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Looking at Pro-Poor Growth from an Agricultural Perspective

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Looking at Pro-Poor Growth from an Agricultural Perspective

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Abstract

Pro-poor growth has been identified as one of the most promising pathways to achieve the Millennium Development Goals (MDGs) or any subsequent set of goals aiming to reduce poverty worldwide. Related research has developed a multitude of instruments to measure pro-poor growth using absolute and relative approaches and income and non-income data. This article contributes to the literature by expanding the toolbox with several new measures based on the concept of the growth incidence curve by Ravallion and Chen (2003) and the opportunity curve by Ali and Son (2007) that take into account the extraordinary importance of agriculture for poverty reduction in developing countries. The toolbox is then applied to two comparable household surveys from Rwanda (EICV data for the years 1999-2001 and 2005-2006), a country that has experienced impressive economic growth since the genocide in the mid-1990s and that has undertaken considerable efforts to increase the population's access to social services over the last decade. Results indicate that Rwanda achieved in this time period enormous progress in the income, but also in the education and health dimension of poverty, which was in many cases even pro-poor in the relative sense. The new tools further reveal that agricultural productivity of the labor/land productivity-poor increased relatively (but not absolutely) faster than for the labor/land productivity-rich. Lastly, we find indications that the labor productivity-poor dispose of less education than the labor productivity-rich which may imply further potential to increase the poor's productivity levels if their education levels increased.

Keywords: Agricultural Productivity, Inequality, Multidimensional Poverty, Pro-Poor Growth, Rwanda, Sub-Saharan Africa

JEL classification: E6, I3, O1

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1. Introduction

Given that the eradication of poverty worldwide continues to be one of the most important challenges for humanity, much research effort has over the last decades been dedicated to the question how this ambitious goal may be achieved. As a result, the idea of pro-poor growth (PPG) emerged in the late 1990s/early 2000s as a way to accelerate poverty reduction (e.g. Klasen, 2004, 2008). Since then, this concept has received a great deal of attention and its focus on how the poor are benefitting from growth is seen as central to poverty reduction efforts (e.g. United Nations 2000; World Bank 2000a, b; Ravallion 2001; Klasen 2004). The literature on pro-poor growth has developed various instruments providing researchers with the possibility to evaluate from an ex-post perspective the extent to which the poor benefited from recent developments in a country (these instruments are regularly referred to as the "pro-poor growth toolbox"). Most notably, Ravallion and Chen (2003) introduced the growth incidence curve (GIC) as a central tool to measure pro-poor growth which provides income growth rates by quantiles (e.g. vintiles or percentiles) ranked by income. Grosse et al. (2008) and Klasen (2008) showed with the so-called non-income growth incidence curve (NIGIC) that the concept of the GIC is also applicable to non-income dimensions of poverty such as education or health. Using these GIC and NIGICs one can then assess whether, according to the definitions proposed in Grosse et al. (2008) and Klasen (2008), growth was pro-poor in the weak absolute sense (it increased absolute outcomes for the poor, GIC/NIGIC above 0 for the poor), relative sense (rates of progress were faster for the poor than the non-poor, GIC/NIGIC downward sloping), or strong absolute sense (absolute improvements for the poor greater than the non-poor, absolute GIC/NIGIC downward sloping). A related approach was also pursued by Ali and Son (2007) who developed the so-called opportunity curves which are likewise focused on non-income dimensions of poverty and plot the level of access to certain social services against the cumulative share of the population ranked by income.

However, all of the above-mentioned tools focus to far on income and non-income dimensions of well-being. One reasonable way to further extend the concept is to examine how pro-poor productivity improvements have been. Given the extraordinary importance of agriculture for poverty reduction worldwide (e.g. World Bank 2007; de Janvry and Sadoulet 2010; Valdés and Foster 2010; Christiaensen et al. 2011), we suggest in this article that it is straightforward to define the "poor" not only in terms of income, education or health, but also in terms of agricultural productivity. Such an approach can be readily implemented in the PPG-toolbox by slightly modifying some of the existing tools. The resulting new instruments can be called "productivity growth incidence curve" (PGIC) and "productivity opportunity curve" (POC) and allow us to look at pro-poor growth from a complementary, agricultural productivity-based perspective.

To illustrate the potential of this extended toolbox, we then apply it to two waves of the nationally-representative EICV[1] household survey from Rwanda (years 1999-2001 and 2005-2006). Rwanda was chosen for our empirical application for three reasons. First, the Rwandan economy has since the genocide in 1994 gone through an impressive development and Rwanda belongs currently to the most rapidly growing countries in Sub-Saharan Africa (average annual growth rate of *per capita* income between 2000 and 2010 was 4.67% compared to an SSA average of 2.65% (WDI 2012)). Second, the Rwandan government has over the last decade undertaken considerable efforts to increase the population's access to social services (e.g. Saksena et al. 2011) which is one of the reasons why the United Nations consider Rwanda – despite the very challenging situation after the genocide – as one of the countries largely on track to achieve many of the Millennium Development Goals by the year 2015 (UNDP 2003, 2007). Third, Rwanda has the highest population density in Sub-Saharan Africa (approx. 431 inhabitants per square kilometer compared to an average of SSA countries of approx. 36 inhabitants per sq. km.) and its population keeps on growing rapidly at a rate of approx. 2.96% annually (all numbers from WDI 2012). As a consequence of this combination, the Rwandan government finds itself in the challenging situation of having to increase the (land) productivity of the agricultural sector to ensure food security where land is an increasingly scarce factor which cannot be expanded much anymore.

The results of our analysis indicate that Rwanda has in recent years achieved impressive progress in both, income and non-income dimensions of poverty. The observed progress was in many cases not only pro-poor according to the weak-absolute but also to the relative and sometimes even to the strong-absolute definition (e.g. for access to improved sanitation and incidence of illness/injuries in the last 14 days). The new agricultural productivity-based tools, namely the monetary and crop-specific PGICs for labor and land productivity, revealed that the productivity-poor were able to increase their productivity levels relatively (but not absolutely) faster than the productivity-rich. Using the POCs (Type 1) it was further found that the labor productivity-poor exhibit in both surveys conspicuously lower education levels than the labor productivity-rich and that – despite impressive progress also for the labor productivity-poor – the absolute gap in education between both groups has increased. Lastly, the POCs (Type 2) revealed considerably lower labor and land productivity levels for human capital-poor households in Rwanda.

The article proceeds as follows. Section 2 gives a brief overview on different concepts of pro-poor growth and the measurement tools so-far suggested in the PPG-literature. Section 3 discusses the policy relevance and limitations of the hitherto existing toolbox. In addition, it introduces the new instruments which enable us to look at pro-poor growth from an agricultural perspective. Section 4

[1] The French acronym EICV stands for Enquête Intégrale sur les Conditions de Vie des ménages au Rwanda.

describes the EICV household data which are used for the empirical application. The results of our pro-poor analysis are then discussed separately for the hitherto existing PPG-toolbox (section 5) and the new agricultural productivity-based tools (section 6). Lastly, section 7 summarizes the main results of our analysis and discusses potential limitations and policy implications.

2. Definition and measurement of pro-poor growth

Emanating from the critique on the theory of trickle-down (e.g. Chenery et al. 1974) which assumed that the poor will indirectly benefit from economic growth when the rich start to spend their gains, the idea of pro-poor growth has emerged in the late 1990s/early 2000s as one of the key instruments to achieve sustainable poverty reduction[2] (United Nations 2000; World Bank 2000a, b; Ravallion 2001; Klasen 2004). Despite numerous attempts, there is until today no consensus definition of what is meant by pro-poor growth (for attempts see e.g. McCulloch and Baulch 1999; Kakwani and Pernia 2000; Hanmer and Booth 2001; White and Anderson 2001; Ravallion and Datt 2002; Ravallion and Chen 2003; Duclos and Wodon 2004; Klasen 2004; Son 2004), with different groups of researchers/policy makers emphasizing different aspects (Duclos and Wodon 2004; OECD 2006).

As discussed above, we follow Grosse et al. (2008) and Klasen (2008), and distinguish between a weak-absolute, a relative, and a strong-absolute definition. According to the weak-absolute definition, every growth spell where the poor benefited to any, whatsoever small extent (i.e. their aggregated growth rate was larger than zero) must be called pro-poor. The idea behind this notion is that to achieve poverty reduction (at least when applying an absolute concept of poverty) it is not important how the income growth of the poor compared to the one of the non-poor, but only that their incomes increased at all. However, one obvious downside of the weak-absolute definition is that it calls, somewhat counterintuitively, a growth spell pro-poor even when the poor benefited significantly less from it than the non-poor. The relative definition addresses this shortcoming and argues that developments are only pro-poor if the poor's income grew relatively faster than the one of the non-poor (i.e. the growth rate of the poor was larger). Hence, growth must be relatively biased in favor of the poor implying that relative inequality between the poor and the non-poor will fall. The strong-absolute definition goes even a step further since it requires the *absolute* income gains of the poor to be larger than those of the non-poor. Some researchers describe such growth as "biased in a dramatic fashion in favor of the poor" (Klasen 2008, p. 421) or even "super pro-poor" (Kakwani et al. 2004, p. 4). As shown empirically by White and Anderson (2001) the criteria of the strong-absolute definition of pro-poor growth are only rarely satisfied in reality. However, this is particularly true if

[2] One unifying feature of the articles from the pro-poor growth literature is that they doubt that the poor will somewhat "automatically" benefit one-for-one from economic growth as it was found in the widely-discussed cross-country study by Dollar and Kraay (2002).

the analysis is focused on the monetary dimension. When analyzing progress in non-monetary dimensions of poverty, it is not completely unusual to observe pro-poor growth according to all three definitions since many of the indicators are bounded above, i.e. they have by definition a predefined maximum value (e.g. number of vaccinations, share of the population having access to certain services) which particularly facilitates the occurrence of pro-poor growth according to the relative and the strong-absolute definition. Also, as argued by Klasen (2008), in non-income dimensions the strong absolute definition is intuitively more plausible as absolute increments in health and education are usually seen as the relative metric (rather than percentage changes which is more often used in the income sphere).

Based on the above concepts of pro-poor growth, various researchers have suggested tools and instruments aiming to measure *if* and also *how* pro-poor recent developments in a country were. Most notably, Ravallion and Chen (2003) introduced their growth incidence curve which graphically illustrates how the gains from economic growth were distributed. In order to construct the GIC, the individuals are first ranked for each period by their p.c. income and are then subdivided into p quantiles (e.g. vintiles or percentiles). For each of those quantiles the mean growth rate in p.c. income between $t-1$ and t is calculated separately being defined as

(1) $$g_t(p) = \frac{y_t(p)}{y_{t-1}(p)} - 1 = \frac{L_t'(p)}{L_{t-1}'(p)}(\gamma_t + 1) - 1$$

where $\gamma_t = \frac{\mu_t}{\mu_{t-1}} - 1$ is the growth rate in mean income μ and $L_t'(p)$ denotes the slope of the Lorenz curve at time t for quantile p. The GIC is then obtained by simply plotting the quantiles of the population ranked by their p.c. income on the horizontal axis against quantile-specific growth rates in p.c. income on the vertical axis. The concept of the GIC allows distinguishing between the above-mentioned three definitions of pro-poor growth. If $g_t(p) > 0$ (i.e. the quantile-specific growth rates in p.c. income are larger than zero) for all poor quantiles, developments have been pro-poor according to the weak-absolute definition. If the (relative) GIC is sloped downwards (i.e. growth rates of p.c. income were larger for poor than for non-poor households), this indicates pro-poor growth in the relative sense. To test whether developments have even been pro-poor according to the strong-absolute definition, the mean change in p.c. income in *absolute* terms has to be calculated for each quantile. If the corresponding absolute GIC is sloped downwards, this implies pro-poor growth according to the strong-absolute definition.

To further assess the *degree* of pro-poorness of a growth spell, Ravallion and Chen (2003) introduced a measure called pro-poor growth rate (PPGR) which can be formally defined as (notion in line with Grosse et al. 2008)

(2) $$PPGR = g_t^p = \frac{1}{H_t}\int_0^{H_t} g_t\,(\mathrm{p})\mathrm{d}p$$

The $PPGR$ is equivalent to the area under the GIC up to the headcount ratio H_t and thus measures the average growth rate of the poor quantiles. If the PPGR exceeds the growth rate in mean income (GRIM), growth has been pro-poor according to the relative definition. To test for pro-poor growth in the strong-absolute sense, it is necessary to calculate analogously to (2) the mean *absolute* change of the poor

(3) $$PPCH = c_t^p = \frac{1}{H_{t-1}}\sum_1^{H_t} c_t(p)$$

This measure can be called "pro-poor change" (PPCH) and reflects the area lying under the absolute GIC up to the headcount (Grosse et al. 2008). If the PPCH exceeds the absolute change in mean income, then growth was pro-poor according to the strong-absolute definition.

