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The impact of markets and policy on incentives for rice production in Rwanda

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The impact of policy and the market environment on production and wholesale trade incentives for rice in Rwanda

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Abstract

The prioritization of rice as a strategic food and cash crop in Rwanda has paid dividends, with production increasing by one-third during 2010–2015. However, production expansion—driven mainly by land expansion as opposed to yield growth—has failed to keep pace with growing consumption demand, especially in urban areas. In 2015, around 30 percent of national consumption was met by imported long grain rice, which is preferred over locally produced rice perceived to be of a lower quality. The present paper aims to single out the constraints which have been preventing the Rwandan rice sector to fully seize market opportunities in recent years. Looking at Nominal Rates of Protection faced by agents in the rice value chain over 2005–15, we find rice producers and wholesalers enjoy significant price incentives, mostly as a result of protective trade measures. Other factors, however, appear to be hindering investments in land, the adoption of modern inputs, and the production of high quality rice that can more readily substitute imports. This evidence is used along with recent literature and stakeholder interviews to formulate policy recommendations. Investments in land, infrastructure, and irrigation for paddy rice production should be prioritised. Further, there is a need to support and modernize the rice sector so that it can better respond to consumer demand dynamics in urban and rural areas. Agricultural research should be linked with market analysis to promote varieties that match consumer preferences in specific areas or income groups. While agronomic conditions do not necessarily permit large-scale adoption of long grain rice varieties, improvements in milling and grading practices can greatly improve the quality of local rice varieties, thus allowing more effective competition with imports and the expansion of exports to emerging markets such as the Democratic Republic of Congo.

Keywords: Rwanda; Rice production and trade; price incentives

JEL codes: Q02; Q17; Q18.

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1 Introduction

In Rwanda, rice has recently surpassed other staples to become the most important food crop in terms of household food budget allocations. Expenditure estimates from the Fourth Integrated Household Living Conditions Survey (EICV4), conducted in 2013–14, show rice accounted for 8.5 percent of food expenditure, up from 7 percent in 2010–11 (EICV3), and ahead of other major staples such as dry beans (7.5 percent) and Irish potatoes (6.9 percent) (NISR, 2012, 2015b). The increase in the rice budget share was entirely accounted for by imported rice (see Table 1 in the Annex), which still represents about a third of national supply (UN Comtrade, 2016).

Rice-growing conditions are favourable in Rwanda, with farmers consistently achieving yields of around 5.5 tonnes per hectare, outperforming those of neighboring countries such as Burundi, Uganda and Tanzania (2.5 tonnes per hectare) and Kenya (4.2 tonnes per hectare) (FAOSTAT, 2016). In 2015, the harvested area for rice surpassed 17 000 hectares (NISR, 2015a), but with marshland areas covering around 278 000 hectares (REMA, 2015), some experts believe the harvested area for rice could increase to 66 000 hectares in the coming years (Dr Innocent Ndikumana, Rice Specialist, Rwanda Agricultural Board (RAB), 2016, personal communication, 7 October). Given the perceived production opportunities and recent consumption trends, it is understandable that rice has been identified as a priority value chain in Rwanda's Strategic Plan for the Transformation of Agriculture 2013–2017 (PSTA III).

To spearhead development initiatives in the rice value chain the Ministry of Agriculture and Animal Resources (MINAGRI) launched the National Rice Development Strategy (NRDS) (2011–2018) in 2011. NRDS aims to "*achieve self-sufficiency in rice production by 2018, and to substantially raise the competitiveness of Rwanda rice in local and regional markets*" (MINAGRI, 2013). Among its goals are a large increase in the area of harvested land to 28 500 hectares and raising paddy rice yields to 7.0 tonnes per hectare by 2018.

Rice is also emerging as an important staple crop in other Eastern African countries (KilimoTrust, 2014). With the exception of South Sudan, which produces insignificant quantities of rice, all of Rwanda's fellow East African Community (EAC) member countries—that is, Kenya, Tanzania, Uganda, and Burundi—consume, produce and trade large quantities of the commodity. In recognition of the strategic importance of rice, all of these countries have likewise adopted rice development strategies with multiple objectives of raising production or productivity, attaining self-sufficiency (i.e., substituting imports), and expanding exports. Successful implementation of these rice development strategies requires not only an understanding of the constraints faced within domestic rice value chains, but also how domestic value chains are integrated regionally or globally through trade and affected by trade flows.

Furthermore, as we elaborate in the following section, rice yields are stagnating in Rwanda even though paddy production largely increased in recent years. Low or stagnant staple crop yields are a common challenge in developing countries, especially among subsistence farmers with limited incentives to produce a marketable surplus. However, what makes the Rwandan case for rice somewhat unique is the fact that this crop is predominantly grown as a cash crop. EICV4 data show that while only 5.4 percent of crop-producing households cultivate rice (up from 4.5 percent in 2010/11), 55 percent of rice producers sell more than half their harvest, signifying a clear orientation towards commercialization rather than subsistence rice cultivation. Other major staples such as beans, Irish and sweet potato, and cooking

banana are predominantly grown for own-consumption; for example, 90.3 percent of crop-producing farmers cultivate beans, but only 8.8 percent of them sell more than half their crop. When farmers grow a crop for commercial reasons one would expect an inclination towards investing in their land and in modern inputs, and cultivation of those varieties demanded by the market. The fact that a substantial share of domestic rice demand is still satisfied through imports suggests that incentives to supply the domestic market may be lacking, or that capacity or financial constraints causes the pace of demand shifts to outstrip the pace at which producers respond. This may explain the lack of growth in rice yields.

The following research question is thus proposed: what are the factors which prevent Rwandan rice yields to improve and import dependency to diminish? This study sets out to investigate it. We first consider recent production and international trade trends in Section 2 to obtain a better understanding of the rice value chain and its linkages to regional and global markets. Next, in Section 3, we calculate and assess regionally and seasonally disaggregated price incentives for rice producers and wholesalers to engage in the rice value chain, following a method developed by the MAFAP program of FAO.

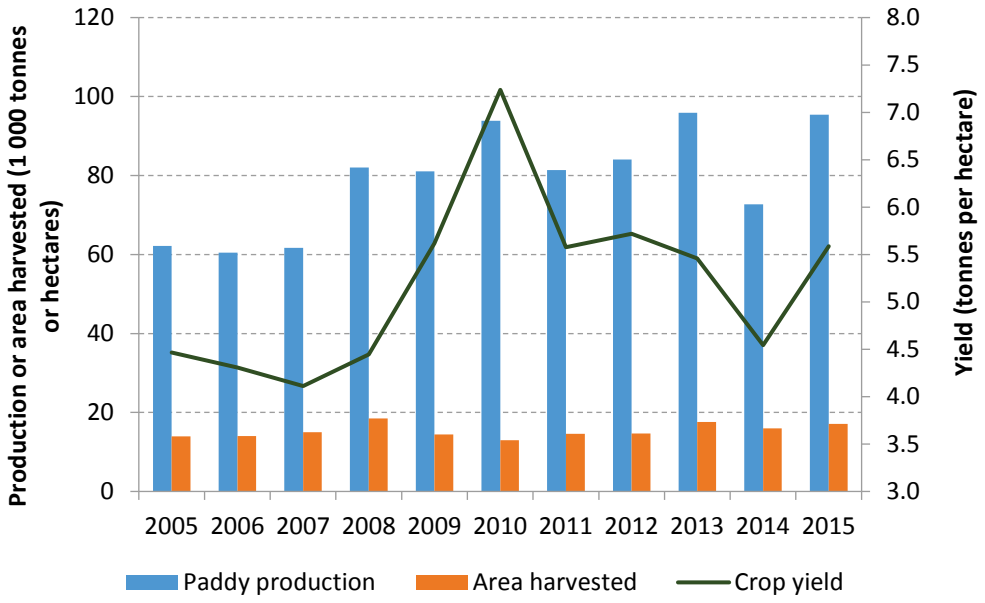
This is followed in Section 4 by a general discussion on constraints to rice production expansion in Rwanda, drawing on the evidence presented in Section 3 and the literature on rice productivity and profitability in East Africa, and complemented by evidence gathered through interviews with RAB, the Rwanda Development Board (RDB), High Performance Services and Business (HPS&B), a rice milling company, the Federation of Unions of Agricultural Cooperatives in Rwanda (FUCORIRWA), and the Cooperative for the Promotion of Rice Farmers in Ntende (COPRORIZ-NTENDE).

