Rwanda's Agricultural Productivity Gap

Paul Brimble

Agriculture is tremendously important for any developing country. While no country has developed through its agricultural sector, it is also true that no country has developed without it. In the majority of countries, there exists an agricultural productivity gap where the value added per worker is much higher in the non-agricultural sector than in the agricultural sector. This phenomenon has been well documented throughout the past century with Lewis (1955), Kuznets (1971) and Gollin, Parente and Rogerson (2002) discussing how these gaps are largest amongst developing economics. Recently, Gollin, Lagakos and Waugh (2013) provide a comprehensive analysis of the size of these gaps across a large cross-section of countries and find that using data from the early 2000s, Rwanda has one of the largest gaps in the world. However, over the past couple of decades, Rwanda has undergone a significant economic transformation. How have these changes translated into agricultural productivity?

The objective of this paper is to outline a new and simple approach for understanding productivity in Rwanda's agricultural sector. The first step is to establish a measure for the agricultural productivity gap in order to evaluate the size of these gaps and observe how they have changed over time. By presenting these trends, I provide a clear picture of how the agricultural sector has responded to the economic and political developments of the past 25 years. The second step is to identify contributing factors that can help to explain the gap. Furthermore, determining the extent of each factor's contribution is essential for understanding the underlying causes of the gap. The third step is to discuss the interpretation of the gap once the contributing factors have been taken into consideration. Finally, I conclude this paper by looking ahead at the future of Rwanda's agricultural sector and laying out the policy implications accompanying the results.

■ *Paul Brimble is an economist on the ODI Fellowship Scheme at the Rwandan Ministry of Finance and Economic Planning. He works at the Macroeconomic Policy Unit in the Office of the Government Chief Economist.*

Trends in Rwanda's Agricultural Productivity Gap

I model the agricultural productivity gap using a theoretical framework derived from a two-sector neoclassical model where the economy consists of the non-agricultural and the agricultural sectors, denoted by n and a respectively following Gollin, Lagakos and Waugh (2013). Given minimal assumptions on the production technologies and equilibrium conditions, this theory predicts that the ratio of value added per worker should be equalised across sectors due to labour mobility.[1] An identical expression for this ratio can instead be calculated using agricultural value added and labour employment shares, denoted by v_a and l_a respectively. Therefore, the agricultural productivity gap can be expressed as follows:

$$\frac{\frac{(1-v_a)}{(1-l_a)}}{\frac{v_a}{l_a}} = 1. \tag{1}$$

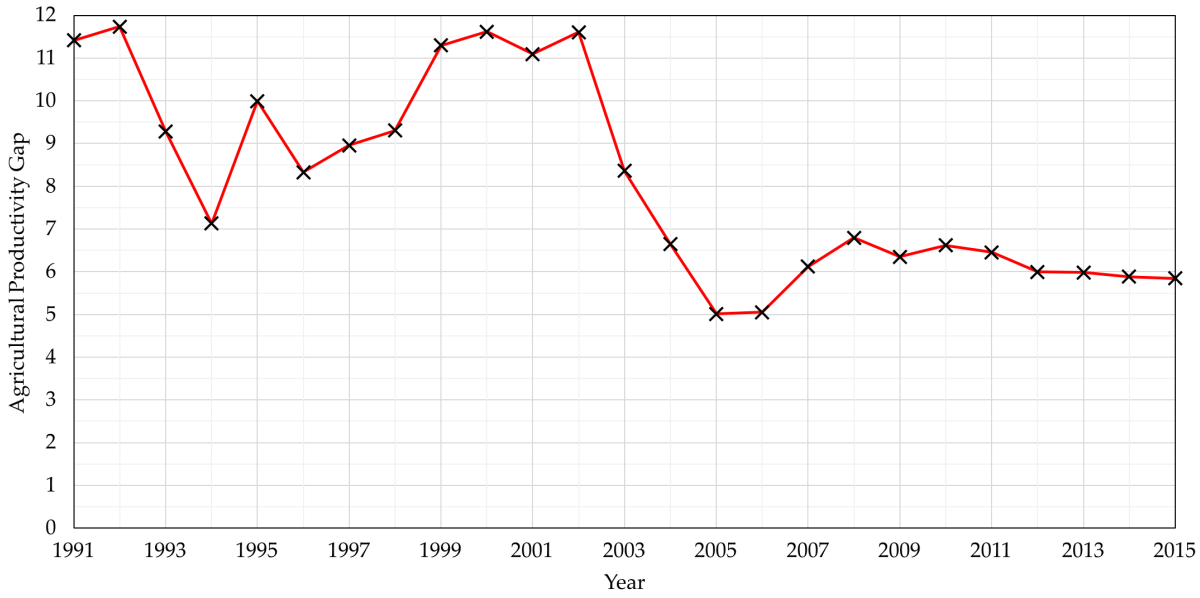
This prediction is based on the idea that if the gap is larger than unity, agricultural workers would be incentivised to switch out of the agricultural sector, where the value of their marginal product is low, and into the non-agricultural sector, where this value would be higher in order to earn more income. After time, this structural shift in labour should equalise the marginal product of labour across sectors, leading to Equation 1. This reallocation of workers would increase aggregate production without any additional increase in labour. This model is intrinsically linked to the work of Rosenstein-Rodan (1943), Lewis (1955) and Rostow (1960) who describe this process of reallocation as fundamental to economic development and can raise aggregate output per worker substantially (McMillan and Rodrik 2011).