One drawback of the growth incidence curves as introduced by Ravallion and Chen (2003) is that they are exclusively focused on the income dimension and therefore do not account for the multidimensionality of poverty (e.g. Sen 1983, 1998; World Bank 2000a) which is, for instance, reflected in the MDGs. Yet, Grosse et al. (2008) and Klasen (2008) showed that the general concept of the GIC and the related measures is equally applicable to non-income dimensions of poverty (using outcome based welfare indicators) yielding the so-called non-income growth incidence curves (NIGIC). These NIGICs are often presented in a "conditional" and an "unconditional" version. The former resembles very much the income GIC since on the horizontal axis the individuals are likewise ranked by their p.c. income. However, on the vertical axis, there is no longer the growth rate in monetary terms but in an appropriate non-income dimension (e.g. years of education, number of vaccinations etc.). Hence, conditional NIGICs answer the question to what extent different parts of the *income* distribution were able to increase their level in the contemplated *non-income* indicator. The unconditional NIGIC additionally differs from the GIC in the sense that on the horizontal axis, the individuals are now ranked by their attainment in terms of the respective non-income indicator in time period $t-1$. Thus, the question answered by the unconditional NIGIC is whether growth in, for instance, years of schooling was relatively or absolutely faster for the education-poor than for the education-rich. Even though there is obviously some correlation between the poor in monetary and non-monetary terms, this relationship is far from perfect (e.g. Anand and Ravallion 1993; Sen 1998). As a consequence, the above two versions of the NIGICs regularly yield different results whereat the information provided by both types can be of considerable relevance for policy-makers (see section 3).

A third approach to measure pro-poor growth[3] was introduced by Ali and Son (2007) with the so-called "opportunity curves" which are closely related to the idea of a social welfare function. The general idea of these curves is relatively similar to the one of a conditional NIGIC with the exemption of two things. First, as in the case of conditional NIGICs, there are quantiles of the population ranked by p.c. income on the horizontal axis; however these quantiles are in the case of the opportunity curves *cumulated*. With this procedure, Ali and Son (2007) want – in line with the inherent idea of pro-poor growth – to implicitly weigh the opportunities enjoyed by the poor higher than those enjoyed by the rich. As a second difference, the opportunity curve plots the *level* and not the *growth* in the access to certain services on the vertical axis against the cumulative share of the population.

3. Policy relevance and limitations of the hitherto existing pro-poor growth toolbox

As the above explanations have shown, the literature so far has come up with a wide range of tools to measure pro-poor growth. The combination of all these tools provides researchers and policy makers with the possibility to ex-post evaluate who has benefited from recent developments in a country from quite different angles.

First, the "classical" growth incidence curve as introduced by Ravallion and Chen (2003) gives insights from the purely monetary perspective, thus indicating which parts of the income distribution experienced the highest growth rates/absolute increases in p.c. income whereas it cannot be distinguished whether such gains stem from direct participation in economic growth or from any kind of (governmental) transfers received. Nonetheless, the information provided by GICs is of considerable relevance for policy makers since it must be their goal to assure that no parts of the population are excluded from the benefits of economic growth. Such exclusion is not only problematic from a welfare point of view, but might also undermine opportunities for further economic growth (e.g. Galor and Zeira 1993; Persson and Tabellini 1994; Alesina and Rodrik 1994; Bourguignon 2004).

The insights provided by conditional NIGICs and opportunity curves can be seen as a complementary perspective which is closely related to the first. In particular, such tools allow policy makers to evaluate whether the poor in monetary terms were able to improve their level of well-being in non-income dimensions. As pointed out by Grosse et al. (2008) and Klasen (2008), such an analysis can be seen as an outcome-based incidence analysis (e.g. Van de Walle and Nead 1995; Van de Walle 1998; Lanjouw and Ravallion 1999) which differs from the traditional expenditure incidence analysis in the

[3] We use the term pro-poor growth even though Ali and Son (2007) speak of "inclusive growth". Indeed, there are minor differences between the two concepts; however, for the purpose of this article, we consider these discrepancies as negligible. See Klasen (2010) for a further discussion of inclusive growth.

sense that not the distribution of spending is measured, but the distribution of improvements in outcomes. In doing so, this variant circumvents the commonly criticized assumption of the expenditure incidence analysis that the consumer's benefit from the service can be approximated by the government's provision cost (Van de Walle 1998). From a policy point of view, the information provided by conditional NIGICs and opportunity curves may facilitate the maximization of the income poverty reducing effect of public expenditures for social services since it allows policy makers to evaluate whether the income-poorest have been reached by recent interventions. This can be seen as desirable in order to reduce the vulnerability of income-poor households and hence to enable them to break out of existing poverty traps.

The unconditional NIGIC approaches the issue of poverty from an additional third perspective because it no longer conceives the poor in monetary but in non-monetary dimensions. Consequently, it provides policy-makers with information whether increased social services provision has really reached those being most deficient in the dimension of interest (e.g. health or education). Against the background of the not income-related MDGs 2-6, such information is crucial for many Sub-Saharan African governments since they must try to allocate their scarce resources as efficiently as possible to achieve progress towards the ambitious non-income targets.

All of these measures share the feature that they are concerned with the distributional pattern of development outcomes. But we may also be interested in the distributional pattern of key drivers of development outcomes. For example, it is commonly held that improvements in agricultural output are critical for poverty reduction in low income countries (e.g. World Bank 2007; de Janvry and Sadoulet 2010; Valdés and Foster 2010; Christiaensen et al. 2011). The importance of agriculture is, of course, related to the fact that in most low-income countries an enormous share of the economically active population is still employed in agriculture (average of Sub-Saharan African countries in 2010: 59.08% (FAO 2011)). Furthermore, land of good quality becomes increasingly scarce in numerous SSA countries due to limits to land expansion. Against the backdrop of consistently high population growth rates (average of Sub-Saharan African countries in 2010: 2.50% (WDI 2012)), growth, poverty reduction and food security will heavily depend on success in raising agricultural land productivity.

The extraordinary role of agriculture for poverty reduction has also been highlighted directly and indirectly by several authors from the pro-poor growth literature. Most fundamentally, the poor are regularly characterized as typically living in rural areas, depending directly or indirectly on agriculture for their subsistence and to mainly possess the production factor of (unskilled) labor and to some extent land while human capital is usually rather scarce (e.g. Alderman et al. 2000; Ames et al. 2000; Eastwood and Lipton 2000; Ravallion and Datt 2002; World Bank 2000a). Taking these features together, Klasen (2004) claimed that it is crucial for pro-poor growth to be concentrated on rural areas, to use intensively (unskilled) labor and to enhance agricultural incomes. Eastwood and Lipton (2000) even went a step further and directly related pro-poor growth to the issue of productivity when calling for greater attention that should be given to increasing agricultural productivity in order to attain a significant reduction of poverty. Against the background of such claims, it appears important to assess the distributional pattern of agricultural productivity growth to find out who has benefited from recent improvements.

We therefore propose and apply several new instruments which should be understood as complements to the hitherto-existing PPG-toolbox and allow researchers and policy makers to ex-post evaluate distributional developments in a country from a fourth, agricultural productivity-based perspective. The first tool, which we henceforth call the "productivity growth incidence curve" (PGIC) is closely related to the "classical" GIC of Ravallion and Chen (2003) and plots quantiles of the population ranked now by their initial agricultural productivity on the horizontal axis against quantile-specific growth rates (or absolute increases) of agricultural productivity on the vertical axis. The resulting curves give researchers and policy-makers the opportunity to evaluate to what extent the productivity-poor (e.g. in terms of agricultural land productivity) were able to increase their agricultural production per hectare, and thus allow an assessment of how improvements of agricultural productivity are distributed.

The second newly-introduced tool relies on the idea of the opportunity curve of Ali and Son (2007) and we therefore call it "productivity opportunity curve" (POC) of which two different versions can be constructed. The POC (Type 1[4]) differs from the "classical" opportunity curve in the sense that we no longer have the cumulated share of the population sorted by income on the horizontal axis, but that quantiles are now sorted by agricultural productivity. Hence, such a POC (Type 1) investigates to what extent the productivity-poor were able to increase their education/health levels. In contrast to this, the second version of the productivity opportunity curve plots the cumulated share of the population sorted by education/health/human capital on the horizontal axis against the absolute levels of agricultural productivity on the vertical axis. Thus, it is the goal of the POC (Type 2) to answer the somewhat converse question, namely how the levels of agricultural productivity relate to deprivations in health or education. Both of these questions are relevant for policy makers given that there is nowadays a broad literature indicating considerable productivity-increasing effects of improved farmer's education and health at the micro (e.g. Ali and Flinn 1989; Young and Deng 1999;

[4] It should be noted that it would likewise be possible to construct a productivity-based form of a conditional NIGIC where one would then have vintiles of the population sorted by agricultural productivity on the horizontal axis and growth rates/absolute increases in terms of an appropriate non-income indicator (e.g. years of schooling) on the y-axis.

Alene and Manyong 2006; Asadullah and Rahman 2009 for education and Antle et al. 1998; Croppenstedt and Muller 2000; Loureiro 2009; Ulimwengu 2009; Asenso-Okyere et al. 2011 for health) and the macro level (e.g. Reimers and Klasen 2013). In addition, various studies analyzing the effects of different types of government expenditures on agricultural growth and poverty reduction in developing countries showed that investments in social services provision yield considerable returns in terms of agricultural productivity[5] (see e.g. Fan et al. 2000 and Fan et al. 2008 for India; Fan and Zhang 2008 for Uganda).

The new instruments should be seen as complements to the above-described classical devices from the PPG-literature. In the following empirical application, we will therefore first apply the hitherto existing toolbox (section 5) and then use the newly introduced instruments (section 6) to show that they can provide us with additional insights about recent developments in Rwanda.

4. Data and methodology

For the empirical part of this article, we use data from two waves of the Rwandan Integrated Household Living Conditions Survey (EICV) which were collected in the years 1999-2001 and 2005-2006. These two surveys are nationally representative and cover 6,420 and 6,900 households, respectively (equivalent to 32,153 and 34,785 individuals, respectively). The questionnaires of the surveys consist of a wide array of modules that include detailed questions e.g. about agricultural production, education, health, and household consumption. One particularity of the EICV consumption module is that each household was not just visited once, but numerous times (urban households eleven times at 3-day intervals and rural households eight times with 2-day intervals). Such an approach was chosen to ensure that payday-effects are adequately included for urban wage earners[6] and it can hence be expected that the consumption data from the EICV surveys will probably be more reliable than the ones obtained from other surveys where each household was just visited once. As a complement to the EICV2 household data, a community survey was conducted that includes a detailed price module for agricultural and non-agricultural goods on 28 local markets throughout Rwanda. The data from this price module will be used for the calculation of the agricultural production aggregate (see below).

[5] To be more precise, these studies found particularly high returns for investments in education whereas the returns to government spending on health turned out to be rather limited.

[6] The issue of payday-effects can be expected to be rather less severe for rural areas of Rwanda where only small shares of the population are actually wage earners. Consequently, it was considered less important to maintain the 30-day reference period for rural households and a reference period of 14 days was applied instead (MINECOFIN 2002).

As a first step of data preparation, we calculated a deflated[7] annual consumption aggregate for each household. In doing so, we mainly followed the approach used by the Rwandan National Institute for Statistics (NISR) in collaboration with the Oxford Policy Management Team (OPM) under the lead of Andy McKay and Emilie Perge (see NISR (2012) and Appendix A for a description of the approach).

Secondly, we computed two measures of agricultural productivity (namely labor and land productivity) for each household involved in agriculture whereat both measures were calculated in a four step-procedure as follows. Given that Rwandan farmers regularly report their harvests in non-standard units (i.e. not in kilogram, liters etc.), we had – as a first step – to calculate the average weight for each crop-container combination to be able to convert the harvest reported in non-standard units to kilograms. As a second step, we used the above-described price data from the EICV2 community survey to calculate regional average prices per kg for each crop. The resulting prices are – as a third step – used to convert the total harvest in kg for each crop in each of the in Rwanda typically two harvest periods into monetary values. The fourth step is then to simply aggregate the monetary values of those harvests on a household-level and to divide this sum either by the total size of *active* agricultural plots in hectare (i.e. excluding all plots lying idle in the time period under consideration) or by the total number of adults in a household who consider agriculture as their primary occupation[8]. The resulting measures of agricultural land/labor productivity reflect the theoretical[9] monetary value (in constant 2005 regional market prices) of the household's gross agricultural production per hectare of agricultural land/per adult worker in the 12 months preceding the survey.