Section 5 concludes and presents policy recommendations. The recommendations chiefly target policymakers in Rwanda and the East Africa region, together with development practitioners, donors and academia. They intend to guide interventions in the rice sector so that issues constraining production expansion can be addressed and comparative advantages built up. Rice producers, cooperatives, millers and traders need respond to demand-pulls to achieve higher profitability and output growth levels.

2 Rice production and trade flows in Rwanda

Rwanda has two rice cropping seasons per annum. Rice planted in June/July is harvested in October/December (season "A"), while rice planted in December/January is harvested in May/June (season "B"). As shown in Figure 1, *annual* production expanded rapidly, reaching 95 000 tonnes by 2015, thanks largely to land expansion. Yields however oscillated around 5.5 tonnes per hectare from 2011 on, contrasting with the surge in productivity which occurred during 2007–10.

Figure 1 Yearly paddy rice production in Rwanda, 2005–2015



Source: Production levels were taken from MINAGRI (2016a) for 2005–2013 and from NISR (2014, 2015a) for 2014–15; harvested areas were obtained on FAOSTAT (2016) for 2005–2014 and NISR (2015a) for 2015.

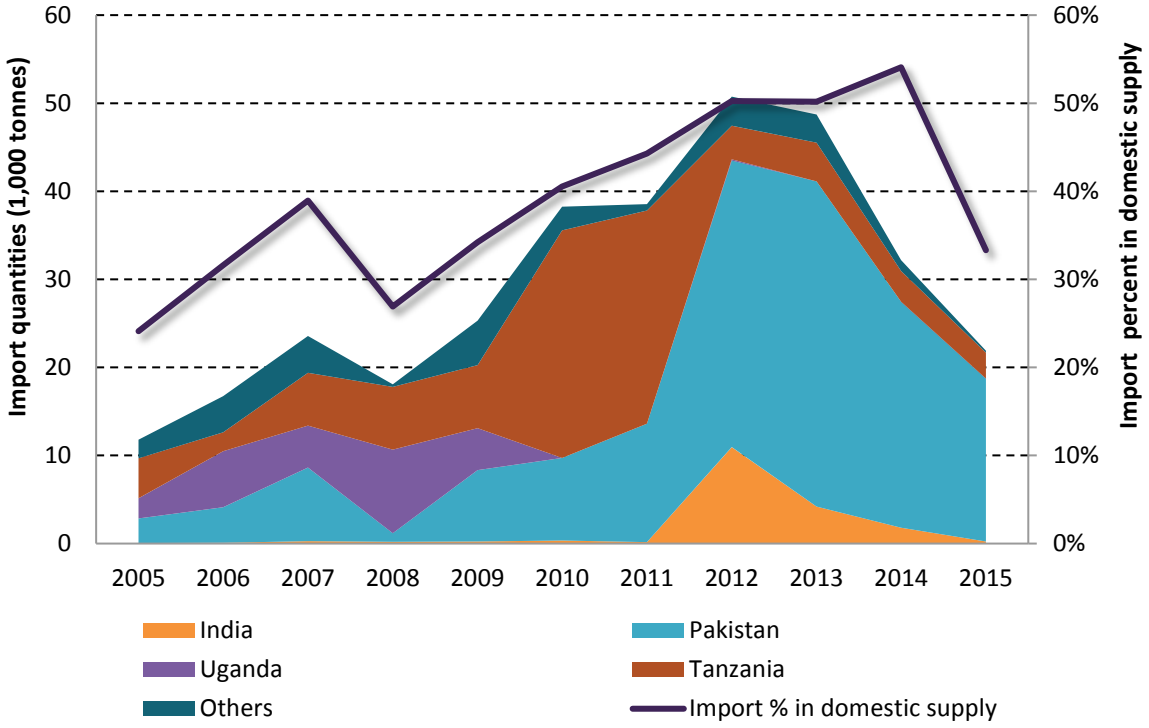
In terms of regional disaggregation, Rwanda's Eastern Province is the largest production area, contributing on average 40 percent to national supply. The balance is supplied in roughly equal shares by the Southern and Western provinces. Production within the Northern Province and the Kigali District is negligible (MINAGRI, 2016a; NISR, 2014, 2015a).

Although rice is an important staple food in urban areas, it is a less important food item for rural households. Only one-in-twenty crop-producing farm households currently engage in paddy rice production (NISR, 2015a). In weight terms, paddy rice production makes up only 10 percent of national cereals production, in sharp contrast to maize which accounts for around 70 percent (FAOSTAT, 2016). Also, within the EAC region Rwanda is a relatively small rice producer, owing in part to its relatively small geographical size. Tanzania, which produces around four-fifths of all the rice grown in the EAC, is 36 times the size of Rwanda. Uganda is the second largest producer with a production share of around 8 percent, followed by Kenya, Rwanda, and Burundi whose contributions have on average ranged from 2–4 percent (FAOSTAT, 2016). An indicative mapping or rice production in the EAC is given in Annex 2.

Rice supply in Rwanda heavily depends on international markets. In 2015, imports represented about 30 percent of total milled rice supply in the country, down from a peak of

around 50 percent between 2012 and 2014 (Figure 2). Consistent with household consumption estimates mentioned earlier, the share of domestic rice demand satisfied by imports increased between 2005 and 2014. However, this share declined sharply in 2015, and more recent estimates suggest it could drop below 20 percent in 2016—as will be further explained below. Just like Rwanda, most EAC countries are net importers of rice. Only Tanzania had a positive rice trade balance in some years between 2005 and 2014 (UN Comtrade, 2016).

Figure 2 Imports of milled rice into Rwanda, 2005–2015



Note: For 2015, monthly data from UN Comtrade (2016) was used.

Source: UN Comtrade (2016) for 2005–14. Production figures from Figure 1 were used to compute the share of imports in domestic supply.

Rwanda's rice exports cannot be neglected. Although within the EAC region Rwandan exports were initially dwarfed by those originating from Tanzania (until 2012) and later Uganda, which benefited from trade restrictions imposed on Tanzanian rice, Rwandan rice exports went from a position of obscurity until 2012 to reach around 16 000 tonnes in 2014, almost equalising Uganda in that year, and about 12 000 tonnes in 2015. Like for Uganda, almost all of Rwanda's rice exports go to the Democratic Republic of Congo (DRC) (UN Comtrade, 2016).

