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Is EU Support to Malawi Agriculture Effective?

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Abstract

We measure the impact of the Farmers Income Diversification Program (FIDP), an EU funded program implemented in Malawi from late 2005 onwards, aiming at increasing agricultural productivity, diversification, value addition, commercialization and trade of subsistence farmers. The geographical spread of the implementation of FIDP is exploited to identify its impact. Computations are based on annual data by Extension Planning Area, 198 in total, fully covering Malawi, for the period 2003-04 to 2009-10. The estimations support a statistically significant impact of FIDP on agricultural productivity, with increases reaching 20% to 24% relative to base period levels, with a lag of at least one year after the start of the program and increasing over the years. Evidence on diversification of crop income is less strong but still suggests increases ranging from 5% to 10%. Results are robust for instrumental variables, synthetic controls, clustering of standard errors and inclusion of additional covariates.

JEL code: F35, O13, O55, Q11, Q13

Key words: agricultural policy, impact evaluation, subsistence farming, Malawi, Africa

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Introduction

Smallholders farmers in developing countries can choose to produce food crops for home consumption or cash crops for the market[1]. High production costs, high transaction costs, and high risks of output and input prices often make subsistence farming – food production for home consumption – the optimal choice (see e.g. De Janvry et al. 1991; Jayne, 1994; Fafchamps, 1999; Key et al., 2000)[2]. Widespread subsistence farming leads to low productivity and low growth in agriculture. And since developing countries have large agricultural sectors with a comparative advantage vis-à-vis non-agricultural sectors, large multiplier effects from agriculture to the remaining sectors of the economy and few alternative growth strategies (de Janvry and Sadoulet, 2010), a stagnant agricultural sector is likely to obstruct the economic growth potential of these countries.

The question arises how one should overcome this subsistence trap. The literature offers some guidance in designing policies to address this subsistence trap. Farmers' behavior may change if transaction costs are lower, if productivity is higher and if there is more transparency and thereby less uncertainty in input and output prices. Hence, policies that aim to achieve these goals are claimed to be conducive to (improved) commercial behavior of farmers. In practice this entails a wide variety of measures, ranging from improvement in input supply, extension services, dissemination of soil management and other fertility improvement techniques, use of compost and manure and related soil and water conservation techniques, contour ridge alignment, development of irrigation infrastructure, establishment of farmers' organizations, development of commercial skills and financial capacity, rural credit, and investments in transport and marketing infrastructure.

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[1] Food crops are not necessarily or exclusively used for subsistence, but may also be sold on the market.

[2] Promotion of either food crops or commercial crops also lies at the heart of policy discussions (see e.g. Harrigan, 2003, 2008).

The EU funded Farmer Income Diversification Program (FIDP) is specifically designed to lift farmers out of subsistence farming and transform subsistence farming to commercial farming. The objective of this paper is to measure the impact of this FIDP. FIDP activities in Malawi have started late 2005 and are restricted to a number of selected districts. The impact evaluation focuses on productivity in agricultural crop cultivation and diversification of agricultural crop income.

1. Malawi agriculture, agricultural policy and the policy debate

Agriculture in the Malawi economy

In this section we discuss the main features of Malawi, the Malawi economy and its agricultural sector, and we summarize the Malawi agricultural policy debate. Malawi is a relatively small landlocked country in sub-Sahara Africa, measuring more than 800 km from north to south, and 100-170 km from east to west, bordering in the north and northeast with Tanzania, on the upper west side with Zambia and enclosed by Mozambique on both the lower west side, the lower east side and the south. A large lake – Lake Malawi – borders the country on the eastern side and stretches from the upper north to around 2/3 down south, culminating in the Shire river, which exits the country in the outermost southern point of the country to eventually feed the Zambezi river. The population has increased from 10.5 million in 2000 to 14.5 million in 2010, of which around 12% lives in the Northern region, around 42% in the Central Region and around 46% in the Southern region, which makes the Central and specifically the Southern region relatively densely populated. Due to its high population density the southern part of the country constitutes the largest market for food crops. Lilongwe (in the Central region) and Blantyre (in the Southern region) are the two major cities with both around 0.5 million people in 2000 increasing to slightly less than 0.9 million in 2010. The towns of Zomba in the south and Mzuzu in the north are also considered to be urban areas. The larger part of the population, however, lives in rural areas (around 87% from 2000-2010). The poverty rate of the mainly rural population is around 70% in remote rural districts (e.g. Chitipa (67.2%) in the north and Nsanje (76.0%) and Chikwawa (65.8%) in the south). For the country as a whole 52.4% of the population in Malawi is poor, and 22% of the population is ultra poor (source: Integrated Household Survey 2005 (IHS-2)).

The agricultural sector is the most important sector in the Malawi economy. Agriculture accounts for 40-45% of GDP. On average 77% of the population above 15 years of age (on average 84% in rural areas) earns an income in agriculture, and this peaks to above 90% is a few rural districts. Major export products are tobacco (36-64% of total exports), sugar (9-21%) and tea (4-17%)[3]. Around 80% of the countries' foreign exchange earnings originate from agriculture. Malawi agriculture is nearly completely rain-fed and rainfall is also the major single determinant of agricultural production. The rainy season is from January to March. Annual rainfall varies from 600 to 1700mm, depending on location and year, with an average of around 1000mm. Average levels of rainfall are relatively high in the districts of Mulanje, Thyolo, Nkhatabay and Nkhotakota and notoriously low in Rumphi. Average rainfall levels affect suitability for cultivation of specific crops: crops like tea require humid conditions with high levels of rainfall and are therefore grown in Mulanje and Thyolo. Tobacco and cotton tend to be better adjusted to low rainfall areas.

Malawi used to be self-sufficient in food but has developed into a food deficit country over the decades due to declining productivity and increasing population. During the last decades the Government of Malawi – which has a clear preference for food sufficiency – has supplied input subsidies to smallholders under various programs. Combined with favourable weather, these programs have significantly increased maize production. However, droughts and floods persist to cause occasional food shortages. Food shortages have triggered

[3] Major imports are fuel for transport (8-14% of total imports) and chemical fertilizer (urea, NPK, around 19%).

substantial inflows of food aid from abroad. Although it is unlikely that distribution of food aid during occasional food shortages has serious negative impacts on food production (see Zant, 2012a), it does appear that addressing the consequences of food shortages has a larger priority than preventing food shortages, especially among WFP, NGOs and some donors. The continuous presence of WFP, NGOs and donors in Malawi has established a perfect and smoothly operating emergency support infrastructure (with the accompanying vested interests) but has left the country with a painfully deficient infrastructure for private sector marketing and trading (see also Zant, 2012c). Food security and rural economic growth are at the heart of the policy debate in Malawi (see also below).

The agricultural sector has two main subsectors, smallholders and estates, of which the smallholder sector is by far the largest. The smallholder sector consists of around two million households, with a median crop area per household of around 0.6 hectare. Smallholders cultivate a wide range of crops: apart from staple food crops (maize, rice, cassava) smallholder farmers in Malawi cultivate vegetables (beans, cow peas, pigeon peas, sweet potatoes) and cash crops for exports (tobacco, groundnuts[4], cotton, tea and sugarcane). Within the smallholder sector maize cultivation dominates crop production. Nearly all households – an estimated 97% – grow maize (2005 Integrated Household Survey (IHS (2005)). Production of maize in Malawi is undertaken by households on subsistence grounds[5]. The importance of maize is also apparent from agricultural revenue and crop area: in all regions maize has the single largest share in crop area ranging of around 50%. Cash crops (tobacco, groundnuts and cotton), root crops (cassava and sweet potatoes) and pulses (beans, soybean, cow peas and pigeon peas) account also for substantial but much smaller shares in total crop area. Cash crops account for a relatively large share of crop area in the

[4] Groundnuts are partly produced for home consumption or consumed domestically.
[5] A share of 81% of the population in rural areas is classified as subsistence farmers (IHS-2, 2005).

central region and a relatively small share in the southern region. Root crops account for a particularly large share of crop area in the northern region and pulses account for a relatively large share in the southern region.