As a last step of the data preparation, we computed various health and education indicators for both surveys. Given that those measures are standard in the literature, we do not explain their calculation in further detail. Before starting to discuss the findings of our empirical application, we would like to emphasize that the results of the following PPG-analysis could generally have been presented in two alternative ways. First, we could have focused the analysis on the entire Rwandan population for the hitherto existing PPG toolbox and have then restricted the analysis to the agrarian population for our newly developed tools where we require detailed agricultural production data. However, this approach would bear the disadvantage that results from the two sections were only to a limited extent comparable since they were actually based on different samples. To provide remedy to this shortcoming, we decided to restrict the sample throughout the entire PPG-analysis to the agrarian

[7] When adjusting for price differences, we used January 2001 as a basis for our consumption aggregate.
[8] Unfortunately, the information on agricultural labor contained in the EICV datasets are relatively crude and we therefore consider our measure for agricultural land productivity as more reliable.
[9] We are using the term *theoretical* since this number relies on the total amount harvested and not the total amount actually sold by the household, i.e. this number includes the monetary value of the harvest used e.g. for self-consumption, seeds, etc..

population which comprises in our case all households where at least one adult household member (aged 15 and above) reported working on the farm as his/her primary occupation. To give the reader a first idea of our sample, Table 1 provides an overview of the means of some key indicators for both EICV surveys.

Table 1: Sample means for EICV1 and EICV2 (agrarian population only)[10]

	EICV1	s.e.	EICV2	s.e
No. of households	5,376		5,397	
No. of individuals	26,705		27,656	
Household size	4.94	(0.034)	5.11	(0.032)
Age of household head	44.39	(0.223)	45.23	(0.219)
Share of male headed households (%)	67.44	(0.706)	71.77	(0.636)
Literacy rate (% - aged 15+)	51.73	(0.459)	63.16	(0.401)
Years of schooling (aged 15+)	2.38	(0.026)	3.42	(0.024)
Years of schooling of household head (aged 15+)	1.30	(0.036)	2.91	(0.041)
Share of households having access to impr. drinking water (%)	67.86	(0.707)	68.06	(0.654)
Share of households having access to impr. sanitation (%)	47.94	(0.751)	56.67	(0.699)
Illnesses/injuries in the last 14 days (%)	26.48	(0.298)	19.76	(0.248)
Real annual consumption expenditures per a.e. (in 1000 RWF)	71.17	(0.729)	78.46	(0.743)
Farm size per household (hectare)	0.80	(0.014)	0.76	(0.015)
Number of adults in the hh having agriculture as prim. occupation	2.17	(0.016)	1.98	(0.014)
Real value of ann. gross production per ha (in 1000 RWF)	460.86	(8.126)	509.49	(6.498)
Real value of ann. gross production per worker (in 1000 RWF)	101.50	(1.711)	128.53	(1.832)

One issue worth mentioning is the relatively low share of male headed households in Rwanda (compared to other Central African states) which has increased by more than 4 percentage points between the two surveys. These low values are still a consequence of the Rwandan genocide in 1994 where mortality was conspicuously larger for men than for women. Besides that, considerable progress can be observed for all three education indicators and also for the three health indicators (perhaps with the exemption of access to improved drinking water sources where progress was rather limited). Furthermore, it can be seen that Rwanda's rapid economic growth over the last years is also reflected in our micro data where the average annual consumption expenditures per adult equivalent (in constant January 2001 prices) grew from approx. 71,172 RWF to 78,455 RWF[11].

[10] These numbers may differ slightly from the means reported in Appendix C due to the fact that in order to construct the PPG-tools, we first need to average the indicator of interest on a household level before taking the means.

[11] It should be noted that these numbers differ from the ones reported in NISR (2012) due to two reasons. First, as described in Appendix A, we decided to exclude the use value of durable goods and the (imputed) rents for the household's dwelling from our consumption aggregate which leads to a lower consumption per adult equivalent. Second, other than NISR (2012) we used an exponent of 0.9 to explicitly account for economies of scale in the household which reduces our denominator when calculating the consumption expenditures per adult equivalent, thus leading to higher values for this indicator. It turns out that the first effect over-

Turning to the agricultural data, the increasingly important problem of land scarcity becomes obvious in the numbers for the avg. land size per farm household where levels were substantially below one hectare in both surveys and, due to population growth, decreased even further between the EICV1 and EICV2 surveys from 0.80 to 0.76 hectare. These values are particularly alarming given that land is in Rwanda distributed rather unequally and that consequently a large share of Rwandan households cultivates less than 0.7 hectares which is – according to the Rwandan Ministry of Agriculture – the minimum land size required to provide a typical Rwandan family with sufficient food for their living (Howe and McKay 2007). The calculated relatively high values of (real) annual gross production per hectare of approx. 460,863 RWF (EICV1) and 509,487 RWF (EICV2) in combination with the relatively low values of (real) annual gross production per worker of approx. 101,495 RWF (EICV1) and 128,528 RWF (EICV2) are therefore not entirely surprising given that farming is until today the main source of income for a considerable share of Rwandan households and that these households have – with limited access to agricultural land and scarce employment opportunities outside of agriculture – virtually no other alternative than trying to increase the productivity of their scarce land by the excessive use of (manual) labor.

5. Results for the hitherto existing PPG toolbox

Figure 1 constitutes the start of our analysis and approaches the question of who has benefitted from recent developments in Rwanda from the income[12] perspective. To illustrate how closely related the above-mentioned samples from the agrarian and the entire population actually are[13], we computed for the case of the "standard" GICs (based on Ravallion and Chen 2003) the curves separately for the entire and the agrarian population.[14]

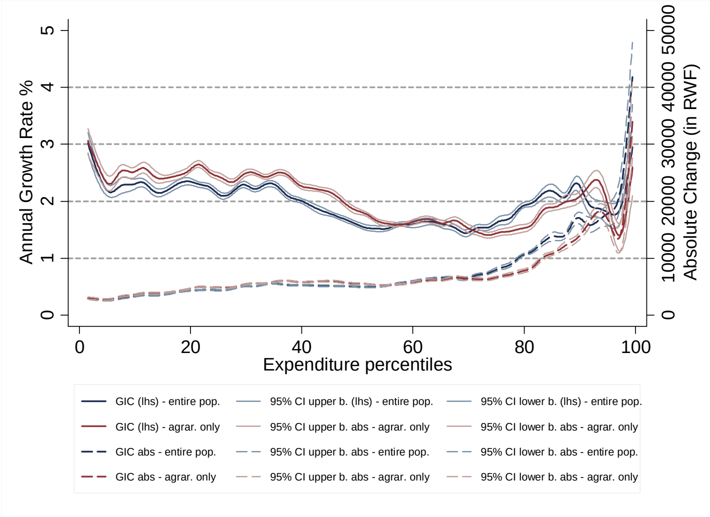
compensates the second and we therefore obtain lower values for the annual consumption expenditures per adult equivalent compared to NISR (2012).

[12] We speak here (and henceforth) of *income-poor* households even though it would be more precise to use the term *expenditure-poor* given that we based our rankings on the consumption expenditures per adult equivalent. However, we think that it is straightforward to still speak of the income-poor since the consumption expenditures were only used as a proxy for income due to the typically high volatility of household incomes in developing countries.

[13] This statement can be corroborated with the fact that in our dataset as much as 89.52% (EICV1) and 82.71% (EICV2), respectively, of all Rwandan households fulfilled the above-described definition of an agricultural household.

[14] It would have been possible to do this analogously for all other tools from the hitherto existing PPG-toolbox. However, we recognized that this would actually overload some of the graphs and would therefore make their interpretation quite complex.

Figure 1: Income growth incidence curves



As can be seen, the resulting relative and absolute GICs[15] lie above zero for all percentiles of the respective populations (i.e. consumption expenditures of all percentiles increased between EICV1 and EICV2) which implies that growth has been pro-poor according to the weak-absolute definition. Comparing the annual growth rates in mean (1.97 % for the agrarian population - see Appendix D) with the mean growth rate of the income-poorest 20%[16] of the same population (2.54% for the agrarian population) further reveals that growth has also been pro-poor in the relative sense.[17] However, as indicated by the upward sloped absolute GICs (bold dashed lines), the absolute increases of the poor were for both samples smaller than those of the non-poor indicating that growth has not been pro-poor according to the strong-absolute definition (abs. increase in the mean of 7,283 RWF compared to an avg. increase for the poorest 20% of 3,556 RWF).

In order to account for the multidimensional nature of poverty, we use the literacy rate[18] for the population aged 15 and above as a first education indicator and construct opportunity curves following the approach of Ali and Son (2007)[19]. As can be seen in Figure 2, the literacy levels for income-poor households are substantially below those of richer households. However, throughout

[15] In line with Grosse et al. (2008) and Klasen (2008), we included in all figures shown below the bootstrapped 95% confidence intervals which are constructed by first drawing 200 random samples (with replacement) for each of the two periods and separately calculating the percentiles, growth rates and absolute increases for each of these drawings. In a second step, we then calculate the mean and the standard deviation over the 200 observations and use the resulting values to calculate the 95% confidence intervals.

[16] In the following analysis, we will always define the poor to be the poorest 20% of the population in terms of the dimension of interest. However, given that this threshold is obviously debatable, we included in Appendix D also the growth rates/absolute increases of other shares of the population.

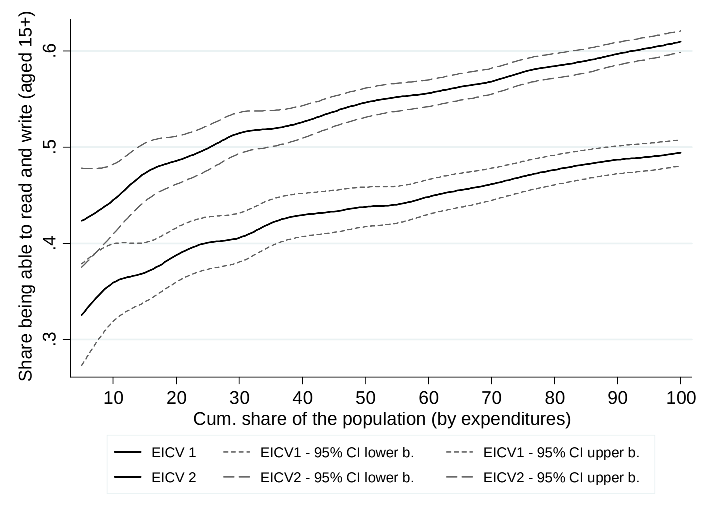
[17] For the entire population, the finding would be very similar, yet with PPG in the relative sense being slightly less pronounced.

[18] In line with the related literature, we define literacy here as the ability to read *and* write.

[19] It should be noted that we calculated the 95% bootstrapped confidence intervals also for the opportunity curves in this article (Ali and Son (2007) did not show any confidence intervals in their original article). However, we think it is important to show the confidence intervals to give the reader a feeling for the precision of the estimations.

the income distribution considerable progress between the two survey rounds can be observed which is reflected in an upward shift of the curve. This can e.g. be exemplified for the poor (again defined as the poorest 20%) of which in the EICV2 survey as much as 48.59% of all adults were literate (see Appendix C) while the corresponding share only amounted to 38.77% in the EICV1 survey which was collected approximately five years earlier.

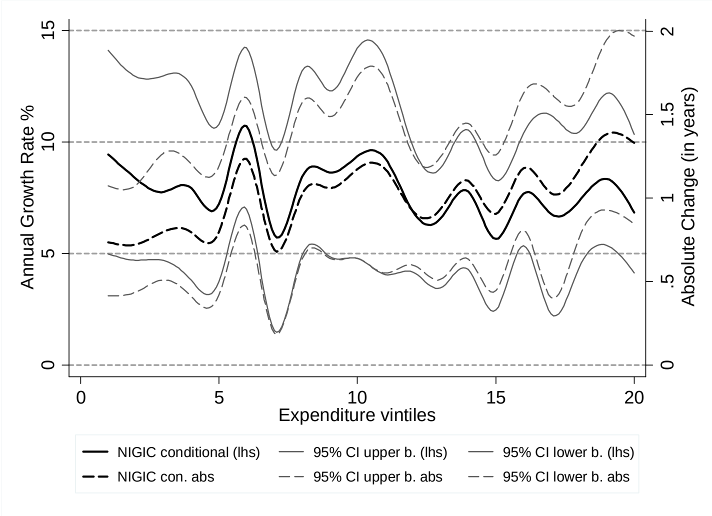
Figure 2: Opportunity curve for adult literacy (aged 15+)



This progress has to be judged as pro-poor in the weak-absolute (given that all poor vintiles of the population were able to increase their avg. literacy levels) and the relative sense (annual growth rate of the poor of 4.66% compared to a GRIM of 4.28%). Yet, progress failed to be pro-poor according to the ambitious strong-absolute definition with the increases for the poor being 9.82%-points (compared to an abs. increase in the mean of 11.53%-points).