Rwanda's situation in rice trade should also be viewed in the context of its membership of two regional organizations, the Common Market for Eastern and Southern Africa (COMESA), which it joined in 1981 together with 18 other countries, and the EAC, which it joined in 2007 (see Box 1).

Box 1 Rwanda's involvement in trade agreements

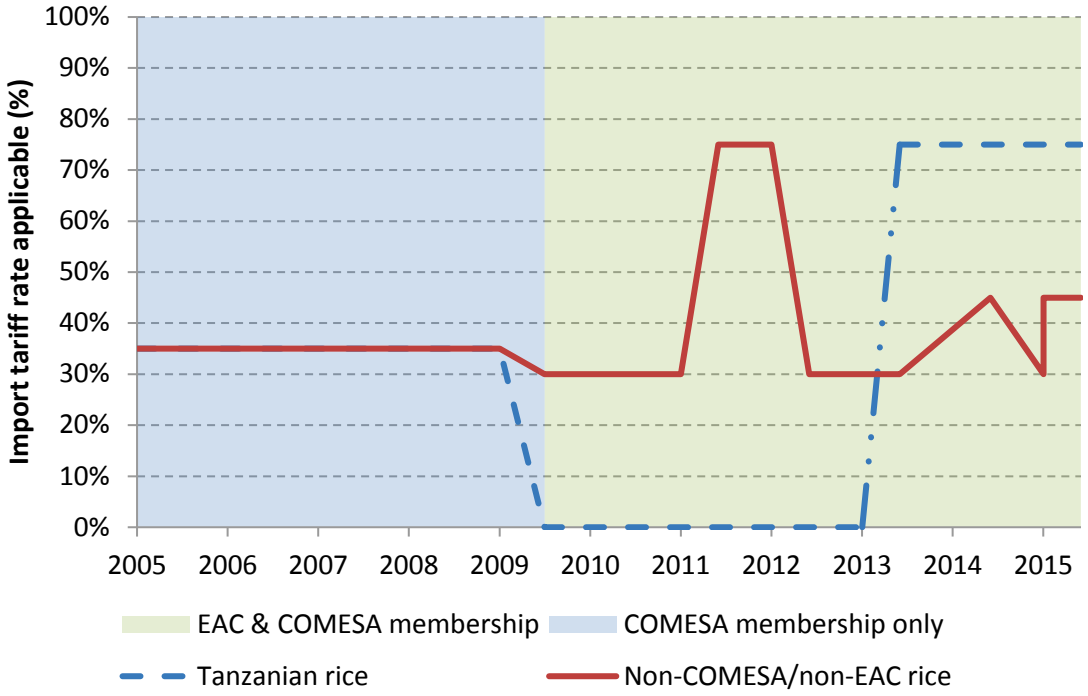
The Common Market for Eastern and Southern Africa (COMESA) was founded in 1981 through a Treaty signed by 19 African countries. Uganda, Kenya, Tanzania, Burundi and Rwanda all were founding members. Tanzania, however, left the COMESA in 2000 (USAID, 2009). The purpose of the organization is to promote regional integration among member countries. In 2000, 9 member countries jointly created a Free Trade Area (FTA), removing tariffs for imports coming from other COMESA members. Rwanda joined the FTA in 2004, together with Burundi. No tariff is thus applied by Rwanda on rice imports coming from COMESA countries. To this day, the COMESA is not a Customs Union. Establishing a Customs Union indeed requires removing customs between members and applying a common tariff and duty regime for trade with third parties (COMESA, 2017). Since most of Rwanda's rice imports come from Pakistan, they are rather insensitive to arrangements under COMESA. However, duty free access to markets in the DRC, also a COMESA member, is beneficial to Rwandan rice exporters.

The East African Community (EAC) was founded in 1967 but was dissolved in 1977. It was relaunched in 2000 by Kenya, Tanzania and Uganda. Rwanda joined the EAC in 2007, the same year as Burundi. South Sudan became an EAC member in 2016. Rwanda joined the EAC Customs Union in 2007, shortly after it was launched in 2005. As part of the Customs Union Treaty, a Common External Tariff (CET) handbook is published by the EAC. It lists applicable tariff rates for commodities coming from third countries. A first version of the handbook was published in 2007. It was updated in 2012 and 2017. Rice (paddy or milled) classifies as a sensitive item in all versions. In the 2007 and 2012 versions, the applicable rate was 75 percent of market value or 200 US$ per tonne, whichever is higher. In the 2017 version, the rate was revised to 75 percent or 345 US$ per tonne, whichever is higher. Members of the EAC Customs Union may however stay application of handbook rates provided other members agree. Agreements are made in the EAC Council of Ministers. The Council regularly publishes the EAC Gazette which outlines decisions and measures taken regarding tariff rates applied by member countries. Since it joined the EAC Customs Union, the CET rate for rice was applied only briefly by Rwanda.

In addition to the COMESA and EAC, Rwanda is a member of the World Trade Organisation since 1996 and of the Commonwealth of Nations since 2009. Rwanda has also signed a number of bilateral investment treaties. However, to our knowledge memberships in the WTO or Commonwealth or bilateral treaties did not affect tariffs or duties applied on Rwandan rice imports or exports over the last decade.

Prior to formally joining the EAC Customs Union in 2009, Rwanda applied a tariff of 35 percent on rice imports originating from non-COMESA members (Figure 3). The EAC recommended its Customs Union members apply a Common External Tariff (CET) of 75 percent on rice imports from outside the EAC. However, member countries were given some autonomy over the precise rate they set; therefore, upon joining the Customs Union Rwanda set its tariff rate at 30 percent. For a brief period during 2011–2012 it did apply the recommended 75 percent tariff rate, but for the most part the tariff rate remained between 30 and 45 percent.

Figure 3 Tariff rates (ad valorem) for milled rice imported into Rwanda, 2005–2015



Source: FAPDA, 2016; EAC, 2016 and TMEA, 2015.

The tariff applied to Tanzanian rice is shown separately in Figure 3. Whereas until 2009 Tanzanian rice was subject to a 35 percent import tariff, the tariff no longer applied thereafter since Tanzania became a fellow EAC Customs Union member. In 2013, however, Rwanda, Burundi and Uganda collectively decided to apply a 75 percent tariff to Tanzanian rice imports following accusations that cheap Asian rice was blended with Tanzanian rice and smuggled duty-free across EAC borders (Kilimo Trust, 2014; TMEA, 2015). Despite remaining an EAC member, the 75 percent tariff on Tanzanian rice remains in place to this day.

The volume and origin of rice imports into Rwanda appears to have been affected by changes in the tariff structure, which directly influence import prices. Between 2005 and 2009 rice imports originated mainly, in equal shares, from Tanzania, Uganda and Pakistan (Figure 2). However, when Rwanda joined the EAC Customs Union, duty-free Tanzanian rice became relatively cheaper, and for a brief period Tanzanian rice made up around 60 percent of total rice imports into Rwanda (2010–2011). The combined effect of a negative production shock in Tanzania in 2012 and the imposition of a 75 percent import tariff on Tanzanian rice in 2013 immediately resulted in Pakistan and India displacing Tanzania as major exporters of rice into Rwanda for the remainder of the analysis period. It is estimated that around 85 percent of rice imports into Rwanda originated from Pakistan in 2015. Looking at UN Comtrade (2016) data reveals most of these imports came via the port of Mombasa in Kenya and reached Rwanda through Kampala in Uganda, along the northern logistics corridor of the EAC. Similarly, the growth in Rwandan and Ugandan rice exports to the DRC has been facilitated by the fact that these countries are all COMESA member states, while non-member Tanzania has not been able to benefit from rapid increases in rice demand in the DRC.