Agricultural policy and the policy debate in Malawi

Agricultural policy plays an important role in the development of Malawi agriculture and Malawi agricultural policy is highly influenced by the donor community, notably USAID, DfID, the EU and the World Bank. Over the past decades the policy discussion has centered around the question how to achieve food security (see e.g. Harrigan, 2003, 2008). One way to achieve food security is to promote food production and to aim at self-sufficiency in food production, through input subsidies and price supports of agricultural outputs. Self-sufficiency in food will lower food prices, and this will make labor cheap, which will create further growth opportunities. This position is favored by the Government of Malawi. Another way to achieve food security is to minimize state intervention in the economic process and to promote market determined production of exportable cash crops like tobacco. Under these circumstance food security is realized by importing food, using the foreign exchange earnings from exported cash crops. This position is favored by donors and the World Bank. Supporters of this view claim that home production of food tends to trap the economy on a slow development path with a high incidence of poverty[6].

The Government of Malawi publishes its policy agenda on agriculture in a sequence of continuously changing documents ("Agriculture Sector Wide Approach: Malawi's prioritized and harmonized Agricultural Development Agenda") of which we have used a March 2009 version (see Government of Malawi, 2009). Like most policy documents this document does not contain a critical assessment of the agricultural sector, but focuses more

[6] See Zant (2012b) for a simulation exercise that shows that food self sufficiency is not inconsistent with a strategy that aims at growth through cash crops.

on plans and intentions (which are, most likely, the result of critical analyses). Following the Malawi Growth and Development Strategy, 2006-2011, agriculture is recognized as the driver of economic growth. Also, food security is recognized as a pre-requisite for economic growth and poverty alleviation. Food security is planned to be achieved through growth in maize productivity, reduction of post harvest losses, diversification of food crops and managing risks associated with national food reserves. Additionally, a strategy is proposed to promote commercial agriculture, diversification, agro-processing, value addition and market development for smallholders. Sustainable land and water utilization is given attention. Policies aiming at broad-based agricultural growth are supported by an allocation of at least 10% of the National Budgetary resources to the agricultural sector, sourced from both GoM and donors. An annual growth of (at least) 6% of the agricultural sector is aimed at[7]. Some measures and activities are further specified (e.g. subsidies on cotton and maize pesticides).

2. The Farmers Income Diversification Program (FIDP) in Malawi[8]

Jointly with other donors, NGOs and the World Bank, the EU runs a variety of programs in sub-Saharan Africa which aim at increasing subsistence farmers' productivity, diversification, value addition, commercialization and agricultural trade. In order to enhance economic growth, the Government of Malawi (GoM) and the European Union (EU) developed the Farm Income Diversification Program (FIDP), funded under the EU's 9th and 10th EDF. FIDP consists of two phases (FIDP I and II) with an overall EU contribution of

[7] Recent growth rates for GDP are*:

	2007	**2008**	**2009**	**2010**	**2011**	**2012**
GDP	5.5%	8.3%	8.9%	6.7%	6.9%	6.6%
Agriculture	11.2%	4.2%	13.1%	2.0%	6.4%	7.3%

* both 2011 and 2012 are estimates; source: GoM, 2011.

[8] For this section we have made extensive use of the only documentation on the Malawi Farmer Income Diversification Program (FIDP) that we could get hold of: Specific Terms of Reference, End-Term Evaluation of Farm Income Diversification Programme (FIDP) Phase I (CRIS/FED/2004/17412) and Mid-Term Evaluation of FIDP Phase II (CRIS/FED/2009/21346).

€36.5 million (FIDP I: €16.2 Million and FIDP II: €20.03 Million). The implementation of FIDP I activities started in August 2005 and ended on 31 December 2010 (excluding a 24 months closure phase). The implementation of FIDP II activities started in May 2010 and will end December 2015 (excluding a 24 months closure phase).

FIDP I was implemented in 11 districts, in particular the northern districts Chitipa, Karonga, Mzimba and Rumphi; the central districts Lilongwe, Salima, Nkhota-kota, and Dowa; and the southern district Balaka, Chiradzulu, and Thyolo[9]. FIDP I did not operate in all Extension Planning Areas (EPAs) in these 11 districts. It is unclear on what grounds districts and EPAs are selected for FIDP activities. FIDP II is implemented in 12 districts: the 11 districts where FIDP I operated and the northern district Nkhata-Bay. FIDP II is intended to expand and consolidate FIDP's presence in the districts by operating in more villages in the EPAs that it is currently working in and in more EPAs within the 12 districts.

In view of the key role of agriculture and agro-processing in achieving economic growth and realizing poverty alleviation, FIDP I aimed at increasing agricultural production, income diversification (less dependence on maize cultivation and less reliance on tobacco export earnings), trade enhancement and sustainable use of soil and water resources. The major innovation of FIDP I was to consider farming as a business, by promoting development of knowledge, skills and entrepreneurial initiatives in the field of agricultural production and marketing. The following results of FIDP I were expected to be realized: Improved knowledge, attitude and organization of rural communities; Sustainable management of soil conservation and soil fertility; Enabling environment for agriculture business initiatives promoted; Improved capacity of rural communities to access and develop post harvest agricultural activities; Timely and relevant education and training opportunities available in horticulture; Improved institutional capacity in trade policy. The midterm review of FIDP I

[9] A map of Malawi in appendix B shows the districts where FIDP 1 is implemented.

(2009) considered the program a success story and paved the way for the implementation of FIDP II.

FIDP II seeks to continue the activities implemented under the FIDP I program. Most notably FIDP II aimed at reversing the decline of the natural resource base, reducing post harvest losses and increasing agro-processing, to diversifying and increasing agricultural production and promoting income generation through agri-business initiatives. Similar to FIDP I increasing productivity and producing greater value from agriculture is intended to help farmers convert from subsistence farming to commercial farming. Expected quantifiable results of FIDP II are: sustainable management of natural resources; improvement of post-harvest storage and processing; growth of productivity and increase in diversification of smallholder agriculture; promotion of agri-business. Additionally, a number of qualitative results relating to community development and empowerment are expected, in particular improved capacity in FIDP communities, the Ministry of Agriculture and Food Security and other stakeholders; enhancement of social development of FIDP communities; and enhancement of coordination and knowledge management.

The above description of the FIDP program reflects the degree of detail on this program that is documented in publicly available resources. It goes without saying that we would have appreciated more detail on type, timing, budget and geographical distribution of activities: unfortunately this is as far as we can get. Also, as already mentioned above, the criteria for selecting districts and EPAs for FIDP activities are not documented and hence obscure.

3. Methodology

Estimating Impact of Interventions with Panel Data

The impact of an intervention is estimated using a fairly standard and straightforward framework for impact evaluation with panel data (see e.g. Duflo et al., 2007). A reasonably general specification to identify the impact of an intervention with a panel of observations runs as follows:

$$Y_{it} = \beta_0 + \beta_1 I_{it} + \sum_k \beta_{2k} X_{k,it} + \gamma_i + \delta_t \quad (1)$$

where Y_{it} is the outcome indicator, I_{it} is a binary intervention variable with a unit value in case of an intervention and zero elsewhere (hence, zero before the intervention and without intervention), $X_{k,it}$ is a set of k exogenous control variables, and γ_i and δ_t are respectively household (location) and time fixed effects. Control variables ($X_{k,it}$) may also include observed household (or location) invariant and time-invariant fixed effects. The coefficient of the intervention variable (β_1) is the parameter of interest. By allowing impacts to vary over time, we increase the flexibility of the specification and the informational content of the data. This modifies equation (1) into:

$$Y_{it} = \beta_0 + \sum_t \beta_{1t} I_{it} + \sum_k \beta_{2k} X_{k,it} + \gamma_i + \delta_t \quad (2)$$

Impact of FIDP on Malawi agriculture: empirical specification

We use the basic model set out above to estimate the impact of the Farmer Income Diversification Program (FIDP) on agricultural productivity and crop diversification[10]. In order to transform equation (2) to an equation that can be estimated empirically, we simply insert agricultural productivity and crop diversification as outcome indicator and add error terms:

[10] There are various alternative outcome indicators that make good sense in view of the goals of FIDP (e.g. share of maize revenue). However, we rather focus this evaluation to the main goals and we also think that agricultural productivity and crop diversification sufficiently cover the main goals of FIDP. Additionally it should be noted that the empirical expressions used for agricultural productivity and crop diversification are restricted to crop production per se: these expressions will not pick up agricultural productivity growth due to value addition and diversification outside crop cultivation.

$$ar_{it} = \beta_0 + \sum_t \beta_{1t} I_{it} + \sum_k \beta_{2k} X_{k,it} + \gamma_i + \delta_t + \nu_{it} \quad (3)$$

$$cd_{it} = \varphi_0 + \sum_t \varphi_{1t} I_{it} + \sum_k \varphi_{2k} X_{k,it} + \eta_i + \zeta_t + \varepsilon_{it} \quad (4)$$

where ar_{it} and cd_{it} are agricultural productivity (agricultural return) and crop diversification of EPA i in year t, and ε_{it} and ν_{it} are error terms with zero mean and constant variance. We use the specification of equation (3) and (4) as the basic specification of our estimations, with appropriate restrictions on coefficients. The restrictions are apparent from the tables with estimation results.

We need to define the outcome indicators agricultural productivity (agricultural return) and crop diversification. Since we are keen to analyse the impact of the program on aggregate crop income, we need to aggregate yields of different crops – where yield is production per hectare – in order to arrive at an indicator of productivity growth in smallholder crop production. Using farm gate crop prices is a natural way to aggregate over crops: hence, we use gross crop revenue per hectare ($\sum_i p_i q_i / \sum_i a_i$ where p_i, q_i and a_i are respectively farm gate price, production and area, all for crop i) as the indicator of agricultural productivity. In the case of productivity a positive sign of the intervention variables indicates an increase in productivity.

Crop diversification elaborates further on the concept of gross crop revenue: if the share of crop *i* in gross crop revenue is defined as s_i (where $s_i = p_i q_i / \sum_i p_i q_i$) we use the Herfindahl-Hirschman-index (HH index) as the indicator of diversification of crop income. The HH index is defined as the sum of squares of crop revenue shares ($HH = \sum_i s_i^2$). The closer the value of the HH index to zero the higher the degree of diversification. In the case of diversification a negative sign of the intervention variables indicates a decrease in concentration, and thus an increase in diversification.

Table 1 Agricultural productivity and crop revenue diversification: descriptive stats

ADD	Agricultural productivity (gross crop revenue per hectare) 2005-2007 pre-intervention	2007-2010 intervention	Crop revenue diversification (HH index of gross crop revenue) 2005-2007 pre-intervention	2007-2010 intervention
Karonga	42764	63691	0.328	0.275
Mzuzu	49439	70475	0.380	0.327
Kasungu	42139	60968	0.279	0.287
Salima	48599	74913	0.362	0.351
Lilongwe	41103	58676	0.331	0.311
Machinga	38875	45531	0.384	0.280
Blantyre	39902	41656	0.284	0.229
Shire Valley	27527	29855	0.261	0.239

* The table reports the un-weighted median of real gross crop revenue per hectare and the un-weighted median of the HH index of gross crop revenue of EPAs, by Agricultural Development Division (ADD) and by pre-intervention (2005-2007) and intervention period (2007-2010). The pre-intervention year 2003-2004 and 2004-2005 (for which we do have data) are ignored since these years are characterized by extremely poor harvests. The median is used to control for skewness of the distributions. Gross crop revenue per hectare is in 2010 constant Malawi kwacha. Regions can be identified by shading: from top to bottom, north-central-south.

In Table 1 we have presented descriptive statistics of productivity and diversification, summarized by Agricultural Development Division (ADD). From the table we extract that gross crop revenue per hectare is the highest in Mzuzu ADD and Salima ADD, approximately 18 to 28% above the Lilongwe level, and the lowest in the south, most notably in Shire Valley with levels of approximately 51 to 67% of the Lilongwe ADD level. Mzuzu ADD and Salima ADD are also least diversified, with levels of the HH index 5 to 15% above the Lilongwe ADD level. Blantyre ADD and Shire Valley, both ADDs with typical low productivity levels, are most diversified, with levels of the HH index as low as 74% of the Lilongwe ADD level.

A variety of $X_{k,it}$ covariates is used: in case of agricultural productivity potential candidates are climatic variables, fertilizer use and crop prices. Climatic variables, most notably rainfall, are likely to correlate with production outcomes and productivity. Chemical fertilizer inputs used in crop cultivation is another obvious candidate to include. It should be noted that chemical fertilizers are nearly exclusively used for maize cultivation (and some for tobacco).

For convenience we have restricted crop prices to maize prices, since maize is by far the most important crop, and tobacco prices, the most important cash crop. Further, to avoid endogeneity we have used lagged values of prices. In case of diversification of crop revenue it is much less straightforward to find appropriate candidates: the expected correlation with diversification is not always clear. For example, the differential impact of rainfall on crops is not known, and thereby also its impact on diversification. On the other hand, we may expect crop revenue diversification to decrease / increase if crop revenue with a large (small) revenue share increases more relative to other crops. This means, for example, that maize prices are likely to be negatively correlated with diversification. We decide to use all covariates that are also used in the case of productivity.

Identification and instrumental variable strategy of intervention locations

Crop years in Malawi run from April to March and FIDP activities have started in August 2005, which is half way crop year 2005-2006. Consequently, we have assumed that a potential impact of FIDP may be identified from the 2006-2007 crop year onwards. The implementation of FIDP by district is apparent from the description of the program (see also Appendix B for a map of Malawi highlighting the districts where FIDP is implemented). We do not know the exact criteria for selecting the districts to implement FIDP: the documentation is simply not publicly available. Whatever information we have is outright vague and inaccurate. There are some indications that FIDP did not target food insecure beneficiaries, but rather those that had the capacity and willingness to join the agri-food business. Despite this lack of information, we assume that selection into the FIDP program is determined by a series of socio-economic criteria. If this is the case the standard response in the literature on identification of impacts is to instrument the intervention (see e.g. Duflo and Pande, 2007). We have instrumented the intervention variable with per capita gross crop production (+), population density (+), distance to Lilongwe (-) and poverty head count (-), where the sign in brackets reflects the expected sign of the variable on the probability of being selected. Instruments are lagged to avoid problems of endogeneity.

EPAs or districts that are excluded from the activities of the FIDP are used as controls and enable us to double difference. Following the estimation in equation (3) and (4) all EPAs have an equal weight. As nearby and / or similar EPAs are likely to be superior controls, we consider to construct, for each individual intervention EPA, a synthetic control by estimating weights for control EPAs, instead of treating all non-intervention EPAs as equally weighted controls (see Abadie et al. 2010).

Data for estimations

The impact estimations are based on annual data of agricultural production, crop area and farm gate prices at the level of Extension Planning Area's (EPAs). Data, data sources and variable construction are documented in Appendix A. Here we comment on a few data related issues. A total of 198 EPAs is identified covering the entire country. EPAs are subdivisions of districts and have an average area of 523 km2 (median: 489 km2 [11]), an average population of around 68,000 (median: 60,000) and an average of around 17,000 households (median: 16,000). Data by EPA are available for the crop years from 2003/04 to 2009/10, hence we have a seven year EPA panel data set. However, data are not entirely complete, especially at the start of the sample period.

A total of fifteen crops is identified: local maize, composite maize, hybrid maize, rice, cassava, sorghum, millet, beans, pigeon peas, cow peas, soybean, sweet potatoes, groundnuts, cotton and tobacco. It is believed that these crops cover the major crops in Malawi agriculture[12]. The original data distinguish summer crops (or rain-fed crops), estate crops and

[11] A few districts have very large sized EPAs (Kasungu and Nkhotakotha, respectively above 1300km2 and 1050km2 and one very small EPA (Likoma, 18km2). The bulk of the EPAs has a size between 230km2 and 800km2.