Given that the adult literacy rate is for various reasons a rather imperfect education indicator (Barro and Lee 1993; for recent evidence see Reimers and Klasen 2013), we use the average years of schooling for individuals aged 15 and above as a second measure for education.

Figure 3: Conditional NIGICs for avg. years of schooling (aged 15+)

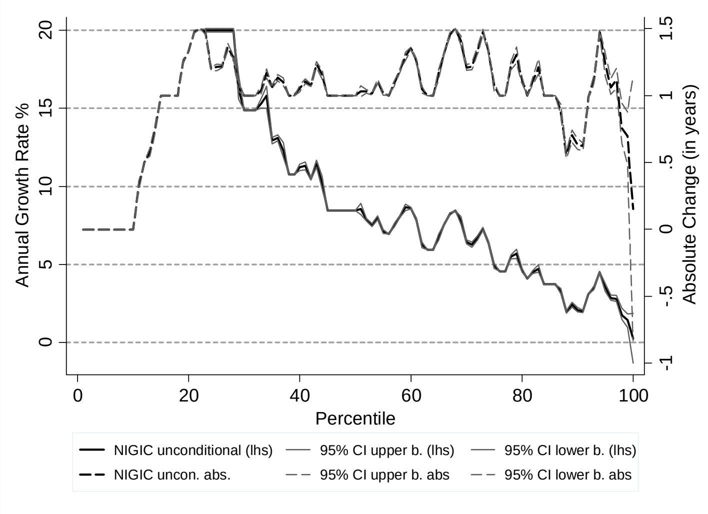


The conditional NIGICs for the avg. years of education (Figure 3) generally confirm the above-described results for the adult literacy rate. In particular, we find that all vintiles[20] of the population were able to increase their average level of schooling in the time period under consideration (i.e. growth has been pro-poor in the weak-absolute sense) and that the annual growth rate of the poor (8.38%) exceeded the growth rate in the mean (7.73%) which implies that growth has been pro-poor according to the relative definition. Yet, progress failed again to be pro-poor in the strong-absolute sense since the absolute increase for the poor (0.76 years of schooling) was considerably smaller than the absolute increase in the mean (1.01 years of schooling). Nevertheless, it should be pointed out that for both indicators the magnitude of the achieved progress is impressive given that the adult literacy of the income-poor increased in only about five years by as much as 9.82%-points or put differently, an income poor Rwandan adult observed in the EICV2 survey had received approx. 0.76 years of schooling more than an income-poor adult observed in the EICV1 survey. This is particularly remarkable since most of the older individuals no longer attend any form of education and act therefore as a kind of inbuilt-inertia for the indicator; thus the improvements derive mostly from poorly educated cohorts dying and being replaced by better educated younger cohorts.

As a last step of the analysis in the field of education, we calculated the unconditional NIGIC for the avg. years of schooling where we no longer rank households by income per adult equivalent on the horizontal axis but by the endowment in terms of education (i.e. years of schooling). As can be seen from Figure 4, the shape of the unconditional NIGIC greatly differs from the conditional NIGIC which is to some extent a consequence of the fact that there is in both surveys a considerable share of households where no adult has received any education.

[20] In line with the recent literature (e.g. Grosse et al. 2008 and Klasen 2008), we used vintiles instead of percentiles of the population for the conditional NIGICs (and likewise for the opportunity curves) given the relatively high heterogeneity of non-income achievements (and related growth rates) within income quantiles.

Figure 4: Unconditional NIGICs for avg. years of schooling (aged 15+)



However, this share decreased extraordinarily between the two EICV surveys from approx. 24% to 9% which is reflected in the graph by the increase of the *absolute* NIGIC[21] from 0 to more than 1 year between the percentiles 10 and 24. From a pro-poor growth perspective, this means that considerable progress has been made in providing the education-poor with schooling. Furthermore, also for those quantiles where household members had already in the EICV1 survey received some education (to the right from percentile 24), the absolute increases in terms of schooling were – with an average increase of more than one year – very impressive. When comparing these findings to the results presented by Grosse et al. (2008) for Bolivia and Burkina Faso, it can be recognized that Rwanda in fact was much more successful than Burkina Faso and even slightly more successful than Bolivia in increasing the education-levels of the education-poor.

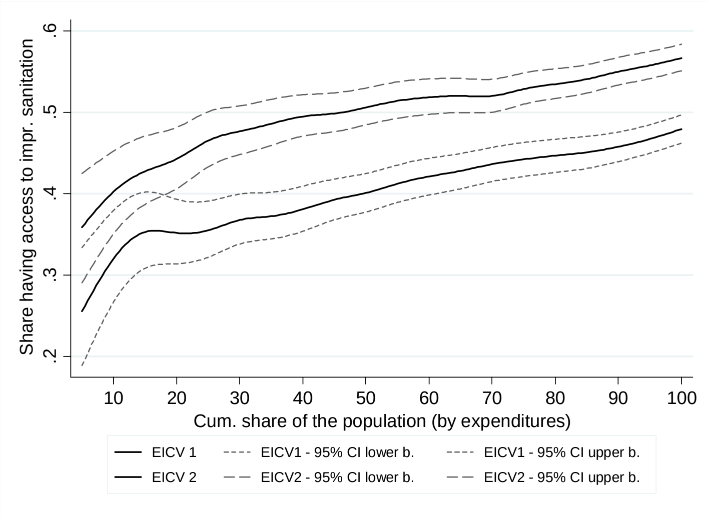
Turning to the health dimension of poverty, we analyzed – as a first step – how the agrarian population's access to improved sanitation[22] developed in the time period under consideration. As shown by the opportunity curves in Figure 5, the level of access to improved sanitation of poor households was considerably below the one of non-poor households. However, we see a considerable upward shift of the opportunity curve between the two EICV surveys which can e.g. be illustrated by the increase in the access to improved sanitation for the poorest 20% of the population from 35.18% (EICV1) to 44.27% (EICV2). This progress has to be judged as pro-poor according to all three definitions given that the access to improved sanitation has increased for all vintiles of the population and that both, the annual avg. growth rate (4.92% compared to a GRIM of 3.40%) as well

[21] It should be noted that a relative unconditional NIGIC is up to percentile 23 not defined given that the denominator for the growth rate is in these cases equal to zero. For this reason, we also refrain from categorizing the progress into the three pro-poor growth classifications.

[22] The categorization of sanitation facilities into improved and unimproved systems was done based on the definition provided by the Joint Monitoring Programme of UNICEF and WHO (JMP 2012).

as the avg. absolute increase (9.09%-points compared to an avg. absolute increase in the mean of 8.73%-points) have been higher for the poor than for the non-poor.

Figure 5: Opportunity curve for access to improved sanitation

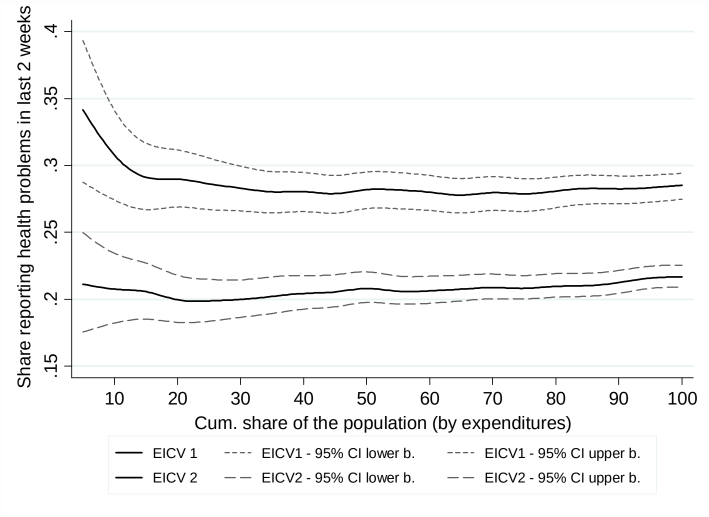


As a second health indicator, we then looked at the access to improved drinking water sources[23] (Appendix E) where the picture was much less positive and the data even suggest that the access of the income-poor to improved drinking water sources deteriorated in the time period under consideration (from 69.07% to 66.28%). Despite the admittedly relatively broad confidence intervals of these curves, this is certainly a point which requires particular attention of the Rwandan authorities and where considerable progress can potentially be made in the future.

Lastly, we analyzed data for self-reported illnesses/injuries in the two weeks preceding the interview (Figure 6). Against the background that the perception of being ill or injured may differ greatly between individuals, such numbers have always to be seen with the necessary caution. However, one would expect that – on average over the whole population – this subjective assessment will remain relatively stable over time (at least for relatively short time periods) and it may therefore be worthwhile to look at time trends for this indicator.

[23] The categorization of drinking water facilities into improved and unimproved systems was likewise done on the basis of the definition from JMP (2012).

Figure 6: Opportunity curve for health problems in the last two weeks



The resulting opportunity curves in Figure 6 reveal an extraordinarily rapid reduction of levels for this indicator in the time period under consideration. While in the EICV1 survey still 28.97% of the poor were reportedly injured or ill in the two weeks preceding the interview, this share amounted just to 19.96% in the EICV2 survey. Not entirely surprisingly, this enormous progress implies pro-poor growth according to all three definitions since the incidence of illness declined for all poor quantiles of the population and decreased more rapidly in relative and absolute terms for the poor than for the non-poor (-7.08% for the poor compared to a GRIM of -5.33% and -9.01%-points reduction for the poor compared to an abs. decrease in the mean of -6.84%-points).

6. Results for the agricultural perspective

Until now, we applied the existing pro-poor growth toolbox and concluded that household per adult equivalent incomes have not only increased in the mean, but also for the poor significantly between the two surveys. Furthermore, the analysis revealed that the education and health levels of the income-poor (and the education-poor for the case of the years of schooling) improved considerably and that this progress has on various occasions been pro-poor not only according to the weak-absolute, but also according to the relative and sometimes even to the strong-absolute definition of pro-poor growth (particularly true for the health dimension with the exception of access to improved drinking water sources).

We now want to look at pro-poor growth from the agricultural perspective and ask to what extent the poor in terms of agricultural productivity were able to increase their productivity levels between the two survey rounds. However, before we start to present the results of the analysis, we would like to point the reader’s attention to the importance of the relationship between land size and agricultural productivity in the Rwandan case. As is well known, over the last decades there has been a quite controversial debate in academic literature about the reasons for the typically observed inverse relationship between farm-size and agricultural land productivity (often referred to as the IFSP relationship) which seems to contradict the presumed scale advantage of larger farms due to the lumpiness of various expensive inputs such as farm machinery etc. (Binswanger et al. 1995; Kimhi 2006). According to Barrett (2010), it is possible to distinguish between three major lines of explanations for this phenomenon. The first claims that for the existence of the inverse farm-size productivity relationship, failures on (multiple) factor markets are required which cause unobservable inter-household variation in the shadow prices of the production factors. This variation implies in turn differentials in the input intensity levels which are correlated with farm size and therefore could explain the IFSP (Barrett et al. 2010). With regard to the question how such imperfections could actually look like, numerous suggestions have been made in the literature (e.g. Sen 1966; Bardhan 1973; Barrett 1996). A particularly well-known argument suggests that family and hired labor are actually heterogeneous inputs and that labor productivity of hired workers on large farms is positively associated with the level of supervision by the landowner (Feder 1985; Frisvold 1994). Hence, large landowners will regularly exhibit a higher optimal land-to-labor ratio than smallholders and – given imperfections on the land market – the IFSP relationship will emerge (Assunção and Braido 2007). The second class of explanations states that an omitted variable bias (e.g. due to differentials in soil quality) is actually driving the IFSP (e.g. Bhalla 1988; Bhalla and Roy 1988; Benjamin 1995). The underlying assumptions are that if better soil quality actually leads to higher output and if soil quality has a negative correlation with farm size, then the IFSP may be detected if the analysis does not adequately account for differentials in soil quality (Barrett et al. 2010). The more recent third class of arguments (e.g. Lamb 2003) claims instead that measurement error/reporting bias in the farm/plot size data may be responsible for the IFSP relationship if smallholders misreport the size of their farms systematically differently from large landowners (Barrett et al. 2010).[24]

Turning to the Rwandan case, we observe in our data a clearly inverse farm-size *land* productivity relationship, but, as it is often found, a positive association between farm-size and *labor* productivity. This finding is also in line with the relatively recent results of Ansoms et al. (2008) and Byiringiro and Reardon (1996) who empirically tested some of the above-described explanations of the IFSP for the Rwandan case. More specifically, Byiringiro and Reardon (1996) recognize that Rwandan households who dispose only of relatively small farms crop their land more intensively, make more ample use of

[24] It should be pointed out that various relatively recent articles have tried to empirically test the validity of the above-mentioned arguments, but have come to rather conflicting results (see e.g. Kimhi 2006; Assunção and Braido 2007; Barrett et al. 2010).