I calculate the agricultural productivity gap using national accounts data and so refer to these estimates as the macro APG throughout this paper.[2] The estimates are presented in Figure 1, covering a period of 25 years from 1991 to 2015. For the entire sample, the average gap is 8.11, significantly higher than the global average of 3.50 from Gollin, Lagakos and Waugh (2013). However, Figure 1 clearly shows that there are three distinct stages describing the trends in Rwanda's agricultural productivity gap. Firstly, during the pre-transition stage from 1991 to 2002, the gap is incredibly large and volatile with an average of 10.15.[3] Secondly, the transition stage from 2002 to 2005 is marked by a steep and permanent decline in the gap from 11.61 to 5.01 over this short time period. Finally, the post-transition stage from 2005 onwards sees the gap stabilise significantly, averaging a much more respectable 6.01 during this decade.

These three stages closely correspond to Rwanda's economic and political developments of the past 25 years. The large and volatile gap during the 1990s unsurprisingly coincide with the highly unstable economic and political landscape of that decade. It was not until the early

[1] Given the model assumptions, the ratio of the marginal products of labour is equivalent to the ratio of the average products of labour.
[2] Data for the value added and labour employment shares come from the United Nations National Accounts Statistics and the International Labour Organisation (ILO) respectively. These data sources are used to make the results from this paper comparable to the estimates from Gollin, Lagakos and Waugh (2013).
[3] This value is consistent with the estimate of 10.22 for Rwanda by Gollin, Lagakos and Waugh (2013).

Figure 1
Rwanda's Agricultural Productivity Gap (1991-2015)



Source: Author's calculations.

2000s after the country had begun its recovery path that the gap began to improve substantially. The transition stage can be directly linked to favourable macroeconomic conditions and supportive government policies such as the Vision 2020 strategy (Government of Rwanda 2000) which emphasised the importance of developing the agricultural sector away from subsistence farming towards high productivity market-oriented agricultural activities. While the stability of the gap from 2005 onwards comes as no surprise given Rwanda's strong and robust economic performance, the size of the gap itself remains persistently high.

Contributing Factors Explaining the Gap

While the pre-transition and transition stages are easy to comprehend, the post-transition stage is quite puzzling. Despite Rwanda's impressive growth over the previous decade, it appears that these economic developments have not translated into reducing the gap at all. In this section, I identify the factors responsible for this gap and evaluate the extent of their contribution. In this paper, I distinguish between two types of factors that affect the gap differently. Firstly, there is potential for mismeasurement of the gap that arises from the use of data at the macro level. Secondly, the inclusion of hours worked data and human capital estimates can vastly improve measures of labour inputs. By taking into account these data and labour adjustments, I can then calculate an adjusted agricultural productivity gap which describes more accurately the economic situation.

