

Resource Allocation and Productivity in Agriculture[†]

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ABSTRACT

Labor productivity in agriculture is extremely low in poor countries. A symptom of this productivity problem is the small operational scale of farms in poor countries which serves to further discourage the adoption of modern technologies, intermediate inputs, and other productivity-enhancing investments. I propose that at the core of the productivity problem in agriculture in poor countries is resource misallocation, particularly misallocation associated with imperfections in land markets. I discuss some direct evidence of resource misallocation in agriculture and its broader implications.

Keywords: land reform, misallocation, land markets, productivity, agriculture, micro data.
JEL codes: O1, O4.

[†]These notes developed from my participation in the plenary panel “Agricultural Policy in Africa” during the conference on Economic Development in Africa organized by the Centre for the Study of African Economies (CSAE) at the University of Oxford in March 2015. It does not intend to survey the literature but rather to present my own research findings on the topic. I thank Margarida Duarte for useful comments. Any errors or omissions are my own. I gratefully acknowledge the financial support from the Social Sciences and Humanities Research Council of Canada.

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1 Introduction

An important fact behind the large differences in standard of living across countries is that agriculture in poor countries is much less productive than non-agriculture compared to rich countries. This fact is relevant since poor countries allocate most of their labor to agriculture.¹ Another important observation across countries is the enormous differences in the scale of operation of production units in agriculture, with poor countries operating at much smaller farm scales than rich countries, see [Adamopoulos and Restuccia \(2014\)](#). As a result of these facts, one question that has captured substantial attention in the literature has been whether or not smallholder agriculture constitutes an impediment for attaining high levels of agricultural productivity in developing countries. I argue that smallholder agriculture is not a problem on its own right, but rather that smallholder agriculture is a symptom of the problem, which is a productivity problem and in a very broad sense I want to characterize as a problem of resource misallocation in agriculture in poor countries.

I argue that factors of production are severely misallocated in agriculture in poor countries and that this misallocation implies substantial losses in terms of aggregate agricultural productivity. In addition, low productivity in agriculture due to resource misallocation means that more resources are devoted to agriculture in order for the economy to produce a certain minimum level of agricultural output per capita, implying lower average operational scales. Many of these farm operations are so unproductive that they basically operate near subsistence levels, with none or little of their output sold in markets.

The broad message I want to convey is that the biggest action poor countries could undertake to improve productivity and development is a better allocation of factors of production in agriculture. And this improvement in productivity would unravel a substantial process of structural change, within-farm productivity growth, and a better selection of farms in agriculture that would contribute to substantial increases in standards of living and reduced inequality.

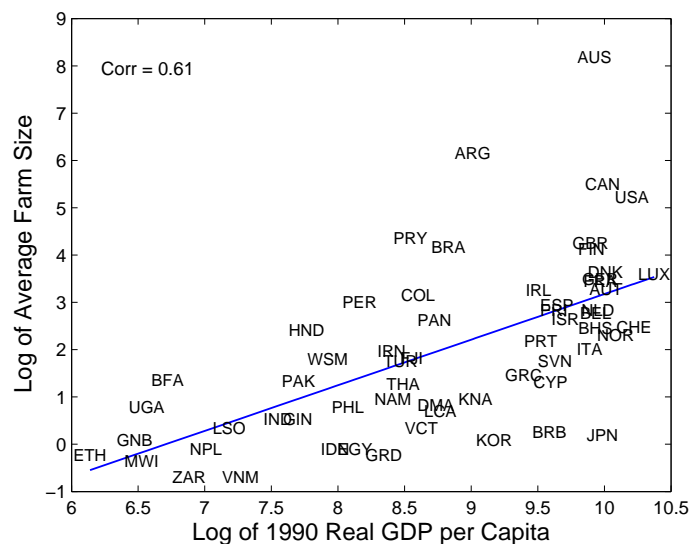
¹See for instance [Restuccia et al. \(2008\)](#) for a detailed documentation of these facts.

To produce these changes, however, a series of non-trivial reforms are required and implementation of the vast reallocation of operational scales will be difficult without the guidance of well-functioning factor markets, including in particular the land market.