[12] The data do not include fruit crops (e.g. mangoes, pineapple, etc), a few vegetables (paprika), a few perennial crops (tea, coffee, cashew nuts, maccademia nuts) and sugarcane. Tea and sugar are important in

winter crops (or irrigated crops)[13]: we restrict the exercise to summer crops (or rain-fed crops) which is by far the largest component. This component is also believed to be homogeneous and most representative for smallholder farmer households. Not all crops are cultivated in all EPAs: maize, cassava, groundnuts and sweet potatoes are cultivated in nearly all EPAs, while cotton and sorghum have a much lower spread.

Prices that farmers receive for their crops at the farm-gate, so-called farm-gate prices, are partly observed and partly constructed. For most crops farm-gate prices are directly observed (all crops except cassava, sweet potatoes, pigeon peas and millet). However, these data on farm-gate prices are incomplete, and much less complete than market prices. Therefore, and whenever necessary, we have used the share of farm gate price relative to market price to construct complete series of farm-gate prices. Monthly market prices of all crops are available for around 70 markets. For a few crops (notably cassava, sweet potatoes, pigeon peas and millet) we have used empirical studies to construct sensible estimates of farm-gate prices. Prices for groundnuts pertain to unshelled groundnuts, prices for rice to rice paddy, prices for millet to finger millet and prices for cassava to cassava root. Prices are averaged over time in order to construct crop prices by crop year. Crop years are from April to March.

4. Impact of FIDP on productivity and diversification

Basic specification

In discussing estimation results of the models elaborated in the previous section we start with showing the straight estimations of the basic specification. Hence, no instrumenting of the

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Malawi, but mainly estate crops: smallholders account for less than 15% of tea and sugar production. Coffee is a minor crop. Little is known about fruits and vegetables. In all, these omissions are assumed not to affect the general message of this study.

[13] The data for the crop years 2003-04 and 2004-05 do not make this distinction. We do not know if the data for these years either include all components (notably "summer crop", "estate" and "winter crop") or are restricted to rain fed smallholder production ("summer crop"). This awaits further investigations.

intervention variable, no additional covariates, and no conversion of non-intervention locations to synthetic controls. These estimation results are reported in Table 1 for agricultural productivity and in Table 2 for diversification.

Table 2 Estimated impact of FIDP on agricultural productivity: basic specification

Dependent variable: aggregate gross crop revenue per hectare by Extension Planning Area ($ar_{i,t}$)

	(1)	(2)	(3)	(4)	(5)	(6)
I(2006-2010)	3463.8	5426.7	5621.5			
	(3.1)	(5.1)	(5.3)			
I(2006-2007)				-2447.8	-2441.9	-2073.3
				(1.5)	(1.6)	(1.4)
I(2007-2008)				-237.2	1764.1	2383.7
				(0.2)	(1.1)	(1.5)
I(2008-2009)				5433.6	10523.0	10976.2
				(3.4)	(6.5)	(6.9)
I(2009-2010)				11291.2	11363.2	12354.1
				(6.9)	(7.4)	(8.2)
dEPA(i)	yes	yes	yes	yes	yes	yes
dYEAR (t)	yes	yes	yes	yes	yes	yes
Number of observations	1313	1294	1287	1313	1285	1272
F (.)	(7,1110) 656.7	(7,1091) 687.8	(7,1085) 691.5	(10,1107) 487.7	(10,1079) 514.8	(10,1068) 526.5
Prob > chi2	0.00000	0.0000	0.0000	0.00000	0.0000	0.0000
Adjusted R2	0.8434	0.8585	0.8597	0.8506	0.8589	0.8611
RMSE	9817.6	9329.8	9309.0	9588.1	9063.4	8888.2

Notes – The table reports estimates of agricultural productivity. Estimations are based on annual data from 2003-04 to 2009-10 (seven years). All equations are estimated with OLS. Absolute *t*-statistics are given in parentheses (.) below the coefficient. Adjusted R2 = coefficient of determination, adjusted for degrees of freedom, and RMSE = Root Mean Squared Error. We do not report coefficients and t-values of the constant term and a complete set of EPA dummies and year dummies (dEPA(i), dYEAR(t)). Estimations in column (3) to (6) follow the specification of equation (3), with restrictions on the coefficients.

In Table 2 and 3 we start with the specification that restricts the impact to a fixed impact over the years (equation (1) to (3) in both tables), while the remaining estimations (equation (3) to (6) in both tables) allow for impacts to vary over the years. Equations in column (1) and (4) are estimated on the basis of the full sample. The other estimations are cleaned for observations that are likely to affect the estimated coefficients in a non-representative way. Error terms could be related to the district or RDP: therefore we have reported in Appendix C the same impact estimation as in Table 2 and 3 with RDP clustered standard errors.

Table 3 Estimated impact of FIDP on crop revenue diversification: basic specification

Dependent variable: Herfindahl-Hirschman-index of gross crop revenue by Extension Planning Area ($cd_{i,t}$)						
	(1)	(2)	(3)	(4)	(5)	(6)
I(2006-2010)	0.0108	-0.0055	-0.0067			
	(1.6)	(0.9)	(1.1)			
I(2006-2007)				0.0183	0.0160	0.0148
				(1.8)	(1.6)	(1.5)
I(2007-2008)				-0.0113	-0.0191	-0.209
				(1.1)	(1.9)	(2.1)
I(2008-2009)				0.0029	-0.0094	-0.0122
				(0.3)	(0.9)	(1.2)
I(2009-2010)				0.0334	0.0247	0.0222
				(3.2)	(2.5)	(2.2)
dEPA(i)	yes	yes	yes	yes	yes	yes
dYEAR (t)	yes	yes	yes	yes	yes	yes
Number of observations	1313	1294	1289	1313	1295	1275
F (.)	(7,1110) 50.36	(7,1091) 53.59	(7,1087) 53.38	(10,1107) 37.01	(10,1089) 37.79	(10,1072) 36.45
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adjusted R2	0.6408	0.6791	0.6817	0.6443	0.6735	0.6761
RMSE	0.0614	0.05453	0.05428	0.06111	.05788	0.05767

Notes – The table reports estimates of crop diversification. Estimations are based on annual data from 2003-04 to 2009-10 (seven years). All equations are estimated with OLS. Absolute *t*-statistics are given in parentheses (.) below the coefficient. Adjusted R2 = coefficient of determination, adjusted for degrees of freedom, and RMSE = Root Mean Squared Error. We do not report coefficients and t-values of the constant term and a complete set of EPA dummies and year dummies (dEPA(i), dYEAR(t)). Estimations in column (3) to (6) follow the specification of equation (4), with restrictions on the coefficients.

The impact of FIDP on agricultural productivity (see Table 2) is positive and statistically significant in all equations. If we allow for a variable impact per year, the impact is small, negative and statistically insignificant in the first year (the first two years in equation (4)). In the three remaining years the impact is positive, statistically significant and increasing over the years. The impact of FIDP on crop diversification (see Table 3) is positive but not statistically significant or only weakly significant, if we impose a fixed impact over the years. If we allow impacts to vary over the years the sign of the impact alternates, with some years having a positive and significant impact (notably crop years 2009-2010 and 2006-2007) and some a negative impact (notably crop year 2007-2008). It should be noted that an increase in the Herfindhal-Hirschman index implies a decrease in diversification of crop revenue. Clustering of standard errors by RDP drastically decreases the significance of the impact variables.

However, the main conclusion can be maintained. It also should be noted that the need for clustering of standard errors is not evident.

Instrumenting the intervention variable and including additional covariates

The selection of intervention EPAs is not random but follows certain conditions. In impact analysis it is common to instrument the intervention variable. From the limited documentation on the modalities of FIDP we extract that selection for FIDP is restricted to districts with relatively high income and a willingness to invest in commercial agriculture and trade. Hence, we assume that selection is correlated, positively with gross crop income and population density, and negatively with poverty and distance to urban centres. The selection of intervention districts is a one-time decision – once an EPA is included to FIDP it remains included till the end of the program – and this decision is entirely determined by pre-intervention values of variables. Consequently, we use the intervention locations of one year (2006-2007) and investigate correlations with variables for the years 2003-2004 to 2005-2006. Since both 2003-2004 and 2004-2005 are crop years with extremely poor harvests, explanatory variables are restricted to 2005-2006. Selection equation estimations are reported in Table 4.