Presently Rwandan rice imports are still about twice as large as exports in quantity terms, while the deficit is probably somewhat larger in value terms given that imported rice varieties are costlier than the local exported varieties. However, the share of imports in domestic supply is declining, while exports are rising rapidly, suggesting Rwanda may well be on track to reduce its rice trade deficit.

3 Price incentives perceived by rice producers in Rwanda

A comparison of farm gate or wholesale prices against world prices, adjusted for trade and transport margins and other access costs, reveals whether value chain actors such as producers or rice millers receive price incentives to engage in market activities. Following the method developed by the MAFAP program (see Barreiro-Hurle and Witwer, 2013), we compute regionally and seasonally disaggregated Nominal Rates of Protection (NRPs) for rice producers and wholesalers in Rwanda for the period 2005–2015. NRPs measure the relative price gaps between observed farm gate or wholesale prices against reference prices for those same markets. Formally, the NRP is computed as follows:

$$NRP_i = \frac{PG_i}{RP_i} = \frac{P_i - RP_i}{RP_i}$$

NRP_i is the Nominal Rate of Protection computed at point i of the value chain (farm gate or wholesale) at a given point in time; PG_i is the price gap at point i, namely the difference between the real, measured price at point i (P_i) and the estimated reference price at point i (RP_i). Reference prices are derived from world prices and are assumed to be efficient prices free of market or policy distortions. An agent receiving a higher (lower) price than its reference price will face a positive (negative) NRP, which we interpret as a price incentive (disincentive) to engage in production or trade. Details on the computation of reference prices depending on commodity trade statuses are given in Annex 1.

3.1 Assumptions and methods

The computation of NRPs is based on a representative market pathway comprising three transaction points: producer-level (farm gate), wholesale level, and the border. Reference prices at the wholesale and producer levels are derived from border prices that are adjusted for trade, transport and processing costs, referred to collectively as access costs.[1] Because rice is an imported commodity, the reference price at wholesale is obtained by adding access costs incurred between the border and the wholesaler to the border price, which is the price paid at Rwanda's border for a unit of milled rice. The producer's reference price is obtained by subtracting access costs incurred between the producer and wholesaler from the wholesaler's reference price (see Annex 1). Producer price data for our analysis are representative of producers located in rural areas of all provinces except the Northern Province, where rice production is negligible. The representative wholesaler is assumed to be located in Kigali, which is also the point of competition for imported and domestically produced rice.

The border market is assumed to be Mombasa, as most imported Pakistani rice flows through this Kenyan port city. Access costs between the border and the wholesale market therefore include the total cost of shipping a unit of milled rice from Mombasa to Kigali, while access costs between the farm gate and the wholesale market represents the transport cost of paddy rice from the farm gate of a representative producer in different provinces to Kigali. Also included in access costs are milling costs to transform paddy rice into milled rice. We also apply a quantity conversion factor to account for weight loss during the milling process as well

[1] The tariff is not included in access costs because the estimated reference price is an 'ideal', efficient price free of distortions. Comparing observed and reference prices allows to measure the impact of distortions created by domestic policies (such as tariffs) and markets on producer and wholesale prices.

as a quality conversion factor—calculated as the ratio of the local rice retail price to the imported Pakistani rice retail price—to account for quality differences between imported and domestically produced rice.

3.2 Data sources

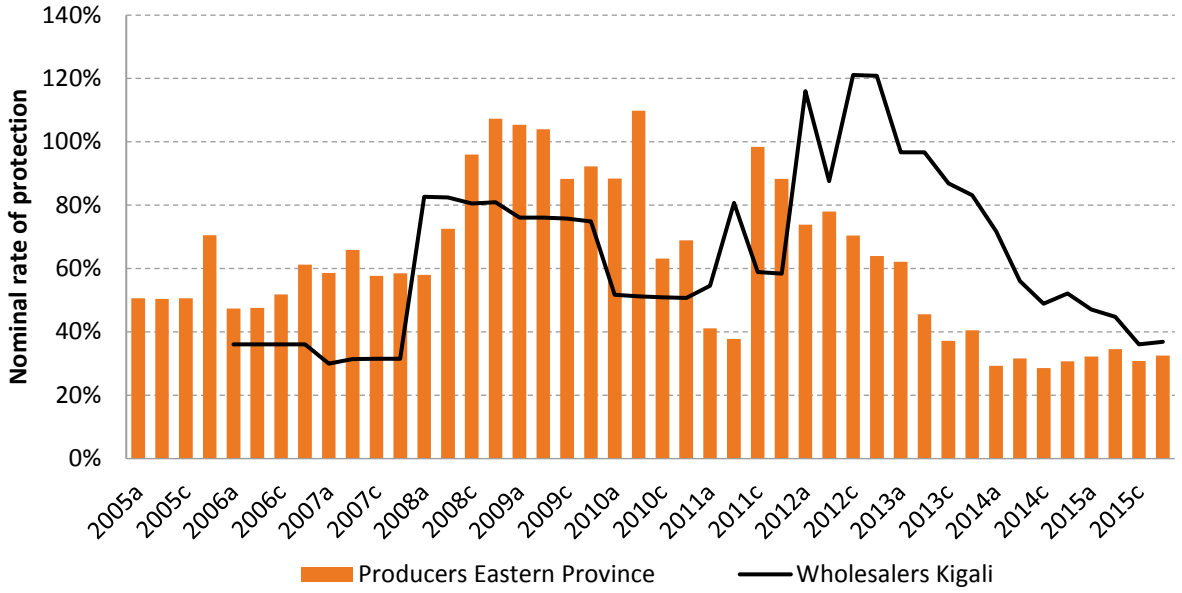
In addition to disaggregating our results by region of Rwanda, we introduce a seasonal disaggregation. As noted before there are two harvesting seasons for rice in Rwanda: rice planted in June/July is harvested in November/December (season "A"), while rice planted in December/January is harvested in May/June (season "B"). We therefore divide each year into four periods: (a) January; (b) February to June; (c) July to August; and (d) September to December. Periods (a) and (c) represent the two post-harvest marketing seasons, while periods (b) and (d) are periods when producers are less likely to market their produce.

Monthly price and cost data are used to compute averages for each of the four periods before the corresponding NRPs are computed. Border prices were taken as the unit values of Pakistani rice imports into Rwanda, based on UN Comtrade (2016) data. Quality adjustment factors were computed as price ratios using MINAGRI's E-soko database of retail prices (MINAGRI, 2016b). Access costs between border and wholesale were estimated using logistics costs data from the World Bank (2011) and the Shippers Council of Eastern Africa (2015), while those between wholesale and farm gate were estimated on the basis of observed price differentials between rural areas and Kigali, as per the E-soko database. Wholesale prices were obtained from the East Africa Grain Council's 'ratin.net' database (EAGC, 2016). No farm gate prices were available, hence retail prices in rural markets averaged by province were used as proxy. A summary of data sources and estimation methods used is given in Table 2 in the Annex.