2 What are the facts?

Using Agricultural Census data across the world, [Adamopoulos and Restuccia \(2014\)](#) document that the land size of the typical production unit in agriculture in the 20 percent richest countries is a factor 34 times larger than that of the 20 percent poorest countries. Figure 1 reproduces the relationship between average farm size and GDP per capita across countries in Adamopoulos and Restuccia’s sample. In hectares, the average farm in rich countries operates 54 hectares whereas in poor countries only 1.6 hectares. In some countries in Africa for instance, the average operational scale is much less than 1 hectare, in China is less than 0.7 hectares.

Figure 1: Average Farm Size across Countries



Source: [Adamopoulos and Restuccia \(2014\)](#).

The question that arises is what explains these large differences in operational farm size across

countries. The answer to this question is not as simple as it may seem, as there are also large differences in average farm size among developed countries and farm size is determined by a variety of factors, including land endowments, geographical conditions and all sorts of other aggregate variables in the economy such as total factor productivity (TFP), the aggregate amount of capital in the economy, among other factors. To see why this is the case, notice that because the main unit of production in agriculture in both rich and poor countries is the family farm, to a first approximation, average farm size is determined by the land endowment of a country and the number of people in farming. We know from sectoral models, such as that in [Restuccia et al. \(2008\)](#), that the number of people in farming depends on all the factors affecting agricultural productivity. But agricultural productivity can be low not only by factors specific to agriculture but also by factors affecting the entire economy such as economy-wide total factor productivity (TFP), the amount of physical and human capital in the economy, among others. So one first question is to what extent the small operational scales we see in poor countries are the result of these aggregate factors of production as opposed to problems that are specific to agriculture.

[Adamopoulos and Restuccia \(2014\)](#) provide an answer to this question. Whereas aggregate factors (economy-wide TFP, aggregate capital, and land per capita) explain the bulk of differences in average farm size among developed countries, these factors only account for one quarter of the differences in farm size between the richest and poorest countries. Another explanation may be that what matters is not only the quantity of land available for agricultural production but also its quality. [Adamopoulos and Restuccia \(2015a\)](#) use data from Global Agro-Ecological Zones (GAEZ) from the FAO, which reports actual and potential yields (output per unit of land) in every plot of land covering the entire world, to assess the relevance of geography and land quality in explaining productivity differences in agriculture across countries. The actual land productivity gap between the richest and poorest countries is a 3-fold factor. Assigning the potential yield in the land in poor countries gives a land productivity gap of only 1.05-fold (see [Table 1](#)). Hence, if poor countries operated their land at their potential yields, which takes

into account the quality of the land endowment, the labor productivity gap between rich and poor countries would virtually disappear. This result implies that while there are important differences in land quality across countries, the differences are not systematically related to development as to explain any significant portion of the farm size differences across rich and poor countries.

Table 1: Land Quality across Countries, Production by Potential Yield

All Crops (<i>country obs.</i> = 162)			
	Actual Yield	Potential Yield	Yield Gap
Rich 10%	739.5	1,220.0	1.65
Poor 10%	235.5	1,160.6	4.93
Ratio	3.14	1.05	1/2.99

Source: [Adamopoulos and Restuccia \(2015a\)](#).

The overall conclusion from these results is that a different set of factors are relevant in explaining the vast differences in farm size and productivity between rich and poor countries and that these set of factors must be related specifically to agriculture. I would like to argue, as it was first emphasized in [Adamopoulos and Restuccia \(2014\)](#), that resource (mis)allocation is at the core of differences in farm size and productivity in agriculture between rich and poor countries.