The estimations support to a considerable extent the postulated correlations. The correlation of the poverty head count and the intervention variable is negative and statistically significant in all equations. Distance to urban centres is only negative and statistically significant if a set of Agricultural Development Division (ADD) fixed effects is included. Per capita gross revenue is positive and statistically significant in most equations. Per capita crop area (of which population density is the inverse) is only negative and statistically significant if ADD fixed effects are excluded and this variable appears to be multi-collinear with per capita gross crop revenue. Including ADD fixed effects substantially improves the performance of the equation.

Table 4 Estimation of selection into FIDP

Dependent variable: FIDP intervention (binary variable: 1 if EPA is selected for FIDP, zero elsewhere)						
	(1)	(2)	(3)	(4)	(5)	(6)
Per capita gross crop revenue		1.3602	0.491		0.4752	0.6511
		(3.1)	(2.2)		(0.8)	(2.0)
Poverty head count	-3.6736	-3.8975	-3.7894	-9.6167	-9.0987	-8.6247
	(6.9)	(6.5)	(6.9)	(9.0)	(8.5)	(8.5)
Distance to urban centre	-0.1312	-0.0948	-0.1865	-0.5321	-0.5444	-0.5531
	(0.7)	(0.5)	(1.0)	(2.1)	(2.2)	(2.3)
Per capita crop area	0.0611	-1.1188		0.7952	0.2587	
	(0.2)	(2.3)		(2.5)	(0.4)	
dADD(j)	no	no	no	yes	yes	yes
Number of observations	170	170	170	168	168	170
WALD chi2 (.)	(3) 56.37	(4) 49.76	(3) 54.94	(8) 109.31	(9) 111.77	(8) 105.95
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.2194	0.2652	0.2378	0.5160	0.5110	0.4892
Log pseudo likelihood	-91.2398	-85.8882	-89.0816	-55.8933	-56.4664	-59.7069

Notes – The table reports estimates of selection into the Farmer Income Diversification Program (FIDP). Estimations are based on annual data of 2006-2007 (for the intervention variable) and data from 2003-04 to 2005-06 (for the pre-intervention explanatory variables). All equations are estimated with PROBIT. Absolute z-statistics are given in parentheses (.) below the coefficient, and these are based on robust standard errors (Huber/White/sandwich estimator). Pseudo R2 = pseudo coefficient of determination. We do not report coefficients and t-values of the constant term and a complete set of ADD dummies (dADD(j)). Agricultural Development Division (ADD) is a geographical unit between district and regions, and compatible with EPAs, districts and regions.

We have used the estimated equation reported in Table 4, column 6 to construct an instrumented intervention variable. Subsequently we have re-estimated the impact equations of Table 1 and 2 using the constructed intervention variable. The instrumental variable estimations are reported in Table 5 and 6.

The estimations reported in Table 5 and 6, columns (1) to (3), appear to be similar to non-instrumented estimations with a number of interesting divergences. Impact of FIDP on agricultural productivity again is positive, statistically significant, increasing over the years, after a lag of one year. However, the size of the impact of the impact has increased, particularly in crop year 2007-2008 and 2008-2009. With respect to crop diversification we find hardly any impact, neither increasing nor decreasing diversification if we use all observations. However, if we omit outliers the estimations generate some, but admittedly not strong, support for increases in crop diversification.

Table 5 Estimated impact of FIDP on agricultural productivity: instrumental variable of the intervention and additional covariates

Dependent variable: aggregate gross crop revenue per hectare by Extension Planning Area ($ar_{i,t}$)						
	(1)	(2)	(3)	(4)	(5)	(6)
I(2006-2007)	-5061.2	-4076.4	-3963.1	-5542.2	-4159.3	-3267.5
	(2.4)	(2.0)	(2.0)	(2.5)	(2.0)	(1.7)
I(2007-2008)	2327.1	6443.5	6691.4	-3650.4	3679.5	7721.5
	(0.9)	(2.5)	(2.6)	(1.3)	(1.4)	(3.0)
I(2008-2009)	2294.4	10330.4	11351.5	524.1	3772.4	11641.9
	(0.9)	(3.9)	(4.3)	(0.2)	(1.5)	(4.4)
I(2009-2010)	9861.2	14826.9	15889.6	4353.3	11374.1	16110.1
	(3.8)	(5.7)	(6.0)	(1.6)	(4.5)	(6.2)
Rainfall				19.803	11.0450	9.8597
				(8.9)	(6.0)	(5.6)
Maize price (lagged)				-15.7		
				(0.0)		
Tobacco price (lagged)				-8321.2		
				(6.1)		
Chemical fertilizer use				-1686.4		
				(0.1)		
dEPA(i)	yes	yes	yes	yes	yes	yes
dYEAR (t)	yes	yes	yes	yes	yes	yes
Number of observations	1313	1286	1266	1089	1313	1286
F (.)	(10,1107) 465.7	(10,1080) 494.1	(10,1063) 496.3	(13,887) 310.4	(11,1106) 439.9	(11,1079) 464.4
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adjusted R2	0.8449	0.8577	0.8599	0.8527	0.8497	0.8615
RMSE	9769.4	9311.9	9281.1	9473.4	9619.3	9185.8

Notes – see Table 2. All equations are estimated with IV of the intervention variable.

The remaining columns of Table 5 and 6 are similar instrumental variables estimations, but now with inclusion of additional covariates. In particular we include rainfall, lagged maize price, lagged tobacco price and chemical fertilizer use. For all four we expect a positive correlation with agricultural productivity. The expected sign in case of diversification is much less clear. Provided that crop revenue is heavily biased towards maize, we expect a positive impact of maize prizes (a positive supply response will increase maize production and maize revenue, increasing the concentration of maize crop revenue even further). A similar reasoning may apply for consumption of chemical fertilizer which is mainly used for maize and tobacco. Coefficients of other variables are difficult – these could be either positive or negative – but a significant correlation with diversification is likely.

Table 6 Estimated impact of FIDP on crop revenue diversification: instrumental variable of the intervention and additional covariates

Dependent variable: Herfindahl-Hirschman-index of gross crop revenue by Extension Planning Area ($cd_{i,t}$)						
	(1)	(2)	(3)	(4)	(5)	(6)
I(2006-2007)	0.0135	0.0125	0.0114	0.0096	0.0025	0.0020
	(1.0)	(1.0)	(0.9)	(0.7)	(0.2)	(0.2)
I(2007-2008)	0.0036	-0.0208	-0.0245	-0.0090	-0.0389	-0.0419
	(0.2)	(1.3)	(1.5)	(0.5)	(2.3)	(2.5)
I(2008-2009)	-0.0195	-0.0545	-0.0582	-0.0288	-0.0555	-0.0585
	(1.2)	(3.2)	(3.4)	(1.7)	(3.4)	(3.6)
I(2009-2010)	0.0018	-0.0282	-0.0310	0.0023	-0.0186	-0.0221
	(0.1)	(1.7)	(1.8)	(0.1)	(1.1)	(1.3)
Rainfall				0.00006	0.00003	0.00003
				(4.2)	(2.6)	(2.4)
Maize price (lagged)				0.0232	0.0294	0.0299
				(1.4)	(1.9)	(1.9)
Tobacco price (lagged)				-0.0063		
				(0.7)		
Chemical fertilizer use				0.8927	0.9443	0.9566
				(6.1)	(6.8)	(6.8)
dEPA(i)	yes	yes	yes	yes	yes	yes
dYEAR (t)	yes	yes	yes	yes	yes	yes
Number of observations	1313	1279	1266	1089	1065	1055
F (.)	(10,1107) 35.24	(10,1073) 38.81	(10,1062) 38.89	(13,887) 28.3	(12,864) 34.77	(12,856) 35.31
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adjusted R2	0.6400	0.6633	0.6643	0.6665	0.6956	0.6986
RMSE	0.06148	0.05855	0.05856	0.05958	0.05599	0.05561

Notes – see Table 3. All equations are estimated with IV of the intervention variable.