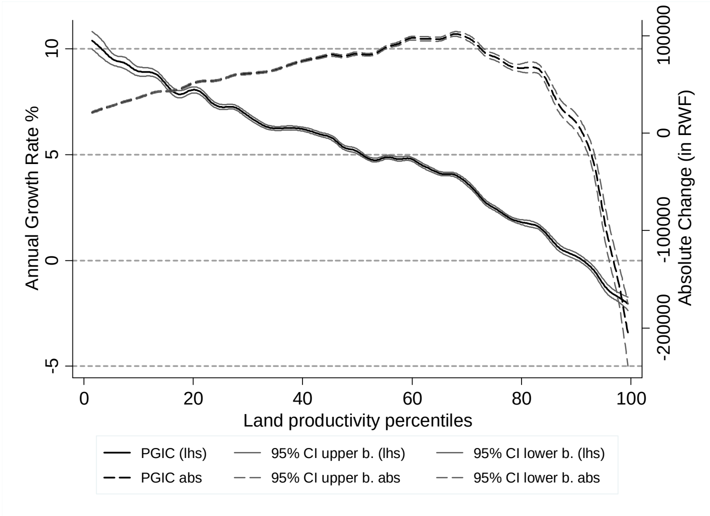
the production factor of labor, let the land more rarely lie idle and invest conspicuously more in soil conservation activities. They further find that the marginal value product of land is considerably higher for the smallest farms than the common land rental rate while the marginal value product of labor amounts to as little as one third of the market wage. This kind of "bottling-up of labor on the smallest farms" (Byiringiro and Reardon 1996, p. 132) hence points in the direction that prevailing imperfections on the land and labor markets are the main drivers for the detection of the IFSP relationship in the Rwandan case.[25]

Against the background of these findings, two things become evident that will be important for our further analysis. First, the fact that some households exhibit relatively high levels of land productivity does not necessarily imply that the production process on these farms is more efficient than on others since the higher land productivity could just have been "bought" at the expense of particularly high levels of labor input. Second, it therefore appears advisable not just to contemplate the land-productivity-poor and assume that these households are automatically also the labor productivity-poor, but to look at both groups separately. This can, for instance, be illustrated with the help of the tables in Appendices F and G which nicely show that both groups actually exhibit quite different characteristics. Furthermore, it can be argued that for policy-makers both types of productivity-poor are actually different, but important target groups. First, the land productivity-poor could be in the focus of governmental efforts to increase agricultural productivity since – from an endowment perspective – the maximization of crop yields on *all* agricultural land has to have top priority in order to ensure food security in the future. Second, policy makers could also pursue the goal of increasing the agricultural productivity of the labor productivity-poor given that these households regularly exhibit relatively low consumption levels and small farm sizes (see Appendices F and G) and given that they are probably those most trapped by the above-described imperfections on the labor and land markets.

As a first step of our analysis for the agricultural perspective, we therefore calculate a *monetary* productivity growth incidence curve where we use as our indicator for agricultural productivity the monetary measure for the household's gross agricultural production per hectare of agricultural land in the 12 months preceding the survey (see section 4).

[25] Yet, it should be emphasized out that Byiringiro and Reardon (1996) cannot entirely rule out the possibility that measurement error/reporting bias is also contributing to the detection of the IFSP relationship.

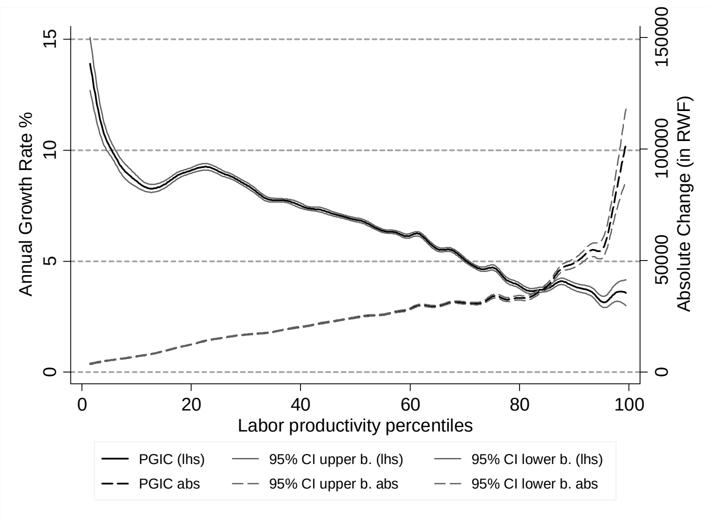
Figure 7: Monetary land productivity growth incidence curves



As shown in Figure 7, the resulting relative monetary PGIC has quite narrow confidence bands and is clearly sloped downwards indicating that agricultural productivity increased relatively faster for land productivity-poor households whereas productivity growth was even slightly negative for the land productivity-richest households. In absolute terms, the curve exhibits a somewhat different pattern with a maximum absolute increase in agricultural productivity for percentile 67. Consequently, the achieved progress has to be judged as pro-poor in the weak-absolute and the relative sense, but not as pro-poor according to the strong-absolute definition.

In line with our explanations from above, we calculated – as a second step – the corresponding monetary PGICs for agricultural *labor* productivity (Figure 8). Again, the absolute PGIC lies above zero for all productivity-poor percentiles and the relative PGIC exhibits a clearly downward sloped pattern which indicates pro-poor growth in the weak-absolute and the relative sense. Yet, given the upward sloped absolute PGIC, one has to acknowledge that productivity growth apparently has not been pro-poor according to the strong-absolute definition. From a poverty perspective these results are nevertheless quite encouraging given that they imply that the labor productivity-poor were able to increase the yield per worker considerably and even relatively faster than the labor productivity-rich.

Figure 8: Monetary labor productivity growth incidence curves



The monetary PGICs in Figure 7 and 8 are generally a relatively straightforward way to evaluate to what extent the productivity-poor (either land or labor productivity) were able to increase their productivity levels. However, there are at least two reasons why the results of these monetary PGICs should be interpreted with some caution. First, in contrast to many of the non-income indicators, increases in agricultural productivity can rather not be seen as the result of a (more or less) steady process but are of relatively volatile nature e.g. they could be due to adverse/good weather conditions. Therefore, one should be rather careful when interpreting the *levels* shown in Figure 7 and 8 since it could theoretically be that the EICV1 data were simply collected in a very bad and/or the EICV2 data in a very good year in terms of agricultural harvest. Second, there may be differentials in the crops planted by the productivity-poor and -rich. For instance, it could be that we observe declining relative PGICs due to the fact that harvests of the most prevalent crops planted by the productivity-rich were rather bad while harvests for the most prevalent crops of the productivity-poor were rather good. Despite these downsides, we interpret the results in Figure 7 and 8 as first indications that – in weak-absolute and relative terms – the increases in agricultural land/labor productivity were rather distributed in a pro-poor manner.

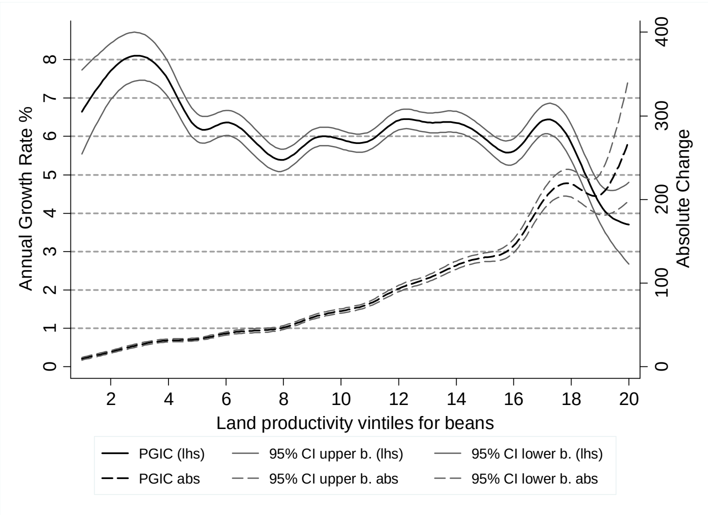
Against the background of the above-described drawbacks, we calculated as a third step of our productivity analysis *crop-specific* PGICs for land productivity[26] for the three most important crops in Rwanda (according to the land use numbers reported in the two EICV surveys) which are in decreasing order of importance: beans, sweet potatoes and sorghum (see Appendix H for the exact share of each crop in the two surveys). Taken together these three crops account for more than half

[26] Given that the EICV data do not contain detailed information on labor input by crop we were unfortunately not able to calculate crop-specific PGICs for agricultural labor productivity.

of all agricultural land reported (more precisely for 51.24% (EICV1) and 53.01% (EICV2), respectively) which underlines the crucial importance of the crops for Rwanda's agricultural sector.

In comparison to the monetary PGICs, these crop-specific PGICs have the advantage that the underlying productivity measure is no longer a combination of the (theoretical) revenues generated by various crops per one hectare of agricultural land, but that it is now simply the total amount harvested (in kilograms) of the crop of interest per hectare. This basically solves the second of the two above-described problems since it is no longer possible that a certain shape of the PGIC is simply a consequence of different crops planted by the productivity-poor and -rich.[27]

Figure 9: Land productivity growth incidence curves for bean production



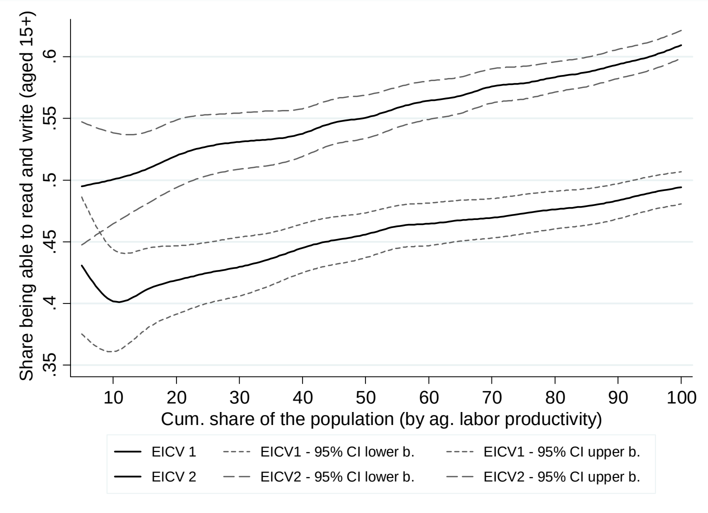
As can be seen from the crop-specific PGICs for bean production in Figure 9, all vintiles of the bean-producing population were able to increase their agricultural land productivity considerably in the time-period under consideration (even though one should – as noted above – interpret the levels with some caution). What is even more interesting is, however, the shape of the relative PGIC which has a negative slope indicating that the productivity-poor (in terms of bean production per hectare) were able to increase their land productivity relatively faster than the average (annual avg. growth rate for the poor of 7.48% compared to a GRIM of 5.40%), i.e. growth has been pro-poor in the relative sense. A similar picture (even though with slightly different shapes of the crop-specific PGICs) is obtained when looking at sweet potato and sorghum production likewise indicating pro-poor growth in the weak-absolute and the relative sense (see Appendices I and J). In this sense, the results of the crop-specific PGICs are in line with the findings from the monetary PGICs and are quite encouraging that recent efforts of the Rwandan government to increase agricultural land

[27] It should be noted that the above-described analysis still assumes both homogeneity in the crops and in the quality of the harvest. However, given that these are common assumptions in the analysis of household-level production data and that there is no real way to solve these issues, we accept it as one possible source of measurement error in our analysis.

productivity of the productivity-poor were successful. Nevertheless, it should be noted that the absolute harvest increases of the productivity-rich were – for all three crops considered – substantially larger than those of the productivity-poor which implies that the absolute gap between the two groups has risen considerably.