3.3 Interpretation of results

Figure 4 shows the NRPs for a representative wholesaler in Kigali and representative producers in the Eastern Province. We plot NRPs over 2005–2015, where each year is divided into the four sub-periods (as discussed) labelled "a", "b", "c", and "d". Producer NRPs for 2005–15 in the Southern and Western provinces, which are not showed here, followed a similar evolution as those of the Eastern Province. Average producer NRPs in the Southern Province (62.1 percent) were close to those of the Eastern Province (61.7). Lower NRPs in the Eastern Province is consistent with this province having the largest milled rice output, which leads to lower producer prices and hence lower price incentives. In the Western Province, average NRPs were somewhat higher, reaching 70 percent. This is consistent with the poor status of market and transport infrastructures in that area and its hilly geography (AFDB, 2012; Promar Consulting, 2012). Farmers therefore face higher marketing costs but also receive higher prices and hence greater incentives.

Figure 4 Nominal Rates of Protection for milled rice faced by a representative producer in the Eastern Province of Rwanda, and by a representative wholesaler in Kigali, 2005–2015

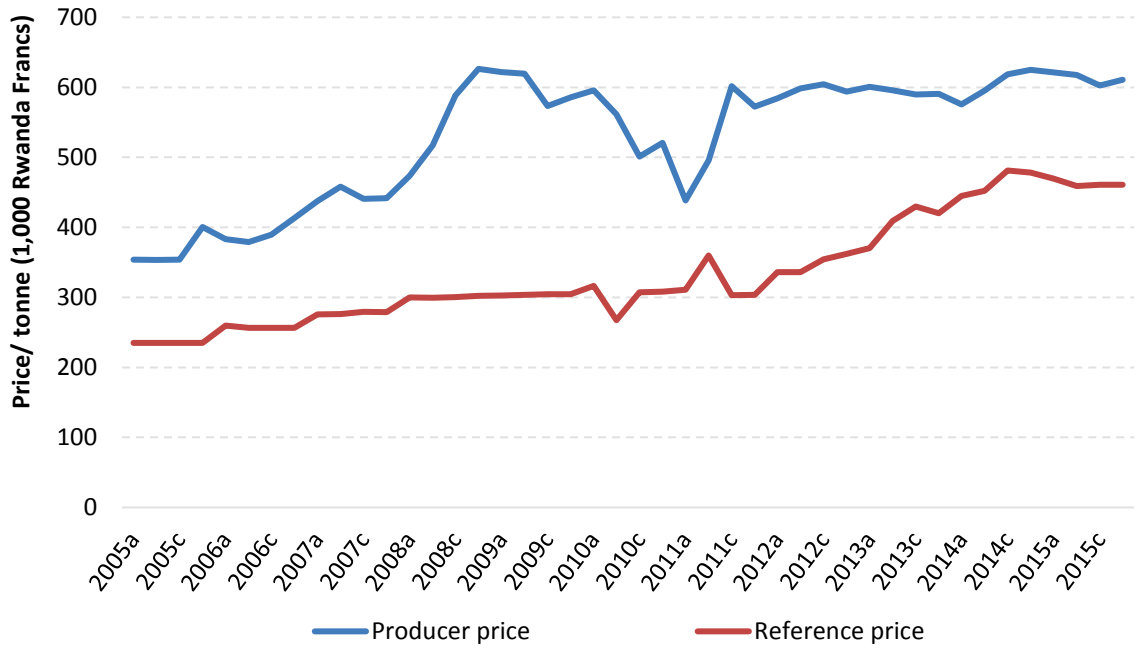


Source: Authors' computations.

The implication of these results is that rice producers in Rwanda consistently received prices that were higher, by 60 percent or more, than the reference price computed from international market prices. On average, producer NRPs were slightly lower in periods "a" and "c" than in periods "b" and "d" in all three provinces, which is consistent with the expectation that farm gate prices are lower during the immediate post-harvest period when supply peaks. While wholesalers frequently faced lower NRPs than producers between 2006 and 2011, their price incentives were consistently above those of producers from 2012 onwards.

Fluctuations in NRP values over time relate to domestic and international price dynamics and local supply and demand shifts. Figure 5 plots producer and reference prices in the Eastern Province over time (i.e., the price gap is the vertical distance between the two line graphs, while the NRP is the price gap expressed as a share of the reference price; see Annex 1). Changes in producers' NRP values will occur when a variation in the reference price is not matched by a similar variation in the observed producer price and vice-versa, as this reduces or increases the price gap. In 2008, for instance, a decline in rice imports seemingly raised demand for domestically produced rice, which in turn caused domestic producer prices to increase while the reference price remained relatively stable. This resulted in higher incentives for producers. Also, from early 2010 up to mid-2011, observed producer prices plunged while reference prices increased steadily, leading to diminished incentives for producers during that period. In this instance domestic producer prices responded to a steady rise in domestic supply as Tanzanian exports to Rwanda started rising.

Figure 5 Producer prices and reference prices for milled rice, Eastern Province, 2005–2015



Source: Authors' computations.

Tariff regimes have a major influence on trade flows, and hence on reference and producer prices. The progressive decline in producer NRPs from end-2011 through 2013 is a good case in point. During this period cheap Asian rice marketed as "Tanzanian rice" entered Rwanda. This unlawful trade practice became increasingly easier once Rwanda joined the EAC Customs Union in 2009 (TMEA, 2015). Uganda and Burundi reported similar "dumping" of rice in their own markets (Kilimo Trust, 2014). Even though international Asian rice prices remained stable during this period (World Bank, 2016), the increased domestic supply put downward pressure on domestic rice prices, and hence lowered incentives for both producers and wholesalers. As soon as Rwanda—together with Uganda and Burundi—applied an import tariff of 75 percent to Tanzanian imports in 2013 (Figure 3), the NRPs freefall was halted. In general, however, market integration within the EAC has facilitated cross-border price transmission (Versailles, 2012). This means that Rwandan rice now competes more fairly with imported rice from within the EAC region, which has led to a stabilization of NRPs at a much lower level during 2013–2015 compared to the levels observed in 2008–2009.

Of course, trade and price dynamics by themselves do not explain why a price gap exists in the first place. Understanding the origin of the price gap requires a consideration of the impact of the policy and market environment on prices. In the discussion that follows we consider several such policy and market factors. The first is the tariff rate applied to rice imports, particularly on Pakistani rice, which makes up the bulk of rice imports (Figure 2). While the rate was largely unchanged between 2005 and early 2011 (30–35 percent), it briefly spiked to 75 percent from mid-2011 to mid-2012. After returning to 30 percent, it was raised again to 45 percent in mid-2014. Since reference prices are exclusive of the tariff cost, import tariffs do offer protection to domestic value chain agents, which pushes observed producer and wholesale prices up. Tariffs therefore provide an incentive to domestic wholesalers and producers at the expense of consumers' purchasing power. The level and evolution of NRP

levels reflect, to a very significant extent, the impact of the tariff as well as changes in the tariff levels over time.