Mismeasurement of the value added and labour employment shares can arise due to a variety of reasons. While in theory, the national accounts data should measure home production, this may not always be the case in practice. As a significant proportion of the agricultural

Table 1
Comparisons of Rwanda's Agricultural Productivity Gaps

		Data Adjustments	Labour Adjustments		
Year	Macro APG	Micro APG	Hrs_n/Hrs_a	H_n/H_a	Adjusted APG
2006	5.05	3.93	1.93	1.46	1.40
2011	6.46	5.32	1.82	1.71	1.71
2014	5.88	4.50	1.89	1.71	1.39

Source: Author's calculations.
Notes: The adjusted APG is calculated using the micro APG and applying both labour adjustments.

sector involves home production and consumption, national accounts data can potentially underestimate agricultural production as seen in Gollin, Parente and Rogerson (2004). When analysing agricultural productivity gaps in U.S. states, Herrendorf and Schoellman (2015) find that there is systematic under-reporting of agricultural income. The relatively large informal sector can also provide additional bias and in combination with under-reported home production can lead to national accounts data omitting large aspects of economic activity. Furthermore, a large proportion of the economically active population consists of self-employed and unpaid family workers who may be excluded from the labour force, biasing the labour employment shares. An additional source of mismeasurement might be the inclusion of value added from large multinational organisations which may not be representative of workers and households. Overall, there are multiple sources of potential mismeasurement which can either overestimate or underestimate the agricultural productivity gap.

The use of household surveys can help to evaluate the extent of this mismeasurement. This is because nationally representative surveys include a wide range of workers, including unpaid family contributors as well as enterprises which many not be properly represented in the national accounts data. In contrast to the macro APG, I refer to the agricultural productivity gap calculated using household surveys as the micro APG. Using data from three Integrated Household Living Conditions Surveys (EICV), I construct measures for value added and labour employment shares for 2006, 2011 and 2014.[4]

The macro and micro APG estimates are presented in Table 1. The differences in these gaps are sizeable with the micro APG estimates consistently lower by a relatively constant proportional factor for all years. The macro APG average is 5.80 compared to the micro APG average of 4.58 during the three household survey years. As the micro estimates are tackling mismeasurement issues, these results provide significant evidence for mismeasurement which once addressed, reduces the agricultural productivity gaps by a factor of approximately 1.3.[5]

[4] These household surveys are referred to EICV2, EICV3 and EICV4. Each survey is assigned to the annual year during which the majority of the data collection occurred.
[5] It is worth noting that the differences between the macro and micro APG estimates are caused by a combination of changes to both the value added and labour employment shares.

Improving labour input measures can also significantly change the size of the agricultural productivity gap. An underlying assumption for the previous analysis is that labour inputs, and consequently workers, are identical across sectors. More precisely, it is sufficient to compare the number of workers in each sector if they all work the same amount of hours and possess the same skills, measured by their human capital. If there are systematic differences in hours worked and human capital per worker across sectors, then these should be taken into consideration. The differences in hours worked and human capital can be considered as quantity and quality differences respectively. Gollin, Lagakos and Waugh (2013) estimate that workers in the non-agricultural sector supply 10 percent more hours than those in the agricultural sector using a cross-section of over 50 countries. Furthermore, both Gollin, Lagakos and Waugh (2013) and Caselli and Coleman (2001) argue that non-agricultural workers have more human capital than agricultural workers.

By adjusting the labour inputs to include the labour employment share, hours worked and human capital across sectors, I can calculate an adjusted agricultural productivity gap which takes into account these differences. This adjusted gap is equal to the unadjusted gap divided by the ratio in hours worked and human capital across sectors. By denoting hours worked and human capital for sector s with Hrs_s and H_s respectively, I can write the adjusted gap as:

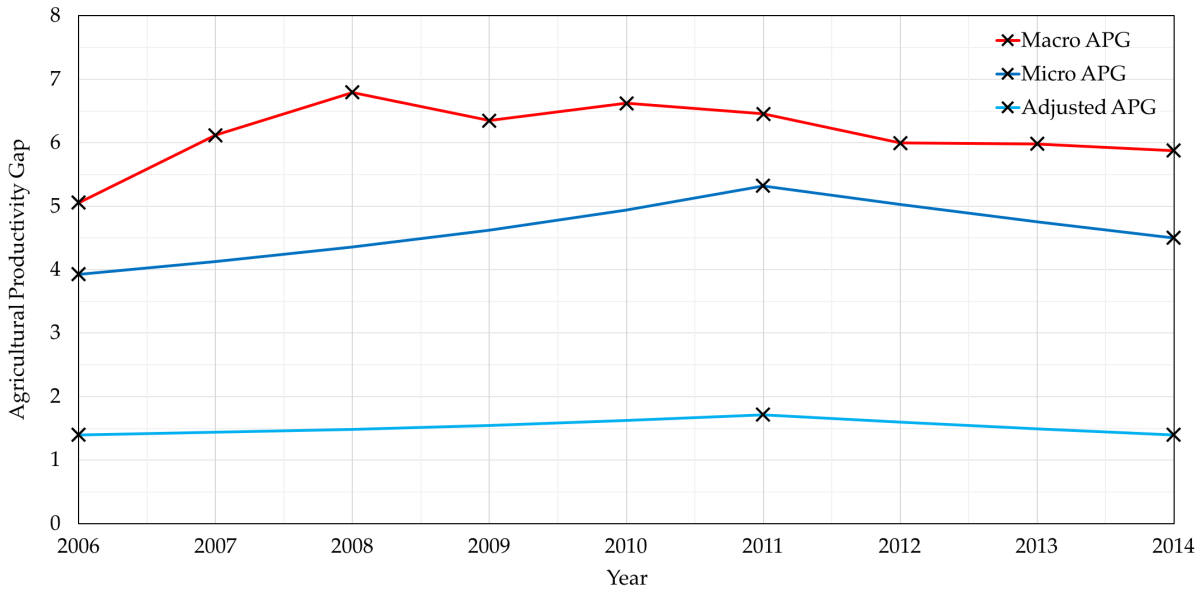
$$\frac{\frac{(1-v_a)}{(1-l_a)}}{\frac{v_a}{l_a}} \div \left(\frac{Hrs_n}{Hrs_a}\right) \div \left(\frac{H_n}{H_a}\right) = 1. \tag{2}$$

This expression clearly relates the adjusted gap to the unadjusted gap from Equation 1 where the two adjustments come from differences in hours worked and human capital. If there are no differences, then the unadjusted and adjusted agricultural productivity gaps will be identical. Using the EICV household surveys, I calculate the ratios of both hours worked and human capital across sectors for 2006, 2011 and 2014 which are presented in Table 1.[6] The results of the two labour adjustments are both significantly large, with non-agricultural workers supplying nearly twice as many hours compared to agricultural workers in addition to sizeable human capital differences.

The adjusted APG which is presented in Table 1 is calculated by applying the two labour adjustments to the micro APG. The results show that a large proportion of the macro APG can be explained by mismeasurement and improved labour input measures which account for differences in hours worked and human capital per worker across sectors. This comparison can also be visualised in Figure 2. Between 2006 and 2014, the macro gap averaged 6.14, significantly higher than the adjusted gap which for the three household survey years averaged only 1.50. This is a massive improvement as the majority of the initial macro APG can be explained by the three contributing factors outlined above.

[6] I calculate human capital using years of formal schooling and returns to schooling estimates from Montenegro and Patrinos (2014). I also control for differences in the quality of education across sectors by using literacy rates.

Figure 2
Comparisons of Rwanda's Agricultural Productivity Gaps



Source: Author's calculations.
Notes: A simple linear imputation for the household survey valued added shares, labour employment shares, ratio of hours worked and ratio of human capital is computed for graphical purposes.

Interpreting the Gap

Taken literally, an agricultural productivity gap of 1.50 implies a sizeable misallocation of labour resources. Closing this gap through the reallocation of labour out of the agricultural sector and into the non-agricultural sector can lead to significant welfare gains at a relatively low cost, even when conditioned for hours worked and human capital. It is worth noting that this reallocation does not necessarily imply rural-urban migration but instead the movement of workers into non-agricultural activities such as agro-processing. This adjusted gap of 50 percent, while significantly smaller than the macro APG estimates are still puzzlingly large and there are three main ways to interpret this gap.