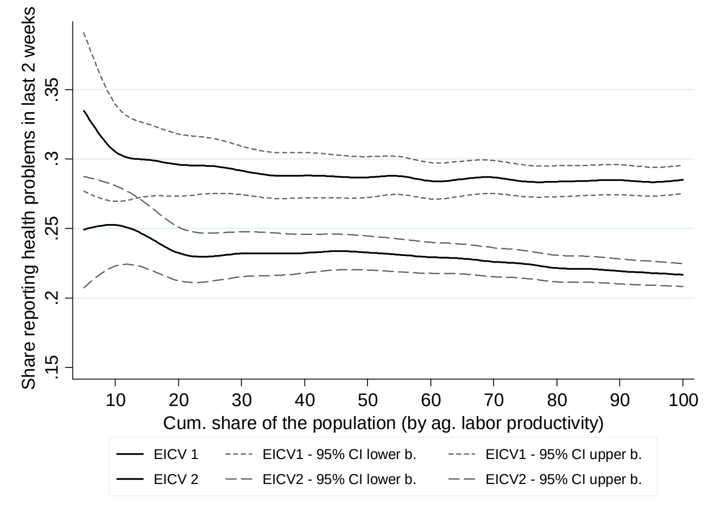
Until now, we studied recent developments in Rwanda from a purely productivity-based perspective trying to answer the question to what extent the land/labor productivity-poor were able to increase their yields per hectare/worker. Given the above-described evidence from the micro and macro level of productivity-enhancing effects from increased education and health, we ask as a next step how well the labor productivity-poor are equipped in these two dimensions. This is done by constructing labor productivity opportunity curves (Type 1) for the adult literacy rate (Figure 10) as well as the incidence of illness/injuries in the two weeks preceding the survey (Figure 11 - the corresponding curves for agricultural land productivity are shown in Appendices K and L).

Figure 10: Labor productivity opportunity curve (Type 1) for adult literacy (aged 15+)



As shown in Figure 10, both labor productivity opportunity curves are sloped upwards implying that literacy levels of the productivity-poor were in both surveys considerably below those of the productivity-rich. Yet, the POCs further show that the productivity-poor were not excluded from the expansion of education in Rwanda and were in fact able to increase their average literacy levels in the time period under consideration from approx. 41.88% (EICV1) to 51.97% (EICV2). This has to be judged as a quite impressive development which was not only pro-poor in the weak-absolute but also in the relative sense (annual avg. growth rate for the productivity-poor of 4.45% compared to a GRIM of 4.28%). Yet, developments failed to be pro-poor in the strong-absolute sense and hence the education gap between the labor productivity-poor and -rich has widened further. Turning to self-reported health problems in the last two weeks, Figure 11 reveals slightly higher incidence levels and a marginally smaller decrease in the indicator of interest for the labor productivity-poor compared to the labor productivity-rich (yet with relatively wide confidence intervals) which implies that developments have been pro-poor in the weak-absolute, but not in the relative and strong-absolute sense. When comparing these findings to those for the land productivity-poor (Appendices K and L), we find indications that the education-levels of the land productivity-poor are likewise smaller than those of the land productivity-rich, however, the magnitude of the discrepancy turns out to be considerably smaller. Yet, we do not find clear evidence for differentials in the incidence of health problems between the land productivity-poor and -rich.

Figure 11: Labor productivity opportunity curve (Type 1) for health problems in the last two weeks

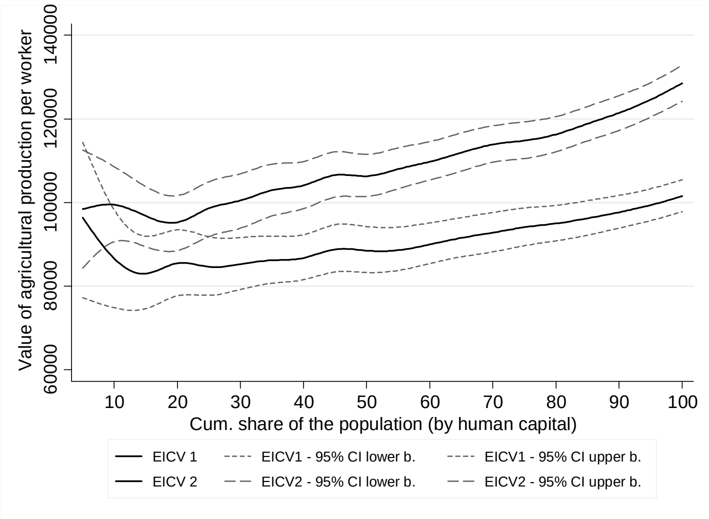


As a last step of our analysis, we pursue the somewhat converse question, namely whether the productivity levels of the human capital-poor are lower or higher than those of the human capital-rich. To be able to answer this question, we calculate productivity opportunity curves (Type 2) separately for land and labor productivity which are constructed in a two-step-procedure as follows. First, we use principal component analysis to calculate a human capital index which reflects each household's endowment with human capital.[28] Based on this index we then rank households (cumulated) on the horizontal axis and plot this against the land/labor productivity levels on the vertical axis. The resulting POCs (Type 2) for the case of agricultural labor productivity can be seen in Figure 12 and reveal a positive slope indicating that the labor productivity levels of the human capital-poor are in fact in both surveys below those of the human capital-rich. Moreover, it seems that indeed both groups were able to increase their labor productivity levels, but that the increase for the human capital-poor was less rapid (annual avg. growth rate for the human capital-poor of

[28] More specifically, we use three education indicators (adult literacy, adult participation in school, adult years of schooling) and three health indicators (self-reported health problems in the last 14 days, access to improved drinking water sources, and access to improved sanitation) to construct our human capital index.

2.32% compared to a GRIM of 4.83%) which hence implies a widening of the gap in labor productivity levels between the human capital-poor and -rich. A similar finding is obtained when looking at the corresponding POCs (Type 2) for land productivity (Appendix M) where developments likewise failed to be pro-poor in the relative sense.[29]

Figure 12: Labor productivity opportunity curve (Type 2) for human capital



7. Conclusion

In the pursuit of sustainable poverty reduction worldwide, pro-poor growth has by many researchers and organizations been identified as probably the most promising pathway to achieve this ambitious goal (e.g. United Nations 2000; World Bank 2000a, b; Ravallion 2001; Klasen 2004). Against this background, multiple authors have made suggestions for how pro-poor growth can be measured which has led to the creation of the so-called "pro-poor growth toolbox". The instruments contained in the existing toolbox look at pro-poor growth mainly from the income or the education/health dimension answering the question to what extent the poor in terms of income or education/health were able to benefit from recent developments. However, we argue in this article that the toolbox could be further extended to take account of the crucial importance of the agricultural sector for poverty reduction worldwide (e.g. World Bank 2007; de Janvry and Sadoulet 2010; Valdés and Foster 2010; Christiaensen et al. 2011). We therefore suggest that one can define the poor not only in terms of income or education/health, but also in terms of agricultural land/labor productivity and that it is possible by slightly modifying some of the existing tools to account for this agricultural productivity perspective on poverty. The resulting labor/land productivity growth incidence curves (in two versions: monetary and crop-specific) and the labor/land productivity opportunity curves (likewise in

[29] Instead of taking human capital as a whole, we also differentiated between the education-poor and -rich and the health-poor and -rich. It turned out that results for human capital are mainly driven by our education indicators and to a smaller extent by the health measures (particularly true for the case of land productivity).

two versions) should be seen as complements to the hitherto existing toolbox and allow researchers as well as policy makers to gain further insights about who has benefited from recent developments in the country of interest from quite different angles.

This was illustrated for the case of Rwanda using two waves of the nationally representative EICV household surveys. The results for the hitherto existing PPG-toolbox indicate that income growth of the poor was relatively faster than for the average, implying that Rwanda successfully achieved pro-poor growth in the weak-absolute and the relative sense. Furthermore, the access of the income-poor to education and health increased impressively in the time period under consideration and this progress was on some occasions even pro-poor according to all three definitions (examples of access to improved sanitation and incidence of illness/injuries in the last 14 days). However, room for improvement was identified for the access to improved drinking water sources where the access levels of the (income-) poor even decreased slightly.

Turning to the agricultural perspective, the two types of monetary PGICs provided us with first indications that productivity growth of the labor/land productivity-poor was relatively faster than for the labor/land productivity-rich while their absolute increases were smaller. This finding was confirmed by the three crop-specific land productivity growth incidence curves (for beans, sweet potatoes, and sorghum) which uniformly suggested that productivity growth was not only pro-poor according to the weak-absolute, but also according to the relative definition.[30] Moreover, the productivity opportunity curves (Type 1) revealed conspicuously lower literacy levels (and slightly higher incidence levels of self-reported illness/injuries) for the labor productivity-poor, thus pointing in the direction that the labor productivity-poor are constrained in their access to social services. Indeed, we observe that both, labor productivity-poor and -rich, were able to improve their education levels considerably between the two surveys, yet this did not prevent the gap in literacy levels between the two groups from widening. Lastly, the POCs (Type 2) showed that the human capital-poor in fact exhibit conspicuously lower levels of labor and land productivity compared to the human capital-rich and that their productivity increases between the two surveys were smaller in both, relative and absolute terms. This result appears not entirely surprising given the above-discussed broad evidence in the literature of positive effects of improved education/health on agricultural productivity on the micro and the macro level.

[30] Yet, it is important to emphasize that the rapid increases in agricultural land productivity have to be seen in the Rwandan context with the necessary caution since they may on the one hand indeed be due to efficiency gains by Rwandan farmers, but may on the other hand also be a consequence of a further “bottling-up of labor on the smallest farms” (Byiringiro and Reardon 1996, p. 132).

We conclude with some caveats and further suggestions. First, we are aware of the fact that all data obtained from household interviews (and particularly information on agricultural production) may be prone to considerable measurement and/or recall error which could bias our results. However, we did our best to reduce such measurement error by systematically cleaning the data from outliers at the most disaggregated level possible (i.e. the crop- and item-region-level for the production and the consumption aggregate, respectively) and included various types of plausibility checks. With regard to the existence of a recall bias, it should be noted that a recent article by Beegle et al. (2012) tested this issue empirically coming to the conclusion that the quality of recalled agricultural production data is actually better than expected. Second, we would like to point out that – by definition – the previous analysis cannot prove any kind of causality and it should further be emphasized that many factors have an impact on agricultural productivity for which we did not control in our analysis (e.g. differentials in climate, infrastructure, input use etc.[31]). Nevertheless, we consider the information provided by such a pro-poor analysis as an interesting first step for policy-makers and practitioners in the development field to pursue the question *who* has actually benefited from recent developments in a country. The results may then contribute to improve the targeting of governmental and non-governmental efforts in the field of education, health or even agricultural policy. Against the background that Rwanda is in many dimensions in a pioneering role for other SSA countries – being it the introduction of a national health insurance or the increasing scarcity of agricultural land – the case study provided in this article should further be seen as an opportunity for other SSA countries to learn from the quite successful Rwandan experience in the last years.

[31] A relatively easy way to account for differentials in location-specific factors such as climate would either be to re-conduct the above analysis on the region/province level or to first run a regression of agricultural productivity on climate indicators and then construct the PGICs/POCs using the residual of this regression. Yet, in an attempt not to overload this article, we decided to leave this exercise for future research.

Appendix A: Construction of the Consumption Aggregate

We included in our consumption aggregate all food purchases, consumption of own produced food, non-food consumption (in line with Deaton and Zaidi (2002) excluding rather "lumpy" expenditures), regular health and education expenses, cost of utilities (such as electricity or drinking water), and wages/transfers/other benefits received in kind (as a counterpart to consumption).[32] For outlier correction, we calculated – in line with NISR (2012) – the natural logarithm of all non-zero consumption values (on a per adult equivalent basis) and identified all those observations as outliers where the observed value was more than 3.5 standard deviations away from the mean value. The identified outliers were then replaced with the mean value for the respective consumption category multiplied with the number of adult equivalents in the household. Given that there may be regional differences in consumption patterns, the above-described outlier correction was not simply done at the item level for food- and non-food consumption but at the item-region level.[33] To take into account differentials in household size and composition, we calculated the number of adult equivalents in each household using equivalence scales that were implemented by FAO already in the 1980s (NISR 2005) and are since then used as the national standard in Rwanda (see Appendix B for the exact scales). To further adjust for potentially existing economies of scale, we decided to use an exponent of 0.9 for the calculation of the number of adult equivalents.[34]

Appendix B: Adult Equivalence Scales

Age groups	Sex	
	Male	Female
Less than 1 year	0.41	0.41
1 to 3 years	0.56	0.56
4 to 6 years	0.76	0.76
7 to 9 years	0.91	0.91
10 to 12 years	0.97	1.08
13 to 15 years	0.97	1.13
16 to 19 years	1.02	1.05
20 to 39 years	1.00	1.00
40 to 49 years	0.95	0.95
50 to 59 years	0.90	0.90
60 to 69 years	0.80	0.80
More than 70 years	0.70	0.70

[32] We deviate from the approach described in NISR (2012) in excluding the use value of durable goods and the (imputed) rents for the household's dwelling since these are probably the two categories where measurement error is highest (particularly against the background that less than 10% of Rwandan households actually pay rent). Given that such measurement error could severely bias the ranking of households needed for the following pro-poor analysis, we decided to favor reliability of our consumption aggregate over its completeness and hence excluded the two expenditure categories.