A second relevant policy consideration is the minimum price policy for paddy rice that was introduced in Rwanda in 2013. Prior to that no price-setting policy was in place (Mr Aloys Rusanganwa, Chief Agronomist, FUCORIRWA, 2016, personal communication, 20 July; this is also consistent with what is indicated in Kathiresan (2010, 2013) and Nabahungu and Visser (2011)). The approach adopted in 2013 was for the Ministry of Trade and Industry (MINICOM) to propose a minimum price using their own estimates of production and milling costs. However, it appears the price was set quite low, because in that year we note a fairly significant drop in producers' NRPs, leading to discontent among farmers. Therefore, in 2014 and 2015 MINICOM gave producers and millers more autonomy in the negotiation process, limiting its own role to mere facilitation. Under this model each party proposes buying or selling prices based on their respective production and milling cost estimates. This appears to have contributed to stabilization and even slight increase in producer NRPs from early 2014 onwards. Thus, whereas wholesalers received higher incentives than producers for much of the period since 2011, producer and wholesaler incentives were roughly similar by the end of 2015. Rice cooperatives and paddy producers are generally satisfied with the new pricing mechanism introduced in 2014 (Mr Jean de Dieu Sinzamuhara, Director, COPRORIZ-NTENDE, 2016, personal communication, 21 July).

Finally, NRP levels or trends may also reflect other market inefficiencies. Whereas NRPs were excessively high during 2008–2009 they had stabilized to levels much more comparable to the tariff rate that applied around 2014–2015 (i.e., 45 percent). Put differently, in 2015, almost four-fifths of the price gap at farm gate level was explained by the import tariff, whereas around 2009 it was only around one-third. This reflects the existence of monopsony power enjoyed by rice wholesalers and importers during earlier years, which allowed them to keep rice prices inflated. However, with increased domestic and regional competition it appears that market distortions have gradually subsided. In technical terms we can conclude that producer prices now more closely adhere to the law of one price.

4 Looking beyond price incentives: constraints to domestic rice cultivation

Despite the persistent presence of price incentives for rice farmers in Rwanda, paddy rice yields have stagnated between 2005 and 2015. Domestic producers have also not expanded output at the same rate at which consumption has grown. In this section we further explore possible constraints that may have prevented farmers from exploiting apparent opportunities in the sector. The constraints relate either to the supply- or demand-side of rice markets. For instance, farmers may lack capacity to increase output even though prices are high, due to small plot size or inadequate inputs. Insufficient storage or distribution networks could also prevent traders link producers to consumers. We discuss these issues in a first subsection by referring to secondary literature and stakeholder interviews. Similarly, understanding trends in consumer behaviour is necessary to assess whether the value chain is responsive to the evolution of demand. In a second subsection, we compute income elasticities for different commodities using household survey data and look at how consumer preferences for rice are changing over time.

4.1 Supply-side considerations

Price incentives *per se* do not guarantee profitability, and profitability is a critical factor determining whether farmers will engage in production. If production costs are high, farmers may earn low or negative margins, which would make production unattractive despite the presence of price incentives. Several studies of the Rwandan rice sector suggest that rice cultivation is, on average, profitable. Nkurunziza (2015) collected data from 31 rice cooperatives across Rwanda's Eastern Province. On average, private costs of rice production were found to amount to 1 365 US$ per hectare, of which 61 percent were labour costs, 21 percent input costs, and 8 percent machinery costs. Average revenue was 2 007 US$ per hectare, leading to a seasonal return on investment (i.e., the ratio of the margin to the initial investment) of 47 percent. In season 2016 "A", farmers in COPRORIZ-NTENDE had a production cost of 205 RWF per kilo for short grain paddy rice, which they could sell at 250 RWF per kilo, providing a return on investment of about 22 percent. Other sources report returns ranging from 27 to 46 percent (USAID, 2009; Kathiresan, 2013).

However, these figures mask substantial disparities among areas and farmers. Firstly, production performance varies widely across the country, with yields fluctuating between 4 and 6 tonnes per hectare across districts. District-level seasonal yields recorded between 2005 and 2013 over the whole country have a standard deviation of more than 1 tonne per hectare (MINAGRI, 2016a). Secondly, land endowments vary greatly among farmers. Large scale farmers with access to 10 hectares or more make up less than two percent of producers in the nationally representative sample of the Seasonal Agricultural Surveys (NISR, 2014, 2015a). By contrast, the average producer cultivates around 0.2 hectares, which is well below the 0.5 hectares threshold above which rice farmers are generally considered to be 'rich' (Nabahungu and Visser, 2011). Several other studies have highlighted the severe inequality in land endowments in Rwanda (see Musahara, 2006; Isaksson, 2011; USAID, 2011).

Land inequalities directly translate into performance and income inequalities among farmers, with larger farmers typically earning higher income levels. Nabahungu and Visser (2011) collected data from 253 farmers operating in the Cyabayaga (Nyagataere district, Eastern Province) and Rugeramigozi (Muhanga district, Southern Province) wetlands. The authors

observed a yearly average difference in gross margin between rich (0.5 hectares or more) and poor (0.25 hectares or less) farmers of more than 60 US$ per farm for wetland cultivation. The size of land owned by farmers was found to be positively correlated with households' gross margin and net cash flow. Ingabire et al. (2013) produced similar results. They considered a sample of 46 rice farmers also in Cyabayaga and found only producers cultivating a plot of at least 0.6 hectares in marshlands had a positive Net Present Value (NPV) for seasonal production investments.

Several explanations can be offered for why land size is a key determinant of profitability of rice production. Nabahungu and Visser (2011) indicate that farmers with smaller land holdings are more sensitive to variations in production that threaten food security, and hence they are also less willing or unable to risk engaging in innovative farming practices. Estimates from the Seasonal Agricultural Surveys show that large scale farmers tend to use more inorganic fertilisers and pesticides, with respect to smallholders (NISR, 2014, 2015a). Farmers cultivating a larger plot typically grow a greater proportion of long grain rice, which sells at a higher price. Nabahungu and Visser (2013) show that farmers in Cyabayaga have larger fields, sell a greater share of their production, cultivate more long grain varieties and have a higher income than farmers in Rugeramigozi.

Hence, even though rice production in Rwanda should be profitable on average, only a small proportion of rice growers operate on plots that are sufficiently large to allow for attractive profit margins. Increasing average plot size may be a key solution to raising profitability and boosting rice production in this context. However, implementing such measures would be no easy task. Since the introduction of the Rwanda National Land Policy in 2004, marshlands are the property of the State. To farm in marshlands, it is necessary to belong to a registered cooperative which is accountable to government (MINITERE, 2004). Some have argued that the land tenure system acts as a constraint to productivity increases: producers who do not own the title to their land have limited incentives to invest in it (Kayiranga, 2006; Nabahungu and Visser, 2011, 2013; Nkurunziza, 2015).

Perspectives of value chain stakeholders on matters of tenure and productivity were gathered through interviews with experts at RAB (Dr Innocent Ndikumana, Rice Specialist, 2016, 7 October), RDB (Mr Modeste Nkikabahizi and Mr Birasa Nyamulinda, Agribusiness Division, 2016, 14 September), FUCORIRWA (Mr Aloys Rusanganwa, Chief Agronomist, 2016, 20 July) and COPRORIZ-NTENDE (Mr Jean de Dieu Sinzamuhara, Director, 2016, 21 July). [2] All maintained that public ownership of land in marshlands is, in fact, an essential condition to further develop rice production in the country as it allows the cooperative to eject a producer from his or her plot if he or she does not follow production guidelines. Cultivating rice, they argue, requires skills that are not always mastered by individual farmers.