3 What is resource misallocation?

Before I discuss the available evidence of misallocation in agriculture in poor countries, it is important to convey explicitly what I mean by misallocation. The concept of misallocation is tightly linked to a specific model economy and to a reference allocation in the context of that economy. A commonly-used benchmark is the efficient allocation of factors in the economy, that

is the allocation that maximizes output in the economy. To fix ideas consider the simple case of a static agricultural economy that produces a single good with a given amount of capital, land, and a set of farmers. The production unit is a farm which consists of a farmer and the inputs of capital and land. The size of farms is determined by decreasing returns to scale on capital and land at the farm level. The only difference across farmers is the ability or productivity of the farm operation. A key feature of this specification is that it would not be optimal to allocate all the capital and land in the economy to any individual farm, even the most productive farm, because the increase in output for a given increase in inputs is decreasing as the farm becomes larger. The allocation of factors across farms that maximizes aggregate output in this economy, the efficient allocation of resources, occurs when all farms operate at a point where the marginal (and average) products are the same among them so that there is no increase in output to be had by reallocating capital and land from a farm with low marginal products to another farm with high marginal products. In the efficient allocation, more productive farms command more inputs (capital and land) and so they are larger, while farms with the same productivity command the same inputs and are of identical size. Any allocation different from the efficient allocation (even if it allocates more factors to the more productive farms) will generate lower aggregate output. Given a constant aggregate amount of capital and land, the output loss associated with an inefficient allocation is also an aggregate TFP loss. We refer as misallocation to the situations where resources are not allocated efficiently across production units and the cost of misallocation is often measured in terms of aggregate output or TFP losses. It is important to note that misallocation can arise both across farms with different productivity as well as across farms with the same productivity. A key interpretation of misallocation is that productive units effectively face different prices or wedges to their inputs or outputs. That is, production units face what [Restuccia and Rogerson \(2008\)](#) called *idiosyncratic* distortions. These wedges or distortions support the observed allocation, which differs from the efficient allocation, as an equilibrium outcome.

4 How important is misallocation?

[Adamopoulos and Restuccia \(2014\)](#) document a long list of policies and institutions in poor countries that have the potential to create misallocation in the agricultural sector and show using a quantitative model that these policies and institutions can potentially explain the bulk of differences in farm size and aggregate agricultural productivity between rich and poor countries. As discussed earlier, it must be that these policies and institutions hit particularly hard the agricultural sector and so the focus has been on documenting a set of policies and institutions affecting land allocations as land is a much more important production input in agriculture than in non-agriculture. It should not be surprising to find substantial resource misallocation in agriculture in poor countries given the vast list of policies, institutions and frictions affecting land allocations in poor countries.

I argue that there is overwhelming evidence of resource misallocation in agriculture in poor countries. I will start by describing the evidence for a specific policy, a land reform, a typical land redistribution policy in developing countries. The reform capped the maximum size of farms and redistributed farm land to landless and smallholders by restricting land markets. The evidence exploits panel micro data of households before and after the reform. Land reforms are an ideal policy to study since redistribution of farmlands can be studied in connection to the explicit limits on farm size in the law. [Adamopoulos and Restuccia \(2015b\)](#) study a comprehensive land reform in the Philippines and show that on impact the land reform had a substantial negative effect on farm sizes and aggregate agricultural productivity. Interestingly, the bulk of the size and productivity effects are not due to the cap on large farms, rather the effects are mostly due to the government intervention in the land market by redistributing farm lands to smallholder and landless individuals, creating substantial misallocation of land across productive farmers.

I now discuss evidence of misallocation in a very poor country, Malawi, which is studied in detail