[33] Please refer to NISR (2012) for a very good and more detailed description of the outlier correction procedure used.

[34] This represents another difference to the methodology used by NISR (2012) who do not directly account for economies of scale in a household.

Appendix C: Levels of the contemplated income and non-income indicators for Rwanda (based on EICV1 and EICV2 – agrarian population only)

Indicator	Survey	Tool	Unit	Mean of decile... (cumulated in case of opportunity curves)										Mean	10:1 Ratio	Gini
				1	2	3	4	5	6	7	8	9	10			
Avg. household expenditures per a.e.	EICV1	GIC	RWF	22,547	31,152	38,289	45,175	53,447	63,309	74,297	90,600	112,810	180,403	71,172	8.00	0.34
Avg. household expenditures per a.e.	EICV2	GIC	RWF	25,601	35,202	43,247	50,938	59,229	68,700	80,565	97,407	123,807	199,981	78,455	7.81	0.33
Avg. literacy rate (aged 15+)	EICV1	OC	%	35.90	38.77	40.58	42.95	43.80	44.84	46.14	47.65	48.70	49.42			
Avg. literacy rate (aged 15+)	EICV2	OC	%	44.50	48.59	51.46	52.60	54.62	55.61	56.82	58.44	59.69	60.95			
Avg. years of schooling (aged 15+)	EICV1	Cond. NIGIC	years	1.38	1.74	1.89	2.08	2.07	2.22	2.46	2.75	2.70	3.10	2.24	2.25	0.49
Avg. years of schooling (aged 15+)	EICV2	Cond. NIGIC	years	2.11	2.53	2.90	2.93	3.19	3.27	3.48	3.79	3.80	4.46	3.24	2.12	0.37
Avg. years of schooling (aged 15+)	EICV1	Uncond. NIGIC	years	0.00	0.00	0.31	1.15	1.74	2.22	2.79	3.41	4.47	6.29	2.24	n.d.	0.49
Avg. years of schooling (aged 15+)	EICV2	Uncond. NIGIC	years	0.01	0.88	1.67	2.23	2.83	3.27	4.00	4.75	5.60	7.24	3.24	1168.71	0.37
Access to improved sanitation	EICV1	OC	%	32.02	35.18	36.78	38.08	40.10	42.12	43.64	44.68	45.77	47.95			
Access to improved sanitation	EICV2	OC	%	40.25	44.27	47.68	49.51	50.60	51.85	52.02	53.48	55.01	56.67			
Access to improved drinking water	EICV1	OC	%	68.00	69.07	69.61	69.13	69.00	68.53	68.26	67.61	67.71	67.86			
Access to improved drinking water	EICV2	OC	%	65.36	66.28	66.44	66.62	66.40	67.36	67.10	66.56	67.17	68.06			
Health problems in the last 14 days	EICV1	OC	%	30.77	28.97	28.30	28.04	28.19	28.00	27.96	28.08	28.25	28.51			
Health problems in the last 14 days	EICV2	OC	%	20.76	19.96	19.99	20.43	20.81	20.63	20.88	20.96	21.24	21.68			
Avg. production per ha (all crops)	EICV1	PGIC	RWF	49,969	90,335	133,985	187,125	250,688	332,729	439,248	615,922	910,701	1,600,06	460,863	32.02	0.51
Avg. production per ha (all crops)	EICV2	PGIC	RWF	78,724	134,598	190,747	254,119	329,790	421,000	537,752	694,012	953,796	1,501,93	509,487	19.08	0.44
Avg. production per worker (all crops)	EICV1	PGIC	RWF	8,870	19,102	28,579	40,635	54,858	72,435	96,670	134,404	195,464	364,212	101,495	41.06	0.52
Avg. production per worker (all crops)	EICV2	PGIC	RWF	14,255	28,934	43,816	59,125	77,466	98,743	127,046	166,908	236,223	433,059	128,528	30.38	0.48
Avg. production per ha (beans only)	EICV1	PGIC	kg	32.43	63.93	100.33	143.81	189.11	242.12	313.67	427.20	607.91	1,122.74	322.64	34.62	0.50
Avg. production per ha (beans only)	EICV2	PGIC	kg	46.20	92.90	137.91	188.44	249.47	326.68	427.20	563.48	807.29	1,360.88	419.61	29.46	0.48
Avg. production per ha (sweet potato only)	EICV1	PGIC	kg	176.66	398.25	679.04	970.75	1,377.25	1,964.59	2,923.09	4,405.81	7,007.02	14,759.6	3,451.40	83.55	0.60
Avg. production per ha (sweet potato only)	EICV2	PGIC	kg	281.15	624.15	1,022.10	1,556.03	2,193.89	3,113.80	4,474.99	6,245.79	9,462.65	18,806.6	4,769.34	66.89	0.56
Avg. production per ha (sorghum only)	EICV1	PGIC	kg	45.70	94.85	140.83	205.78	280.69	368.69	490.90	676.52	917.23	1,686.57	489.44	36.91	0.50
Avg. production per ha (sorghum only)	EICV2	PGIC	kg	74.40	150.18	229.53	313.38	415.37	535.67	707.41	928.35	1,296.72	2,221.01	686.00	29.85	0.48

Note: The abbreviation "n.d." stands for not defined and is used in cases where one would have to divide by zero to obtain the 10:1 ratio.

Appendix C (ctd.): Levels of the contemplated income and non-income indicators for Rwanda (based on EICV1 and EICV2 – agrarian population only)

Indicator	Survey	Tool	Unit	Mean of decile... (cumulated in case of opportunity curves)										Mean	10:1 Ratio	Gini
				1	2	3	4	5	6	7	8	9	10			
Avg. literacy rate (aged 15+)	EICV1	Land POC (Type 1)	%	48.73	49.65	48.40	49.17	49.61	49.74	49.89	49.79	49.98	50.36			
Avg. literacy rate (aged 15+)	EICV2	Land POC (Type 1)	%	56.35	56.65	57.64	58.17	58.88	59.79	60.06	60.18	60.47	61.11			
Health problems in the last 14 days	EICV1	Land POC (Type 1)	%	28.13	28.15	27.99	27.62	28.38	28.15	27.93	28.05	28.09	28.10			
Health problems in the last 14 days	EICV2	Land POC (Type 1)	%	22.59	21.82	21.55	21.45	21.46	21.05	20.96	21.08	21.35	21.22			
Avg. literacy rate (aged 15+)	EICV1	Labor POC (Type 1)	%	40.18	41.88	42.96	44.50	45.59	46.46	46.95	47.63	48.35	49.42			
Avg. literacy rate (aged 15+)	EICV2	Labor POC (Type 1)	%	50.05	51.97	53.10	53.77	55.06	56.43	57.59	58.35	59.38	60.95			
Health problems in the last 14 days	EICV1	Labor POC (Type 1)	%	30.52	29.60	29.16	28.81	28.68	28.42	28.68	28.37	28.49	28.51			
Health problems in the last 14 days	EICV2	Labor POC (Type 1)	%	25.26	23.24	23.21	23.24	23.28	22.94	22.61	22.15	21.94	21.68			
Avg. production per ha (all crops)	EICV1	Land POC (Type 2) (by human capital)	RWF	423,987	425,105	441,331	446,571	441,404	440,782	446,875	451,144	455,027	460,878			
Avg. production per ha (all crops)	EICV2	Land POC (Type 2) (by human capital)	RWF	434,442	443,637	463,614	471,958	481,125	483,891	493,203	494,207	503,080	509,449			
Avg. production per ha (all crops)	EICV1	Land POC (Type 2) (by education)	RWF	418,385	420,730	439,073	440,161	440,280	445,159	448,371	452,094	457,164	460,877			
Avg. production per ha (all crops)	EICV2	Land POC (Type 2) (by education)	RWF	444,518	444,734	463,625	473,270	477,727	485,690	486,581	495,109	502,815	509,496			
Avg. production per ha (all crops)	EICV1	Land POC (Type 2) (by health)	RWF	463,178	464,324	460,035	466,248	461,238	450,339	452,251	459,921	462,370	460,848			
Avg. production per ha (all crops)	EICV2	Land POC (Type 2) (by health)	RWF	507,774	511,600	514,423	509,396	509,843	505,512	506,863	505,686	511,990	509,405			
Avg. production per worker (all crops)	EICV1	Labor POC (Type 2) (by human capital)	RWF	86,569	85,472	85,249	86,720	88,488	89,956	92,788	94,997	97,667	101,501			
Avg. production per worker (all crops)	EICV2	Labor POC (Type 2) (by human capital)	RWF	99,463	95,245	100,466	104,101	106,311	109,729	113,865	116,290	121,421	128,500			
Avg. production per worker (all crops)	EICV1	Labor POC (Type 2) (by education)	RWF	89,889	84,242	85,500	87,685	88,138	90,137	93,041	95,357	97,730	101,514			
Avg. production per worker (all crops)	EICV2	Labor POC (Type 2) (by education)	RWF	101,514	98,892	100,817	103,790	108,299	110,714	113,695	117,581	121,957	128,533			
Avg. production per worker (all crops)	EICV1	Labor POC (Type 2) (by health)	RWF	102,301	103,223	101,164	100,915	101,482	100,098	99,623	100,910	101,323	101,499			
Avg. production per worker (all crops)	EICV2	Labor POC (Type 2) (by health)	RWF	114,643	114,096	115,246	117,373	118,314	119,760	122,781	124,784	127,613	128,491			

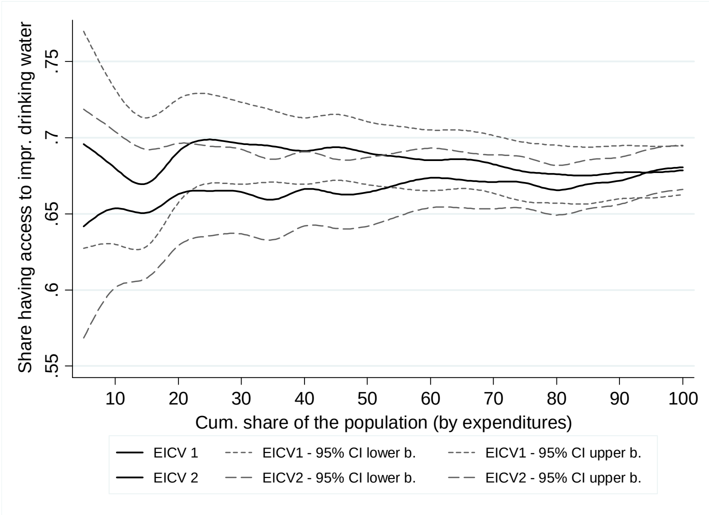
Note: The abbreviation "n.d." stands for not defined and is used in cases where one would have to divide by zero to obtain the 10:1 ratio.