In case of agricultural productivity (Table 5, column 3 to 6) the estimations show a statistically significant impact of rainfall, while the other covariates are insignificant or have the wrong sign or both. Impact variables and goodness of fit are similar to estimations without additional covariates. In case of crop revenue diversification (Table 6, column 3 to 6) the estimations show a statistically significant impact of rainfall, lagged maize price and fertilizer use, while lagged tobacco price is insignificant. Both lagged maize price and fertilizer use have the expected (positive) sign. In case of crop revenue diversification the significance of the impact variables improves substantially. Again, clustering of standard errors by RDP – reported in Appendix C – drastically decreases the significance of the impact variables, but impact variables remain sufficiently significant to maintain the previous conclusions.

Estimation with synthetic controls

In the impact estimation we have treated all control EPAs in a similar way. The non-random selection of intervention EPAs will create a bias in both intervention and control EPAs. Consequently, it is not likely that the control EPAs, with each EPA weighted equivalently, establish a proper counterfactual for the intervention EPAs. To correct for this error we have constructed a synthetic control for each EPA (see Abadie et al., 2010). The synthetic control is an (out-of-sample) prediction of a simple linear estimation of the outcome indicator – in our case gross crop revenue per hectare and diversification of crop revenue – of each intervention EPA on the outcome indicators of non-intervention EPAs, both before the intervention has started. Practically we search for those (combinations of) non-intervention EPAs of which the outcome indicator correlates well with an intervention EPA during the pre-intervention period. In formula this is represented with:

$$Y_{t(0),\ intervention} = \vartheta_0 + \sum_i \vartheta_{1i}\, Y_{i,t(0),non-intervention} \qquad (5)$$

where the subscripts *t(0)* refer to pre-intervention periods, and *(non-)intervention* to (non-) intervention EPAs. In general it make sense to restrict the number of non-intervention EPAs in equation (5) to the EPAs that are preferably bordering to or otherwise nearest to (the left hand side) intervention EPA. In our case, however, the number of non-intervention EPAs is even more drastically restricted by the number of pre-intervention periods: we have only four pre-intervention years and, hence, at most two explanatory non-intervention EPAs[14]. There is a total of 96 EPAs that is covered by FIDP (intervention EPAs) and a total of 102 EPAs that is not covered by FIDP (non-intervention EPAs). In the case of synthetic controls we construct a synthetic control EPA for each intervention EPA. For expositional brevity we do not report the

[14] We use the crop years 2003-2004, 2004-2005, 2005-2006 and 2006-2007 as the pre-intervention years. Formally this is not correct since FIDP operations started at the end of 2005. However, we assume this is justified since estimations in previous sections only indicate statistically significant impacts from 2007-2008 onwards.

(two times) 96 selected estimations results that are used to construct the synthetic controls[15]. Since we construct new control EPAs, the estimation strategy to instrument the selection of intervention EPAs disintegrates. The estimations using synthetic controls are reported in Table 7, the left panel for productivity, the right panel for diversification. The first estimation uses the full sample of observations, the next after cleaning for single observations and single EPAs that have a disproportionally large influence on the impact coefficient.

Table 7 Estimated impact of FIDP on the basis of synthetic controls

Dependent variable:	aggregate gross crop revenue per hectare by EPA ($ar_{i,t}$)			Herfindahl-Hirschman-index of gross crop revenue by EPA ($cd_{i,t}$)		
	(1)	(2)	(3)	(4)	(5)	(6)
I(2006-2007)	-927.7	-841.7	-601.9	-0.0079	-0.0123	-0.0102
	(0.6)	(0.5)	(0.4)	(0.8)	(1.3)	(1.1)
I(2007-2008)	1361.5	2997.4	3327.5	-0.0557	-0.0596	-0.0593
	(0.9)	(1.9)	(2.1)	(5.6)	(6.1)	(6.1)
I(2008-2009)	13848.6	13934.6	14338.3	-0.0168	-0.0207	-0.0169
	(8.8)	(9.0)	(9.3)	(1.7)	(2.1)	(1.8)
I(2009-2010)	10898.9	10984.2	11498.7	-0.0061	-0.0121	-0.0100
	(6.9)	(7.1)	(7.5)	(0.6)	(1.2)	(1.0)
dEPA(i)	yes	yes	yes	yes	yes	yes
dYEAR (t)	yes	yes	yes	yes	yes	yes
Number of observations	1214	1205	1198	1201	1194	1186
F (.)	(183,1030) 34.82	(183,1021) 35.47	(182,1015) 35.91	(181,1019) 14.28	(181,1012) 14.96	(180,1005) 14.87
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adjusted R2	0.8361	0.8397	0.8415	0.6671	0.6793	0.6781
RMSE	8963.7	8869.5	8775.2	0.05685	0.05536	0.05432

Notes – see Table 2 and 3.

In the case of agricultural productivity (Table 7, column 1 to 3) we find a statistically significant and large sized positive impacts in 2008-2009 and 2009-2010, both absolute and compared with the IV estimates. The accuracy of these estimates has improved substantially, relative to the IV estimates. The impact for the year 2007-2008 is much smaller than the impact

[15] The complete output of these estimations is available from the author on request. However, the work is simple but tedious, laborious and hard to program efficiently. In all estimations we selected correlations with statistically significant positive coefficients, and with one but preferably two explanatory non-intervention EPAs, either bordering the intervention EPA or otherwise as near as possible. Estimations with two explanatory non-intervention EPAs appeared difficult: most outcome indicators of intervention EPAs only correlated well with one non-intervention EPA. It should be noted that these restrictions still leave substantial flexibility in selecting equations.

in the last two years and also relative to the same year with IV estimation, and not statistically significant if estimated with the full sample.

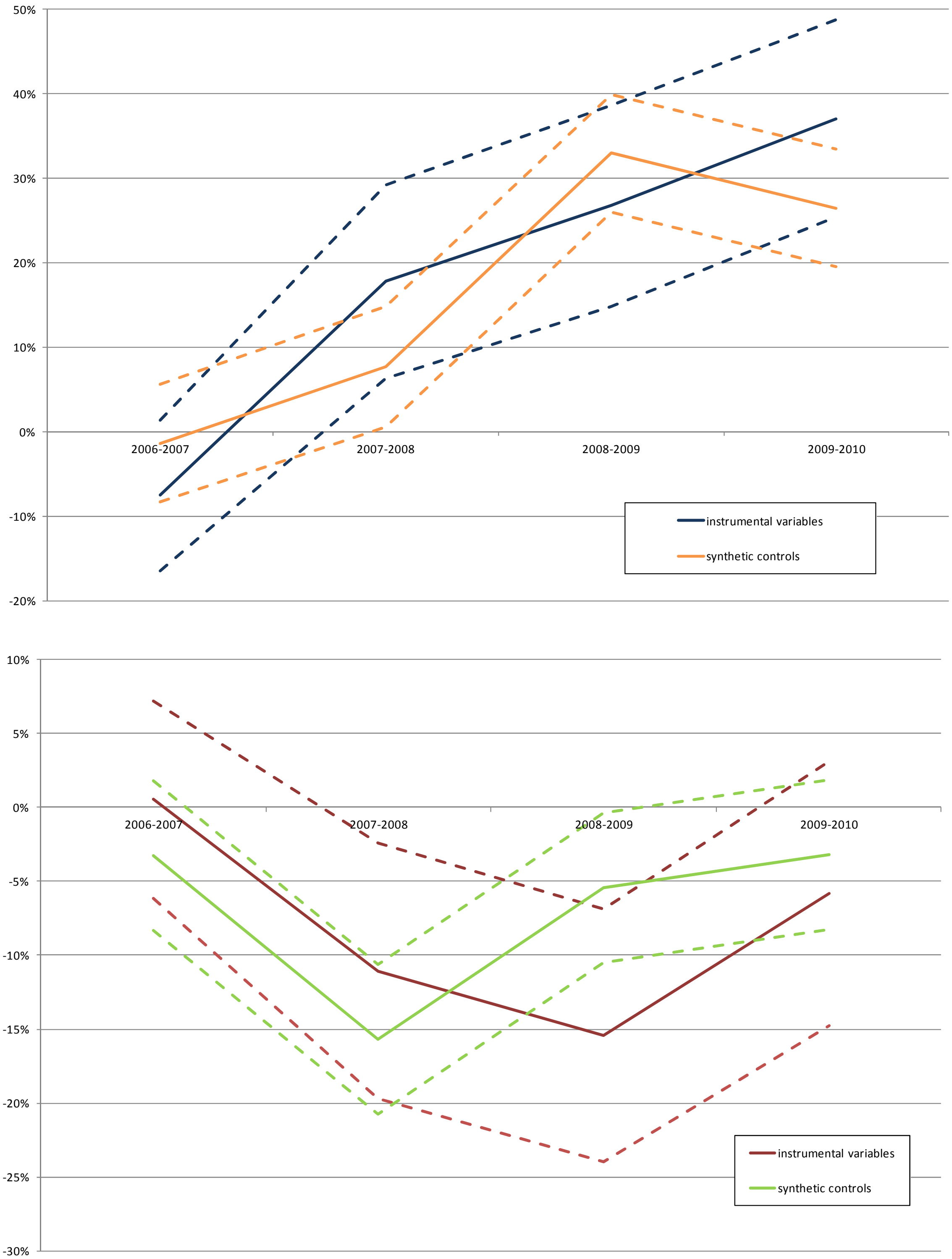
In the case of diversification (Table 7, column 4 to 6) we find statistically significant negative impact in 2007-2008 (highly significant) and 2008-2009 (weakly significant). Recall that a negative impact implies an improvement in diversification. Relative to IV estimates the 2007-2008 results are an improvement in terms of size and significance, and for 2008-2009 the reverse applies. Both at the start in 2006-2007 – and this can be justified – and in the final year in 2009-2010 – and this more difficult to justify – the impact on diversification is marginal to small, just like with the IV estimates.