A more pressing constraint to productivity improvements than the land tenure regime, FUCORIRWA and COPRORIZ-NTENDE experts say, is the low average size of rice fields. However, contrary to the ambitious plans under the NRDS to expand the area of rice under cultivation, they believe that water availability is an important constraint to opening up new rice fields. The alternative of consolidating plots while maintaining the overall footprint of planted rice would, in turn, lead to discontent among those farmers who will inevitably lose rights to the land they farm. RAB puts forward similar views, arguing that significant productivity

[2] All interpretations and opinions expressed are from the interviewed experts and do not necessarily reflect those of the associated institutions.

increases will require an increase in the average plot size through land redistribution. However, they acknowledge that redistributing land would be very hard in practice. Much of the value chain stakeholders' attention is therefore likely to be dedicated to irrigation expansion in the short and medium run.

Irrigation canals are usually maintained by the Water Users Organisation (WUO), which is funded by cooperatives. Cooperatives are also typically responsible for input provision to farmers. Although according to Dr Innocent Ndikumana RAB supports continuous improvements in service delivery by WUO, it also underlines the importance of plot maintenance by farmers for irrigation schemes to be effective. In particular, it is crucial for rice fields to be appropriately levelled, in order to let all rice plants receive the same amount of water. In this line, there is a need for an in-depth evaluation of the cooperatives' financing and responsibility as far as input provision and infrastructure or field maintenance is concerned. Another constraint to irrigation expansion is the high cost of building new water reservoirs or dams. According to RDB experts, it prevents the private sector to invest in irrigation schemes. Authorities should therefore reflect on how to help investors mitigate the risks associated to such high fixed costs, for instance through public-private partnerships.

4.2 Demand-side considerations

As noted previously domestic demand for rice is not only increasing, but there also appears to be a growing preference for imported long grain rice varieties over domestic rice, of which a large proportion are short grain varieties considered to be of lower quality. As noted previously, the increase in the share of the total food budget dedicated to rice between 2010–11 and 2013–14 is entirely accounted for by imported rice. This shift in preference is equally significant in both urban and rural areas. In relative terms, however, urban households spend about three times more on imported than local rice, whereas in rural areas the budget share for local rice is still marginally higher than for imported rice. Although aggregate rice expenditure in rural areas (RWF 41.8 billion) outweighs than in urban areas (RWF 31.5 billion), preference shifts for imported and local rice in urban areas appear to be driving the national trends (see Table 1 in the Annex).

An analysis of income elasticities—defined as the percentage change in consumption expenditure on a particular item for a one percent change in income—reveals that these consumption shifts are likely to continue as incomes rise in Rwanda. Table 3 in the Annex reports income elasticities computed on the basis of a method proposed by King and Byerlee (1978) and applied to EICV3 and EICV4. Several pertinent observations can be made. Firstly, elasticities for rice are not only greater than one, meaning for a one percent increase in income expenditure on rice will increase by more than one percent, but far outweigh those for other staple foods such as beans, roots and tubers, which have elasticities below one. Rice elasticities even outweigh those for animal products, normally considered a luxury food item.

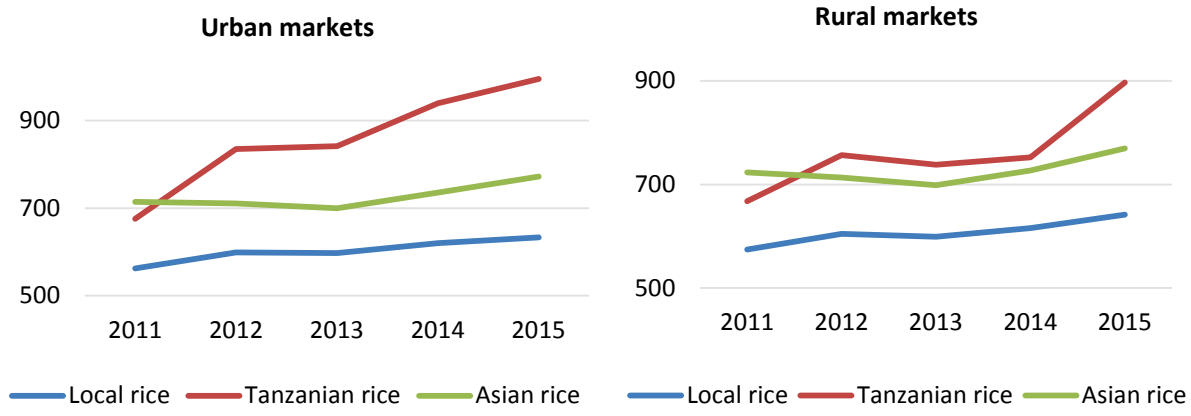
Secondly, income elasticities for imported rice are consistently higher than for local rice, at national level, and across all household subgroups across both periods analysed. This reflects a preference for imported over local rice as incomes rise, as is evident from the analysis of expenditure shifts (Table 1 in the Annex) during a period in which household incomes in Rwanda grew in real terms.

Thirdly, whereas rural households' income rice elasticities exceed one for both local and imported rice, urban households' income elasticities are less than one for local rice varieties.

This is consistent with what was observed in Table 1, namely that local rice expenditure shares declined in urban areas, but increased in rural areas. This suggests that the substitution effects of local for imported rice are much stronger in urban areas, but demand for local rice may remain robust in rural areas as incomes grow. Finally, compared to poor households, defined here as the bottom two expenditure quintiles, non-poor rural households have higher income elasticities for imported rice and lower elasticities for local rice, which suggests that preference for imported and against local rice will eventually also play out in rural areas as incomes grow. These trends will however need to be verified using more recent household survey and trade data, given estimates for 2016 suggest Rwanda's import dependency for rice may be moving below 20 percent.

The analysis of consumption trends and income elasticities suggest that in order to develop its rice value chain, Rwanda not only needs farmers that are sufficiently productive, but also a product that can competitively position itself on domestic and international markets. In this regard, quality plays a key role. Over 2010–13, about 70 percent of yearly rice production in Rwanda was of the short grain variety, while the remainder was long grain (Kathiresan, 2010, 2013). According to Dr Innocent Ndikumana from RAB (2016, personal communication, 7 October), this proportion has widely decreased since then, with about 60 percent of national paddy production being now long grain. Rwandan retailers typically supply three types of rice: local, Asian (Pakistani) and Tanzanian rice. Local rice, on average, is around 16–17 percent cheaper than Asian rice, and 26–28 percent cheaper than Tanzanian rice (Figure 6). The fact that local rice is always cheaper than imported rice varieties is indicative of its persistent lower quality.

Figure 6 Rice retail prices in rural and urban markets in Rwanda



Source: MINAGRI, 2016b.

An explanation for the existence of a quality differential between local and imported rice is the milling process (Stryker, 2010; also reported by Mr Aloys Rusanganwa, Chief Agronomist, FUCORIRWA, 2016, personal communication, 20 July). According to RAB, Rwandan millers often do not grade local milled rice. Local rice bought at the retail level typically is a blend of different varieties and qualities. Such a practice is widespread since producing 'blended' rice allows for better paddy-to-milled transformation ratios. Furthermore, selling a cheap, low quality rice makes it possible to avoid competing with imported rice that offers a good quality/price ratio—hence the growing demand for it as incomes grow.