Appendix D: Pro-poor growth rates and growth rates in the mean for Rwanda (based on EICV1 and EICV2 – agrarian population only)

Indicator	Tool	Ann. growth rate in the mean (%)	Avg. annual growth rate for the poorest... (in %)						Abs. increase in the mean	Abs. increase for the poorest...					
			5%	10%	15%	20%	25%	100%		5%	10%	15%	20%	25%	100%
Avg. household expenditures per a.e.	GIC	1.97	2.71	2.60	2.56	2.54	2.54	2.08	7,283	2,834	3,056	3,312	3,556	3,824	7,294
Avg. literacy rate (aged 15+)	OC	4.28	5.40	4.46	5.05	4.66	4.53	4.32	11.53	9.79	8.59	10.34	9.82	9.82	11.53
Avg. years of schooling (aged 15+)	Cond. NIGIC	7.73	9.45	8.90	8.52	8.38	8.15	7.85	1.01	0.74	0.73	0.75	0.76	0.77	1.01
Avg. years of schooling (aged 15+)	Uncond. NIGIC	7.73	n.d.	n.d.	n.d.	n.d.	n.d.	8.77	1.01	0.00	0.01	0.22	0.44	0.64	1.01
Access to improved sanitation	OC	3.40	7.05	5.01	4.24	4.92	5.66	3.65	8.73	10.36	8.22	7.46	9.09	11.03	8.72
Access to improved drinking water	OC	0.06	-1.60	-0.78	-0.57	-0.80	-0.96	0.05	0.20	-5.40	-2.63	-1.93	-2.78	-3.37	0.20
Health problems in the last 14 days	OC	-5.33	-9.15	-7.44	-6.56	-7.08	-6.95	-5.34	-6.84	-13.02	-10.01	-8.55	-9.01	-8.75	-6.84
Avg. production per ha (all crops)	PGIC	2.03	10.01	9.62	9.31	8.98	8.70	4.86	48,624	24,188	28,737	32,963	36,486	39,965	48,477
Avg. production per worker (all crops)	PGIC	4.84	12.07	10.59	9.84	9.61	9.52	6.70	27,033	4,430	5,386	6,373	7,609	8,936	27,032
Avg. production per ha (beans only)	PGIC	5.40	6.65	7.18	7.48	7.48	7.23	6.12	96.97	9.50	13.70	17.92	21.29	23.60	96.79
Avg. production per ha (sweet potato only)	PGIC	6.68	7.77	9.29	9.37	9.34	9.13	8.39	1,317.93	59.66	104.32	134.27	164.60	191.67	1,310.7 –
Avg. production per ha (sorghum only)	PGIC	6.99	8.00	9.86	9.74	9.76	9.86	8.13	196.56	17.13	28.86	35.13	42.25	49.98	195.67
Avg. literacy rate (aged 15+)	Land POC (Type 1)	3.95	3.28	2.94	2.92	2.66	2.94	3.94	10.75	8.69	7.61	7.69	6.99	7.59	10.75
Health problems in the last 14 days	Land POC (Type 1)	-5.47	-2.35	-4.36	-4.84	-5.01	-5.19	-5.47	-6.89	-3.12	-5.54	-6.15	-6.33	-6.51	-6.89
Avg. literacy rate (aged 15+)	Labor POC (Type 1)	4.28	2.83	4.56	4.42	4.45	4.45	4.27	11.53	6.44	9.87	9.78	10.09	10.26	11.53
Health problems in the last 14 days	Labor POC (Type 1)	-5.33	-5.73	-3.60	-3.93	-4.74	-4.89	-5.35	-6.84	-8.55	-5.26	-5.51	-6.36	-6.51	-6.83
Avg. production per ha (all crops)	Land POC (Type 2) (by human capital)	2.02	0.16	0.48	1.24	0.87	1.06	2.03	48,564	3,284	10,456	26,333	18,531	23,438	48,583
Avg. production per ha (all crops)	Land POC (Type 2) (by education)	2.03	0.72	1.21	0.57	1.07	1.07	1.99	48,624	15,096	26,191	12,533	23,985	24,455	48,636
Avg. production per ha (all crops)	Land POC (Type 2) (by health)	2.02	2.27	1.83	1.84	1.95	2.06	2.08	48,564	57,622	44,528	45,164	47,227	49,595	48,471
Avg. production per worker (all crops)	Labor POC (Type 2) (by human capital)	4.83	0.41	2.98	3.25	2.32	3.19	4.64	26,993	2,000	12,894	13,757	9,773	13,991	27,000
Avg. production per worker (all crops)	Labor POC (Type 2) (by education)	4.84	4.35	2.72	2.73	3.37	3.91	4.66	27,033	17,359	11,625	11,294	14,650	17,448	27,019
Avg. production per worker (all crops)	Labor POC (Type 2) (by health)	4.83	2.41	2.30	2.06	2.02	2.55	4.77	26,993	12,848	12,342	11,009	10,873	13,398	26,992

Note: The abbreviation "n.d." stands for not defined and is used in cases where one would have to divide by zero to obtain the annual growth rate.

Appendix E: Opportunity curve for access to improved drinking water



Appendix F: Comparison of land and labor productivity poor households (based on EICV1)

Indicator	Land productivity poor hhs	s.e.	Labor productivity poor hhs	s.e.
Total consumption per ae	79,166	(657.2)	58,061	(181.3)
Ag productivity per ha	67,584	(869.2)	172,384	(829.8)
Ag productivity per worker	41,744	(151.2)	13,398	(201.9)
Total size of plots (in hectares)	1.27	(0.043)	0.45	(0.020)
Household Size	4.81	(0.086)	5.09	(0.099)
Number of farmers	2.16	(0.043)	2.64	(0.055)
Literacy Rate (aged 15+)	0.50	(0.014)	0.43	(0.015)
Years of schooling (aged 15+)	2.16	(0.071)	1.74	(0.068)
Access to impr. sanitation	0.46	(0.019)	0.44	(0.022)
Access to impr. drinking water	0.67	(0.018)	0.69	(0.020)
Health problems in the last 2 weeks	0.28	(0.011)	0.29	(0.012)

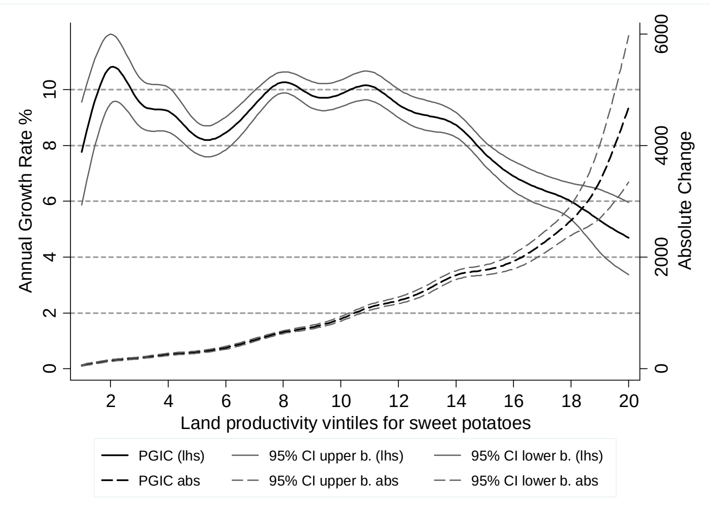
Appendix G: Comparison of land and labor productivity-poor households (based on EICV2)

Indicator	Land productivity poor hhs	s.e.	Labor productivity poor hhs	s.e.
Total consumption per ae	86,535	(427.8)	74,076	(457.3)
Ag productivity per ha	103,113	(1048)	265,454	(907.4)
Ag productivity per worker	77,698	(274.5)	20,692	(269.9)
Total size of all active plots (in ha)	1.46	(0.052)	0.33	(0.014)
Household Size	5.15	(0.076)	4.93	(0.084)
Number of farmers	1.99	(0.033)	2.30	(0.041)
Literacy Rate (aged 15+)	0.57	(0.012)	0.51	(0.013)
Years of schooling (aged 15+)	2.96	(0.070)	2.56	(0.069)
Access to impr. sanitation	0.56	(0.016)	0.49	(0.018)
Access to impr. drinking water	0.66	(0.015)	0.65	(0.018)
Health problems in the last 2 weeks	0.22	(0.008)	0.22	(0.010)

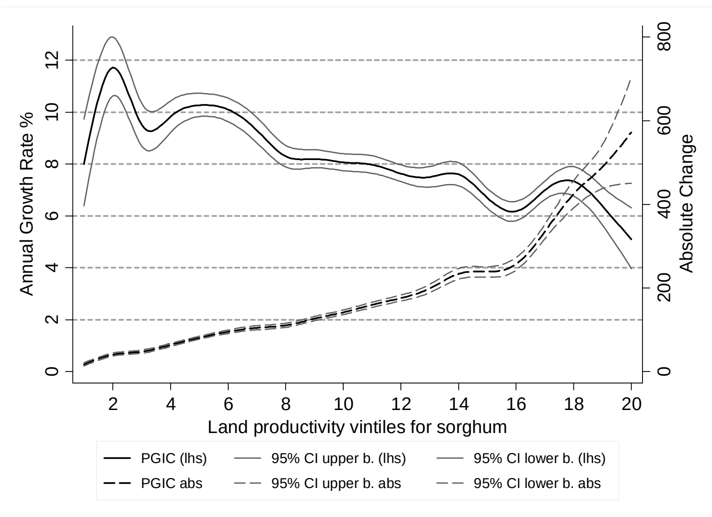
Appendix H: Share of land used in total active agricultural land by major crops (based on EICV household data)

Crop	EICV1	EICV2
Beans	27.18%	28.32%
Maize	8.18%	10.76%
Manioc	10.25%	9.89%
Peas	1.45%	1.82%
Potatoes	7.11%	6.25%
Sorghum	11.37%	12.39%
Soy	1.85%	2.29%
Sweet potatoes	12.69%	12.30%
Taro	1.77%	1.41%
Various types of bananas	10.57%	6.96%
Other	7.57%	7.61%

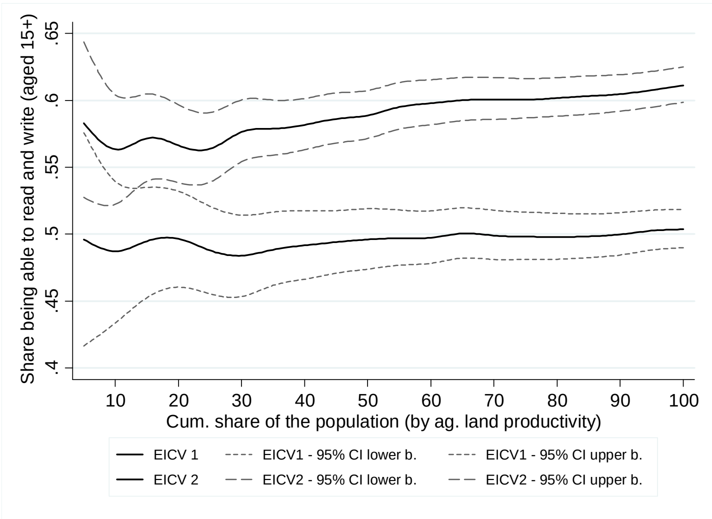
Appendix I: Land productivity growth incidence curves for sweet potato production



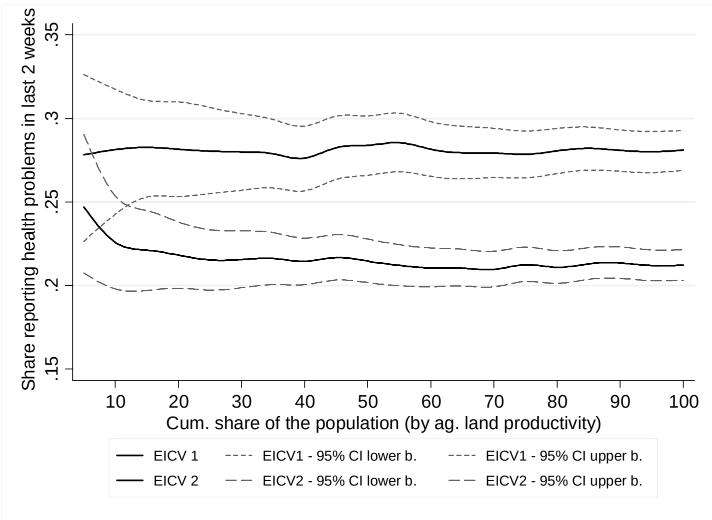
Appendix J: Land productivity growth incidence curves for sorghum production



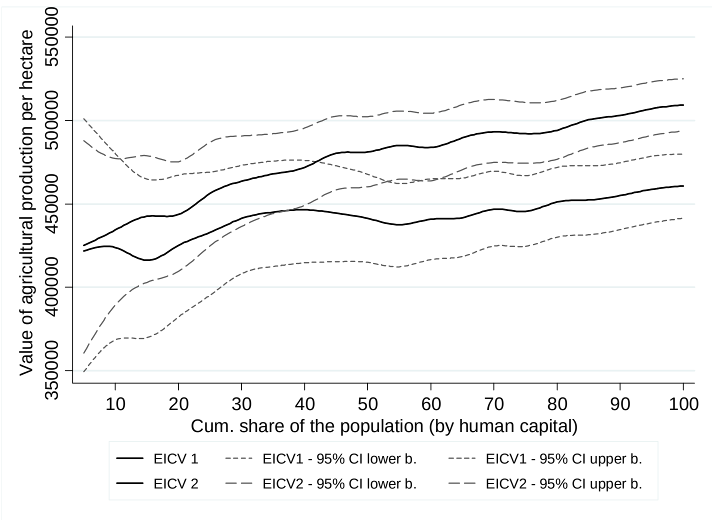
Appendix K: Land productivity opportunity curve (Type 1) for adult literacy (aged 15+)



Appendix L: Land productivity opportunity curve (Type 1) for health problems in the last two weeks



Appendix M: Land productivity opportunity curve (Type 2) for human capital



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