There appears to be a distinct regional pattern (not shown): without elaborating this further the estimations support a large and significant impact in the final years in the central region. The results for the north and the south are mixed, dependent on estimation technique. Estimations by region await further investigations but do suggest useful areas to extend this exercise.

How to evaluate the estimation results?

Statistically significant impact coefficients tell us little about the (relative) size of the impact. Therefore we have expressed the impact coefficients relative to base year levels (of the FIDP EPAs). In terms of "treatment analysis" vocabulary this corresponds with the average treatment effect of the treated. This is shown graphically in Figure 1. The figure is based on the instrumental variable estimation including additional covariates (T5, eq6; T6, eq6) and the synthetic control estimations (T7, eq3 and eq5).

Figure 1 Impact of FIDP on agricultural productivity (upper panel) & crop revenue diversification (lower panel), in % change of base year levels



* The dotted lines indicate 95% confidence intervals.
Notes: Figures are based on estimation results of Table 5, 6 (eq. 6) and 7 (eq. 3 and 6)

The figure supports a substantial impact of FIDP on productivity, increasing to 27-36% in 2009-2010. To stay on the save side we may conclude that the evidence supports a productivity increase of at least 20-24% in 2009-2010 (the lower bound of 95% confidence interval). In the case of diversification the impact is smaller and falls back in the last year: the impact increase over the years to -17% in 2008-2009, to return to -4% in 2009-2010. Again, staying on the save side, a 5 to 10% improvement in diversification in 2007-2009 is likely.

5. Summary and conclusion

In this paper we have measured the impact of Farmers Income Diversification Program (FIDP), an EU funded program implemented in Malawi and aiming at increasing productivity, diversification, commercialization and trade of subsistence farmers. We have specifically looked at the impact on agricultural productivity, measured as crop revenue per hectare in constant prices for a total of 15 crops, and the impact on crop revenue diversification, measured with the Herfindhal-Hirschman index of crop revenue. Computations are based on annual data by Extension Planning Area, 198 in total, fully covering Malawi, for 2003-04 to 2009-10. FIDP is implemented in selected districts of Malawi: we have exploited this selection for the identification of impacts. We have corrected for endogeneity of being selected into FIDP by using instrumental variables. We have also constructed synthetic controls in order to attribute appropriate weights to controls. The estimations support a statistically significant impact of FIDP on agricultural productivity, with increases relative to base period levels reaching 20-24% in 2009-2010, with a lag of one year after the start of the program and increasing over the years. Estimations on diversification of crop income are less strong but still suggest indicate ranging from 5% to 10%. The evidence suggests that the impact on diversification is not continuously increasing over the years. Results are robust for instrumental variables, synthetic controls, clustered standard errors and inclusion of additional covariates.

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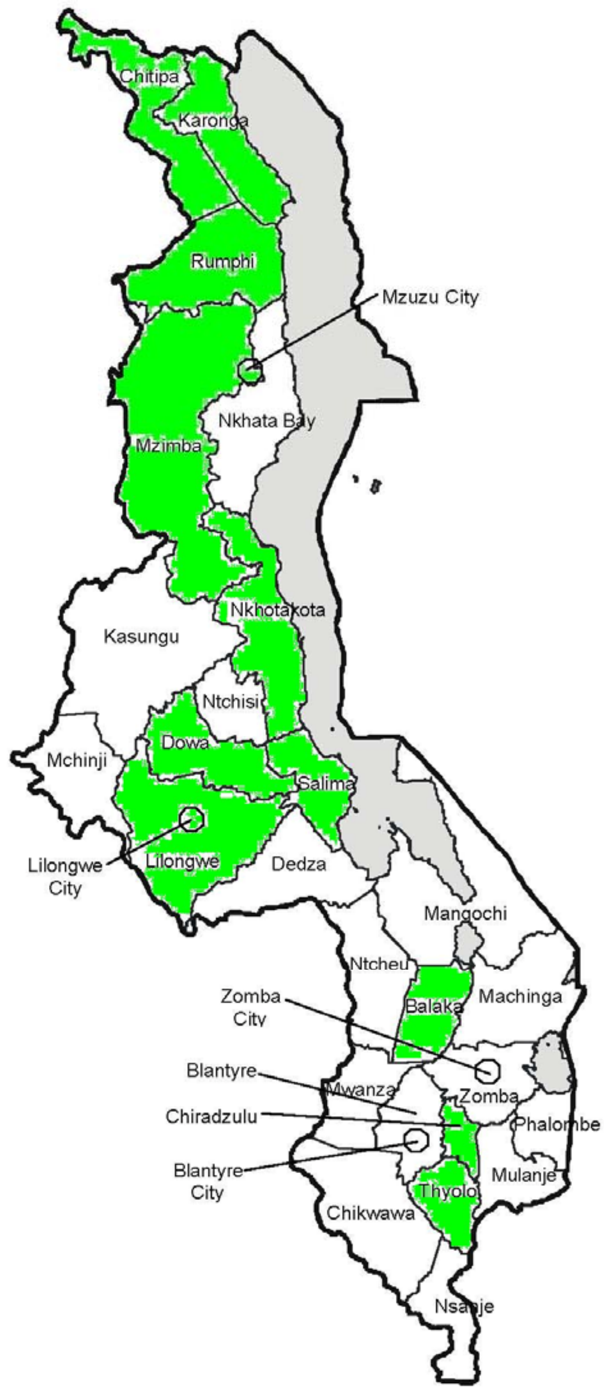
Appendix A Data: conceptual issues and data sources

Annual production, area and price data of agricultural crops are from the Agro-Economic Survey of the Ministry of Food Security and Agriculture in Malawi. Production and area data are at the EPA level, price data are at the market level. A total of fifteen crops is identified: local maize, composite maize, hybrid maize, rice, cassava, sorghum, millet, beans, pigeon peas, cow peas, soybean, sweet potatoes, groundnuts, cotton and tobacco. Production and area of crops is restricted to summer crops or rain-fed crops. All prices are converted to real prices using the rural consumer price index, obtained from National Statistical Office, Zomba (NSO). Data on the poverty head count ratio by district are from the Integrated Household Survey 2005 (IHS-2) and the Welfare Monitoring Survey of 2007 and 2009 (WMS 2007 to 2009), both published by NSO. Annual data on rainfall in mm by district are from the Department of Climate Change and Meteorological Services, Blantyre. Aggregate data on fertilizer use are from the 2007-2008 Annual Agricultural Statistical Bulletin of the Ministry of Agriculture and Food Security. Annual aggregate fertilizer consumption by type of fertilizer is allocated to districts using the allocation of subsidized fertilizer packages (data also from the Ministry of Agriculture and Food Security). Distances in km between district towns and urban centers are obtained from the Travel Distance Calculator (www.mapcrow.info).