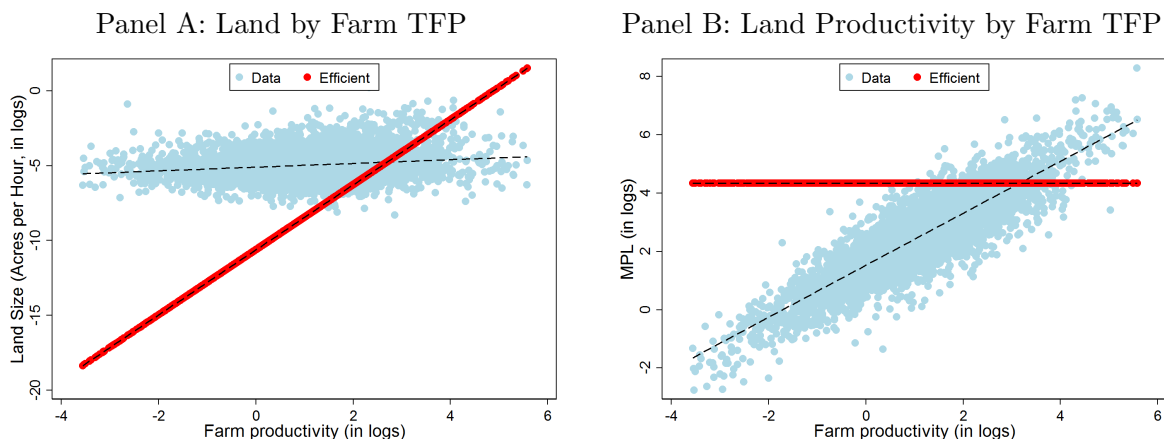
in [Restuccia and Santaaulalia-Llopis \(2015\)](#). I believe this evidence is compelling because of the detailed high-quality data. A key element in assessing resource allocation in agriculture is to be able to construct real measures of productivity at the production unit level, which in this case is the farm. The focus is on family farms as the predominant production unit as emphasized in [Adamopoulos and Restuccia \(2014\)](#). Using household-level data, [Restuccia and Santaaulalia-Llopis \(2015\)](#) measure farm TFP controlling for detailed measures of factor inputs, intermediate inputs, land quality, and other transitory changes in output such as weather and other shocks to agricultural activity.² Equipped with this measure of farm TFP, Restuccia and Santaaulalia-Llopis evaluate resource allocation. The resulting patterns are striking, although as alluded earlier not entirely surprising since Malawi is an economy with no well-defined property rights over land and there is a very limited market for land—only 16% of land is marketed formally or informally in Malawi. The patterns for the land allocation are summarized in Figure 2, panels A and B. In panel A, land operated by each farmer is plotted against farm TFP. Each blue dot represents a farm in the data while the dashed line represents the efficient land size of each farm. The striking pattern is that the actual allocation of land in Malawi is such that there is almost no systematic relationship between operated land in farms and their TFP.³ What this land allocation implies is that the productivity of the land in each farm (also often referred as the yield or output per unit of land) is strongly increasing in farm TFP, suggesting positive gains from reallocation of land from less to more productive farms in Malawi. Whereas the efficient allocation equates the yield in all farms, the observed allocation shows a strong positive relationship between the yield and farm TFP, indicating resource misallocation.⁴ I should note that the average yield in the ten percent most productive farms relative to the 10 percent least productive farms is almost a factor of 60-fold, so there is the scope for large reallocation gains.

²The data is from the Integrated Survey of Agriculture (ISA) of the World Bank and contain precise and detailed household information on all dimensions of agricultural production, see [Restuccia and Santaaulalia-Llopis \(2015\)](#) for more details.

³The same pattern arises for the capital allocation, see [Restuccia and Santaaulalia-Llopis \(2015\)](#).

⁴Constant yield across farms in the efficient allocation is a feature of the assumed output technology which is Cobb-Douglas in capital and land. [Adamopoulos and Restuccia \(2014\)](#) consider a more general technology where the yield is decreasing in productivity in the efficient allocation.

Figure 2: Operational Land Allocation in Malawi



Source: [Restuccia and Santaaulalia-Llopis \(2015\)](#).

