadequate rights protection of people basing their livelihood on small-scale farming. Among other challenges, smallholder farmers are constrained by low production levels and limited quality, which compress market opportunities and therefore income generation. This research work provides evidence about the impact of a development initiative implemented by the Italian NGO Fondazione Giovanni Paolo II in rural Lebanon (Bekaa Valley), whose scope is the revitalization of small-scale agriculture, in the cherry sector, by enhancing technical skills and introducing improved agricultural practices in order to reduce farmers' vulnerability, strengthen their livelihoods and create valuable market opportunities.

The initiative consists in the provision of technical training on agricultural sustainable practices and business management, by means of extension services and accompaniment. Collective training, engaging groups of peers, and individual technical assistance are expected to improve farmers' skills, sustain cooperative attitude and encourage market initiative. This research analyses the efficacy of such an approach in an understudied geographical area (Lebanon) and innovatively contributes to the empirical literature by providing rigorous evidence about technical training impact on multiple agricultural outcomes.

Structured on a quasi-experimental design based on a Difference-in-Differences estimation strategy, we used four alternative outcome variables to measure the impact of the initiative, namely i) total cherry production, ii) average market price, iii) management competency, iv) adoption of improved agricultural practices. In this way, we are able to capture short-run effects (ability to increase yields and their quality) and potential long-run effects (increased agricultural and managerial practices are expected to generate long-lasting effects and nurture the sustainability of the results achieved). We observed the above mentioned agricultural outcomes for both smallholder farmers enrolled in the initiative (the treatment group) and for untreated farmers (the control group) randomly chosen from the same productive areas, over a period of three growing seasons.

This study confirms that the initiative was able to generate a positive impact on three final outcomes out of the four considered. In particular, the beneficiary smallholder farmers were able to significantly increase the level of total production, improve the quality (thus, achieving a higher market price, on average), and ameliorate the agricultural practices adopted, positively contributing to the sustainability of small-scale farming. The management of individual farming activities improved as well, however such variation did not reach any statistical significance respect to the performance obtained by smallholder farmers in the control group, and still remains quite low in absolute levels.

Other things equal, our results suggest that the process of technical assistance, capacity-building and accompaniment are the major determinants of obtained

results. In fact, exploiting a source of heterogeneity in the treatment, we found that the additional provision of material aid (such as basic agricultural tools or plant assemblages) on individual basis shows limited effects, only detected in the quality of production.

Overall, the results show the efficacy of technical training in fostering agricultural outcomes, thus confirming the findings of several case studies. However, the issue of the efficiency of this type of intervention remains unresolved: in fact, technical training require a costly deployment of time and human resources to reach a relatively small number of beneficiaries. This aspect goes well beyond the scope of this paper, but from the point of view of policy implications it is worth emphasizing that the accompaniment process - encouraging the exchange between peers and co-creation of knowledge, applied in group activities during training—may work as an element of scalability of results by relying on the experience of the beneficiaries themselves. In fact, a process envisaging mutual self-help, the sharing of experiences and participatory approach in areas of common interest can successfully mobilise local resources and local knowledge for self-reliant development.

The impossibility of applying a full randomization process to the selection of smallholder farmers under treatment and the limited external validity of the results represent possible shortfalls of this study. Nevertheless, our results suggest that highly vulnerable smallholder farmers can actually improve their agricultural performance in terms of volume, quality and implementation of sustainable agricultural practices, when targeted technical training is provided. On the other hand, improving the business management of small-holder farming activities seems to require a different approach.

Overall, we believe this research is an innovative contribution to the debate about the strengthening of smallholder agriculture in two ways: it provides empirical evidence based on original micro data enriching the relevant literature, mostly composed of qualitative case studies; and it covers a neglected geographical area subject to several environmental and social stressing factors.

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Declarations

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