Appendix B   Districts in Malawi where FIDP is implemented



Appendix C Impact estimations with RDP clustered standard errors

The tables in this appendix report impact estimations with RDP clustered standard errors and correspond with the tables in the main text.

Table 2' Estimated impact of FIDP on agricultural productivity: basic specification

Dependent variable: aggregate gross crop revenue per hectare by Extension Planning Area ($ar_{i,t}$)

	(1)	(2)	(3)	(4)	(5)	(6)
I(2006-2010)	3463.8	5426.7	5621.5			
	(0.9)	(1.7)	(1.8)			
I(2006-2007)				-2447.8	-2441.9	-2073.3
				(0.8)	(0.8)	(0.7)
I(2007-2008)				-237.2	1764.1	2383.7
				(0.1)	(0.6)	(0.8)
I(2008-2009)				5433.6	10523.0	10976.2
				(0.9)	(2.0)	(2.1)
I(2009-2010)				11291.2	11363.2	12354.1
				(2.0)	(2.0)	(2.4)
dEPA(i)	yes	yes	yes	yes	yes	yes
dYEAR (t)	yes	yes	yes	yes	yes	yes
Number of observations	1313	1294	1287	1313	1285	1272
F (.)	(7,26) 68.35	(7.26) 107.95	(7,26) 108.17	(10,26) 48.98	(10,26) 58.19	(10,26) 59.49
Prob > chi2	0.00000	0.0000	0.0000	0.00000	0.0000	0.0000
Adjusted R2	0.8434	0.8585	0.8597	0.8506	0.8589	0.8611
RMSE	9817.6	9329.8	9309.0	9588.1	9063.4	8888.2

Notes – see Table 2 in the main text. Equations in this table are estimated with RDP clustered standard errors.

Table 3' Estimated impact of FIDP on crop revenue diversification: basic specification

Dependent variable: Herfindahl-Hirschman-index of gross crop revenue by Extension Planning Area ($cd_{i,t}$)						
	(1)	(2)	(3)	(4)	(5)	(6)
I(2006-2010)	0.0108	-0.0055	-0.0067			
	(0.8)	(0.4)	(0.5)			
I(2006-2007)				0.0183	0.0160	0.0148
				(0.9)	(0.8)	(0.7)
I(2007-2008)				-0.0113	-0.0191	-0.209
				(0.7)	(1.4)	(1.6)
I(2008-2009)				0.0029	-0.0094	-0.0122
				(0.1)	(0.5)	(0.6)
I(2009-2010)				0.0334	0.0247	0.0222
				(1.7)	(1.3)	(1.1)
dEPA(i)	yes	yes	yes	yes	yes	yes
dYEAR (t)	yes	yes	yes	yes	yes	yes
Number of observations	1313	1294	1289	1313	1295	1275
F (.)	(7,26) 7.5	(7,26) 6.65	(7,26) 53.38	(10,26) 10.93	(10,26) 10.67	(10,26) 10.33
Prob > chi2	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
Adjusted R2	0.6408	0.6791	0.6817	0.6443	0.6735	0.6761
RMSE	0.0614	0.05453	0.05428	0.06111	.05788	0.05767

Notes – see Table 3 in the main text. Equations in this table are estimated with RDP clustered standard errors.

Table 5' Estimated impact of FIDP on agricultural productivity: instrumental variable of the intervention and additional covariates

Dependent variable: aggregate gross crop revenue per hectare by Extension Planning Area ($ar_{i,t}$)						
	(1)	(2)	(3)	(4)	(5)	(6)
I(2006-2007)	-5061.2	-4076.4	-3963.1	-5542.2	-4159.3	-3267.5
	(1.5)	(1.3)	(1.2)	(1.8)	(1.4)	(1.1)
I(2007-2008)	2327.1	6443.5	6691.4	-3650.4	3679.5	7721.5
	(0.5)	(1.7)	(1.7)	(0.6)	(0.8)	(2.2)
I(2008-2009)	2294.4	10330.4	11351.5	524.1	3772.4	11641.9
	(0.3)	(1.4)	(1.6)	(0.1)	(0.5)	(1.6)
I(2009-2010)	9861.2	14826.9	15889.6	4353.3	11374.1	16110.1
	(1.2)	(2.1)	(2.3)	(0.7)	(1.4)	(2.5)
Rainfall				19.803	11.0450	9.8597
				(3.5)	(2.2)	(2.3)
Maize price (lagged)				-15.7		
				(0.0)		
Tobacco price (lagged)				-8321.2		
				(2.4)		
Chemical fertilizer use				-1686.4		
				(0.0)		
dEPA(i)	yes	yes	yes	yes	yes	yes
dYEAR (t)	yes	yes	yes	yes	yes	yes
Number of observations	1313	1286	1266	1089	1313	1286
F (.)	(10,26) 67.34	(10,26) 63.80	(10,26) 66.15	(13,26) 72.3	(11,26) 87.51	(11,26) 78.97
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adjusted R2	0.8449	0.8577	0.8599	0.8527	0.8497	0.8615
RMSE	9769.4	9311.9	9281.1	9473.4	9619.3	9185.8

Notes – see Table 2 in the maintext. All equations are estimated with IV of the intervention variable. Equations in this table are estimated with RDP clustered standard errors.

Table 6’ Estimated impact of FIDP on crop revenue diversification: instrumental variable of the intervention and additional covariates

Dependent variable: Herfindahl-Hirschman-index of gross crop revenue by Extension Planning Area ($cd_{i,t}$)						
	(1)	(2)	(3)	(4)	(5)	(6)
I(2006-2007)	0.0135	0.0125	0.0114	0.0096	0.0025	0.0020
	(0.5)	(0.5)	(0.5)	(0.6)	(0.2)	(0.1)
I(2007-2008)	0.0036	-0.0208	-0.0245	-0.0090	-0.0389	-0.0419
	(0.2)	(1.5)	(1.8)	(0.3)	(1.7)	(1.9)
I(2008-2009)	-0.0195	-0.0545	-0.0582	-0.0288	-0.0555	-0.0585
	(0.6)	(1.9)	(2.1)	(0.9)	(2.0)	(2.1)
I(2009-2010)	0.0018	-0.0282	-0.0310	0.0023	-0.0186	-0.0221
	(0.1)	(1.2)	(1.4)	(0.1)	(0.9)	(1.0)
Rainfall				0.00006	0.00003	0.00003
				(2.7)	(1.6)	(1.5)
Maize price (lagged)				0.0232	0.0294	0.0299
				(0.9)	(1.2)	(1.2)
Tobacco price (lagged)				-0.0063		
				(0.4)		
Chemical fertilizer use				0.8927	0.9443	0.9566
				(2.5)	(2.6)	(2.6)
dEPA(i)	yes	yes	yes	yes	yes	yes
dYEAR (t)	yes	yes	yes	yes	yes	yes
Number of observations	1313	1279	1266	1089	1065	1055
F (.)	(10,26) 11.80	(10,26) 11.69	(10,26) 12.63	(13,26) 15.9	(12,26) 12.93	(12,26) 14.68
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adjusted R2	0.6400	0.6633	0.6643	0.6665	0.6956	0.6986
RMSE	0.06148	0.05855	0.05856	0.05958	0.05599	0.05561

Notes – see Table 3 in the main text. All equations are estimated with IV of the intervention variable. Equations in this table are estimated with RDP clustered standard errors.