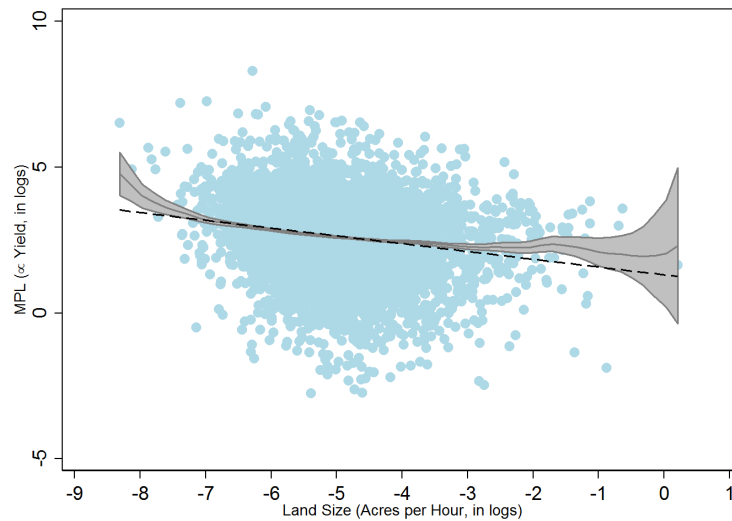
An important element of the evidence of agricultural resource misallocation in Malawi is that it is strongly linked with the extent of land markets. [Restuccia and Santaaulalia-Llopis \(2015\)](#) compare resource allocation of farmers whose operated land was all obtained in the market (rented or purchased either formally or informally) to those farmers whose operated land is not marketed. Even though land markets are so imperfect in Malawi that is unlikely that farmers with marketed land obtained the desired or optimal level of land, the reallocation gains from these farmers are much lower than for farmers with no marketed land. Whereas the reallocation gains for farmers with no marketed land are a factor of 4.2-fold, for farmers with all marketed land is 1.6-fold (and for farmers with purchased titled land 1.4-fold). This implies that, relative to farmers with marketed land, the reallocation gains of farmers with no marketed land is still a factor of 2.5-fold. This large *relative* gain implies that gains from reallocation are substantial even if there remain measurement and specification issues that should affect both set of farmers similarly.

Before showing more evidence of land misallocation for other countries and evaluating the broader implications of misallocation in agriculture, I want to contrast the preceding view of resource allocation from estimates of farm TFP in the micro data, with the more common view from standard analysis of yields by farm size as guidance of resource allocation. Figure

3 reports the land productivity (yield) data for Malawi farmers as related to farm size. There is an inverse relationship between land productivity and farm size which is consistent with a very large literature in development economics on the inverse productivity-size relationship. In contrasting these views I emphasize two elements. First, farm size is different from farm TFP. This echoes the work of [Restuccia and Rogerson \(2008\)](#) emphasizing the role of idiosyncratic distortions in altering the size of production units in poor countries. In an efficient allocation, size and productivity go hand in hand but in the presence of misallocation, size is less correlated with productivity, and in extreme cases, uncorrelated with productivity as is the case in farms in Malawi. Second, land productivity or yield is not necessarily a good measure of productivity. To appreciate this point note that in the framework of [Restuccia and Santaaulalia-Llopis \(2015\)](#) the efficient allocation features no differences in yields across farms even though there is wide disparities in farm TFP. To put it differently, the only reason why more productive farms have higher yields in Malawi in the actual allocation is that there is substantial misallocation of land, reallocation of operational scales would eliminate these disparities and render the yield a weak measure of productivity. Any reform or policy that improves resource allocation in this setting is bound to reduce disparities in yields across farms. The literature has emphasized farm sizes and yields largely as these measures are easily observable, whereas measuring farm TFP is much more demanding. Also note that the land productivity ratio between the ten percent smallest farms and the ten percent largest farms is only a factor of 3-fold, whereas the ratio of land productivity between the ten percent most and least productive farms (by TFP) is a factor of more than 60. So again, distortions in farm size act to confound the magnitude of reallocation gains. These considerations are relevant not only in terms of the focus of what reallocation is needed, but also whether or not a better allocation of resources can be achieved in centralized ways and operated by observable measures such as farm size.

There is more evidence of resource misallocation in agriculture. [Chen et al. \(2015\)](#) study resource misallocation in Ethiopia. Ethiopia is an interesting case because it is a very poor country in Africa, featuring strong institutional restrictions on land markets. For instance, in