Firstly, there may be additional factors contributing to this gap which have been omitted. The identification of such factors could reduce the size of the adjusted gap. This view is particularly appealing as it suggests that there is no significant misallocation of labour resources. Given the stability of the gap during the post-transition stage, it is possible that the adjusted gap can be reduced even further with the addition of several factors. These include improving human capital measures since there are other factors which determine human capital beyond years of schooling. The inclusion of experience and training into human capital could significantly improve these measures as evidenced by Lagakos et al. (2012). Costs of living may also be a contributing factor to the gap as these may differ across sectors. If non-agricultural workers incur a higher cost of living, then this can reduce the adjusted gap. Finally, if labour is used more intensively in agricultural production than in non-agricultural production, this

would further reduce the adjusted gap although evidence from Gollin (2002) indicates that the labour intensities are quite similar across sectors.

The second interpretation is that the agricultural productivity gap is driven by market forces. The main argument for this interpretation relies on selection effects such that more skilled workers select into the non-agricultural sector, leading to an agricultural productivity gap between average workers across sectors. Evidence of this can be found in Lagakos and Waugh (2013), Young (2013), Beegle, De Weerdt and Dercon (2011) and Miguel and Hamory (2009). An alternative argument incorporates the gender dimension instead. Since the share of female workers in the agricultural sector is higher than in the non-agricultural sector, the presence of a gender pay gap will disproportionately affect the agricultural sector, creating an agricultural productivity gap. Under this interpretation, the gap is not a result of any misallocation of labour.

The final interpretation takes the adjusted gap literally as a result of the misallocation of labour resources. The fact that the gap has remained rather stable for the past decade implies that there are structural factors preventing the gap from closing. On the supply side, labour mobility frictions prevent workers from moving between sectors. A promising area of research focuses on financial and community networks. These small networks, such as tontines, cooperatives and *ikibina* are important in the Rwandan context as they provide informal social insurance and other financial services. Munshi and Rosenzweig (2016) highlight the role of these community networks in preventing migration and causing wage gaps as they are often more prevalent in rural areas which lack formal financial institutions. On the demand side, a weak private sector can fail to generate sufficient non-agricultural jobs for workers to fill. While this paper focuses on the differences between the agricultural and non-agricultural sectors, there is significant overlap with the rural-urban divide and disentangling these two concepts such as in Michaels, Rauch and Redding (2012) who explore the relationship between urbanisation and structural transformation can be beneficial.

Looking Ahead and Policy Implications

The future of Rwanda's agricultural sector is promising. While the current state of agricultural productivity is much improved from the 1990s and early 2000s, there are still significant areas for improvement. Approximately two-thirds of all workers are still employed in the agricultural sector, with a substantial share of these people working on subsistence farms. Moving towards market-oriented agricultural activities and adopting new technologies will be essential in keeping the adjusted gap tight as the non-agricultural sector continues to perform well.

In the long term, it is clear that policy should target the contributing factors of the gap. Investment in human capital, especially amongst future agricultural workers, will be critical. If the relatively low hours worked amongst agricultural workers is due to an abundance of available labour, then as workers move towards the non-agricultural sector, agricultural workers will be able to increase their working hours and subsequently their incomes. Policies that equalise the quantity and quality of labour across sectors will help to close the unadjusted gap.

In the short and medium term, the appropriate policy implications depend on the interpretation of the adjusted gap. In the case that there are additional contributing factors, policy should focus on equalising these factors across sectors once they are identified. If market forces are driving the gap, then policy should target workers who lose out such as unskilled and female workers through supportive programmes that improve their economic opportunities. Finally, if the gap is a result of the misallocation of labour resources, then policy should aim towards eliminating the structural factors preventing the gap from closing. This includes removing labour mobility frictions and adopting strong private sector development strategies. Overall, a combination of these policies will most likely contribute to closing the gap. Further research on this topic will help to inform more effective policy.

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