Figure 3: Land Productivity (Yield) by Farm Size in Malawi

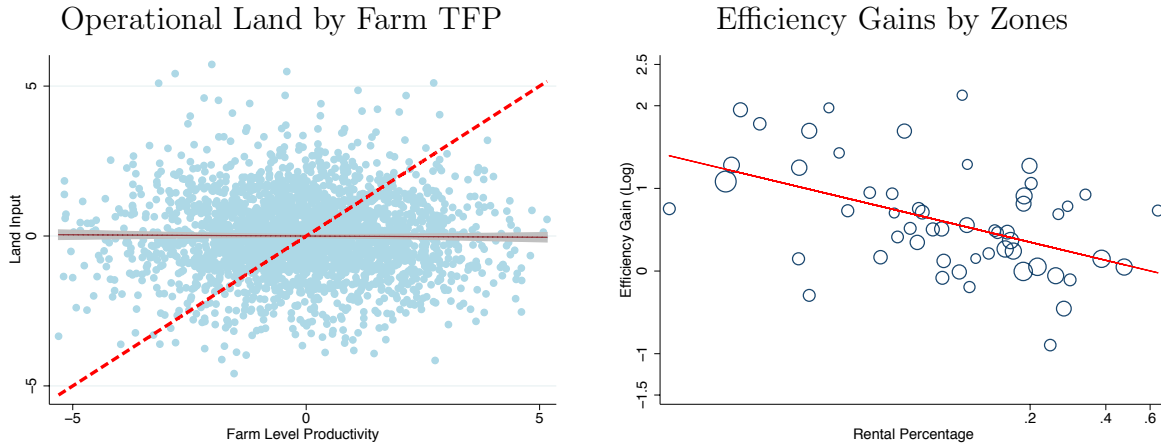


Source: [Restuccia and Santaaulalia-Llopis \(2015\)](#).

Ethiopia land is owned by the state and hence cannot be sold. In addition, there is explicit prohibition of rentals and even if they were allowed as it has been the case in some Zones, use rights are ill defined and strongly enforced by local leaders. Use rights are allocated by local leaders on a fairly egalitarian basis within members of the Kebele. Only recently Ethiopia has started a process of certification of use rights presumably with the purpose of allowing a more flexible allocation of land. Figure 4, Panel A, documents the actual allocation of operational land across farmers in Ethiopia by farmer's TFP. As it was the case for Malawi, the land allocation is not positively related to farm productivity as the efficient allocation would dictate. Because different regions have taken a differential approach to the allocation of use rights and allowing for rentals, [Chen et al. \(2015\)](#) compare the reallocation gains across Zones in Ethiopia by the share of land that is marketed (farmers that operate more land than their land use right). There is a strong negative relationship between the extent of marketed land in a Zone and the reallocation gains, with Zones with more marketed land observing smaller gains, meaning that their actual allocation is closer to the efficient allocation.

[Adamopoulos et al. \(2015\)](#) study resource allocation in China. China is also an interesting case

Figure 4: Misallocation in Ethiopia



Notes: Panel A, the red dashed lines is the counterfactual efficient allocation. Panel B, there are 55 Zones (equivalent to States/Provinces). Included are Zones with positive percent of rental land and more than 20 observations. The size of each circle indicates the number of observations in each zone. The regression line is also weighted by the number of observations in each zone. The slope of the line is -0.295 , significant at the 1% level.

because despite being a growing economy with substantial reallocation, the level of agricultural productivity remains well below non-agriculture and shows no systematic tendency to improve. In addition, as the case in Ethiopia, individual farmers only have use rights on their land with implicit “use it or lose it” rules. Not surprisingly, the land allocation in China is also not strongly related to farm productivity and, as a result, reallocation gains are substantial. [Adamopoulos et al. \(2015\)](#) show that a nationwide reallocation of land and capital across farmers would increase aggregate agricultural productivity by 84%. Using the panel dimension of the data, by estimating a permanent component of farm productivity, reallocation gains are still large, more than 80 percent of the cross-sectional gains. [Adamopoulos et al. \(2015\)](#) show that over time there is no tendency for misallocation to improve in China, which contrast with the results for the manufacturing sector in [Hsieh and Klenow \(2009\)](#).

There are important issues of measurement and specification that can make the reader suspicious of the evidence as measuring TFP at the farm level is an enormous difficult task. Measuring TFP at the farm level requires a lot of good-quality data. Nevertheless, it is important not to lose sight of the big picture. I argue that the best evidence paints a fairly consistent picture

that while the specific number of reallocation gain may depend on some of these data issues, the overall direction and importance of misallocation remain. In the absence of panel data, the micro data allows in some cases to control for many variables that may temporarily affect output in agriculture for an individual farmer such as temporary health issues, death in the family, or marriage disruptions. Moreover, relative gains in the case of Malawi between farmers with marketed land versus farmers with no marketed land is a more robust measure as it is unlikely that measurement, specification, and pure randomness issues are systematically related to these two groups of farmers. Even in the panel data in the case of China, where a permanent component of farm TFP can be estimated, the reallocation gains remain high, more than 80 percent of the overall cross-sectional gains. Taken together, the evidence points to substantial factor misallocation in agriculture in poor countries, specially in those with weak or limited land market institutions, and a strong negative effect on aggregate agricultural productivity.

5 Broader implications

The increase in aggregate agricultural TFP due to reduced misallocation can have very broad implications by altering within farm investments, promoting structural change, improving selection of individuals across sectors, as well as, altering relative prices and affecting inequality.

To illustrate some of these effects, consider the hypothetical situation in Malawi of a reduction of misallocation in agriculture that according to [Restuccia and Santaaulalia-Llopis \(2015\)](#) can increase aggregate agricultural productivity by a factor of 3.6-fold. Table 2, Panel A, reports the potential inequality implications of this increase. The assumption in this scenario is that the reallocation of factor inputs from the actual to the efficient allocation is done via rental markets: whereas in the actual allocation farmer's income comes mostly from agricultural production, in the efficient allocation less productive farmers complement their income with rental of their endowment of capital and land to more productive farmers. Looking at the top and bottom 20

percent of farmers by productivity (the fifth and first quintile of the productivity distribution), the actual allocation of agricultural income features a lot of inequality, a factor of 34-fold between the fifth and first quintiles. That is, factor equalization is not an effective instrument for equating incomes of farmers since income inequality reflects differential abilities of farmers to produce agricultural output. The efficient allocation features much lower inequality between these groups, a factor of 3-fold between the fifth and first quintiles (vs. 34-fold in the actual allocation). Interestingly, income increases for all farmers, but income increases more for the poorest households. So, the huge reallocation of operational scales implied in attaining the efficient allocation leads to a substantial decline in income inequality and the poorest households are those that benefit the most. That is, the reallocation of factors also reduces poverty.

Table 2: Implications of Reduced Misallocation

Panel A: Inequality

Total Farmer's Income	Quintiles		
	First	Fifth	Ratio
Actual	.14	4.8	34.1
Efficient	4.3	14.7	3.4
Ratio	30.6	3.1	–

Panel B: Structural Change

	Actual	Reallocation
Total Factor Productivity in Agriculture	1.0	3.6
Share of Employment in Agriculture	0.65	0.04
Output per unit of Land (Yield)	1.0	1.0
Labor Productivity in Agriculture	1.0	16.2
Average Farm Size	1.0	16.6

Source: [Restuccia and Santaaulalia-Llopis \(2015\)](#). Panel A: Actual farm income includes output in agriculture whereas efficient income includes output of operated factors plus the rental income of capital and land not operated.

In the context of a simple two-sector model of agriculture and non-agriculture with constant agricultural consumption per capita, an increase in agricultural productivity would imply a reallocation of labor from agriculture to non-agriculture. [Restuccia and Santaaulalia-Llopis \(2015\)](#) show that a reduction in static misallocation in agriculture in Malawi can generate a substantial reduction in the share of employment in agriculture that would go from 65% to 4%,

much closer to the levels of agricultural employment observed in rich countries. This reduction in the share of employment in agriculture would allow farm sizes to increase and further increase agricultural labor productivity. These effects can be further amplified if there is selection into the productivity of those who stay in agriculture and if the increase in farm size allow for further investments in farm productivity (the adoption of modern intermediate inputs, mechanization, among others) both of which are channels that have empirical support in the literature.

6 Conclusions

Resource misallocation in agriculture is highly pervasive in poor countries. At the root of resource misallocation in agriculture is strong restrictions to land markets. A key challenge in poor and developing countries is how to facilitate a better allocation of factors in agriculture. This is not an easy task. I envision that better functioning markets and institutions are key in this process. Centralized government programs, while well intended, are unlikely to promote a better allocation as reallocation needs guidance as to the best uses of resources.

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