The aforementioned series of interviews allowed to shed more light on how supply responds to demand. According to experts at FUCORIRWA and COPRORIZ-NTENDE, Rwandan farmers cultivate a large number of rice varieties. These include Watt, Buryohe, Ngaruye, V600, Yun-Yine and V30. Watt is a long grain variety that offers good prospects, but the short grain varieties such as Buryohe are much more widely cultivated due to their improved resistance to floods or insects. Although national demand is shifting towards long grain varieties at the expense of short grain rice, the cooperatives explain that millers are not systematically pushing for more long grain rice to be produced. For instance, COPRORIZ-NTENDE tends to sell more long grain rice in season "A" and more short grain rice season "B". During season "A", the dry season, other crops such as maize are harvested, which raises the purchasing power of households and allows them to buy long grain rice. Millers therefore demand short or long grain varieties to the cooperative depending on the season. Schools are major clients and since they prefer cheaper short grain rice some millers remain ardent about producing short grain rice. The interviewed cooperative members conclude that they would not support an authoritative government policy that would impose to use some varieties instead of others. They also note that in addition to short grain rice plants' resilience to weather and pests, long grain rice requires more labour input and a reliable irrigation system. Short grain also has a better transformation ratio: for every 100 kilos of paddy rice, 75 kilo milled rice is obtained from short grain varieties compared to 62 kilos for long grain varieties.

Another interview was conducted with Mr Jean-Bosco Nahimana, Executive Director at HPS&B, on 14 September 2016. HPS&B mills paddy rice produced by 13 cooperatives located in the Muhanga and Ruhango districts, Southern Province. It produces about 1360 tonnes of white milled rice per year, of which 90 percent is short grain (Yun-Yine, mainly) and the remainder long grain (Watt, mainly). HPS&B apparently does not adopt the same market behaviour as millers buying from COPRORIZ-NTENDE. Indeed, it aims to produce the largest possible quantity of high-quality, long grain rice in order to compete with Asian imports. It therefore has limited interest in reinforcing its position on lower quality short grain markets and pushes rice farmers in the 13 cooperatives it supports to shift as much as possible to high quality long grain varieties. Given that, as reported by Dr Innocent Ndikumana from RAB (2016, personal communication, 7 October), most millers prefer not to compete with imported rice, HPS&B appears to be an outsider on the market.

It therefore seems that agents in the Rwandan rice value chain can exhibit diverging preferences. While cooperatives are mainly concerned with agronomic constraints, millers make strategic choices to gain market shares and maximise profits. If long grain varieties are becoming easier to grow, pushing millers to enhance their grading practices will be key to achieve import substitution. Market opportunities for cheap, low quality rice should however not be neglected. Rwandan rice exports to the DRC are growing. Becoming a preferred supplier of this large neighbouring market could be an attractive option to foster the Rwandan rice value chain's development.

5 Conclusions and policy recommendations

Although rice production in Rwanda increased between 2005 and 2015, yields stagnated around 5.5 tonnes per hectare and rice remains a minor crop in comparison with maize. Furthermore, imports still represented about 30 percent of total rice supply in 2015. NRPs computed for representative producers in major rice-producing provinces of Rwanda revealed rice growers have perceived high price incentives during the last decade. Barriers to trade, the existence of a monopsony of rice wholesalers and the application of import tariffs led to producers receiving prices that were 60 percent higher, on average, than estimated reference prices.

Price incentives varied depending on trade flow dynamics in Rwanda and the EAC. Cheap (expensive) rice imports and high (low) domestic supply led to decreases (increases) in incentives. Price transmission between the international and the domestic market improved in recent years, during which MINICOM implemented a minimum price policy. By 2015 almost all incentives result from the tariff applied on Pakistani rice imports, which dominates the import market, suggesting some improvement as far as domestic market structure and value chain efficiency is concerned.

Several constraints explain why productivity improvements and import substitution are not as fast as what would be expected in view of the protection induced by the tariff regime. We summarise them in the following table.

Supply side	Demand side
• Most rice producers cultivate small plots of about 0.2 hectares in government-owned marshlands	• Consumer demand evolves towards more high quality rice, especially in cities. The capacity of the domestic value chain to respond to that trend is limited, for instance because of the difficulty of efficiently growing long grain rice in the country
• Increasing plot size would improve profitability, but land consolidation is politically and economically challenging	• Weak average quality of milling
• Increasing overall harvested area is marred by infrastructural challenges and water availability	• Lack of systematic grading of milled rice
• Reviewing the land tenure system and allowing private land ownerships in marshlands is not favoured by value chain stakeholders since public ownership is used as a means to enforce farming practices	• Some millers and wholesalers find it more profitable to remain focused on cheap rice markets

Given the presence of high price incentives for rice and the persistence of constraints to increased paddy production, the following policy actions should be considered to accelerate government's National Rice Development Strategy.

- Research on the impact of the land tenure regime on on-farm investment and profitability should be conducted.
- A bold strategy for irrigation development and water access to allow for land expansion should be developed.
- Cooperatives should receive support from either the public or private sector to expand training activities and level up farmer skills, especially in regards to plot maintenance and levelling of rice fields.
- The capacity to monitor and analyse demand trends and the evolution of regional rice markets should be enhanced.
- Agricultural research on rice varieties should be linked with market analysis so that specific consumer groups can be explicitly targeted. Cost-benefit analyses should be conducted in this regard, by taking into account agronomic constraints. If making a complete shift towards high quality long grain rice with the view of substituting imports is too costly or unprofitable, the focus could be moved to more drought and pest-resistant short grain varieties that are acceptable to a wider range of consumers. With improved milling and grading practices, a value-for-money rice could supply rural communities across the Eastern African Community and eastern DRC. As we have seen for the case of Rwanda, demand for locally produced rice is robust in rural areas.
- Policy interventions aiming to improve processing capacity (milling and grading) should be designed.

Lastly, Rwanda should anticipate a gradual relaxation of trade protection policies in line with international commitments. Establishing itself now as a preferred supplier of good quality but affordable rice within the EAC region is crucial if it wishes to compete effectively in the longer run.

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Annexes

Annex 1 Price incentive methodology

Computing Nominal Rates of Protection (NRPs) allows to measure price incentives for producers and other market agents along agricultural value chains. The methodology has been used by FAO's Monitoring and Analysing Food and Agricultural Policies (MAFAP) in about 15 African countries over 2009-15.

Reference prices: reference prices are calculated from the international price of the commodity at the country border where the commodity enters (if imported) or exits the country (if exported). This price is considered as the **benchmark price** (P_b) free of influence from domestic policies and markets. The calculation of reference prices is also based on **access costs**. These are all the costs incurred by bringing the commodity to different points in the value chain, such as costs for processing, storage, handling, transport and the different margins applied by agents in the value chain. Access costs are measured between the border and wholesale (AC_{wh}) as well as between the farm gate and wholesale (AC_{fg}). The equations for calculating the reference prices at wholesale (RP_{wh}) and farm gate $\left(RP_{fg}\right)$ are as follows:

$RP_{wh} = P_b + AC_{wh}$ (for imported commodities)

$RP_{wh} = P_b - AC_{wh}$ (for exported commodities)

$RP_{fg} = RP_{wh} - AC_{fg}$ (for imported and exported commodities)

The reference price is the price that could be obtained if market and trade policies were removed and in the current state of market performances.

Price gaps: Observed reference prices are then subtracted from the domestic prices at wholesale (P_{wh}) and farm gate (P_{fg}) levels to obtain the price gaps. The price gaps provide an absolute measure of the market price incentives/disincentives faced by agents. They capture the effect of distortions from trade and market policies directly influencing the price of the commodity in domestic markets (e.g. price ceilings and tariffs), as well as overall market performance. The equations for calculating the **price gaps** at wholesale (PG_{wh}) and farm gate $\left(PG_{fg}\right)$ levels are as follows:

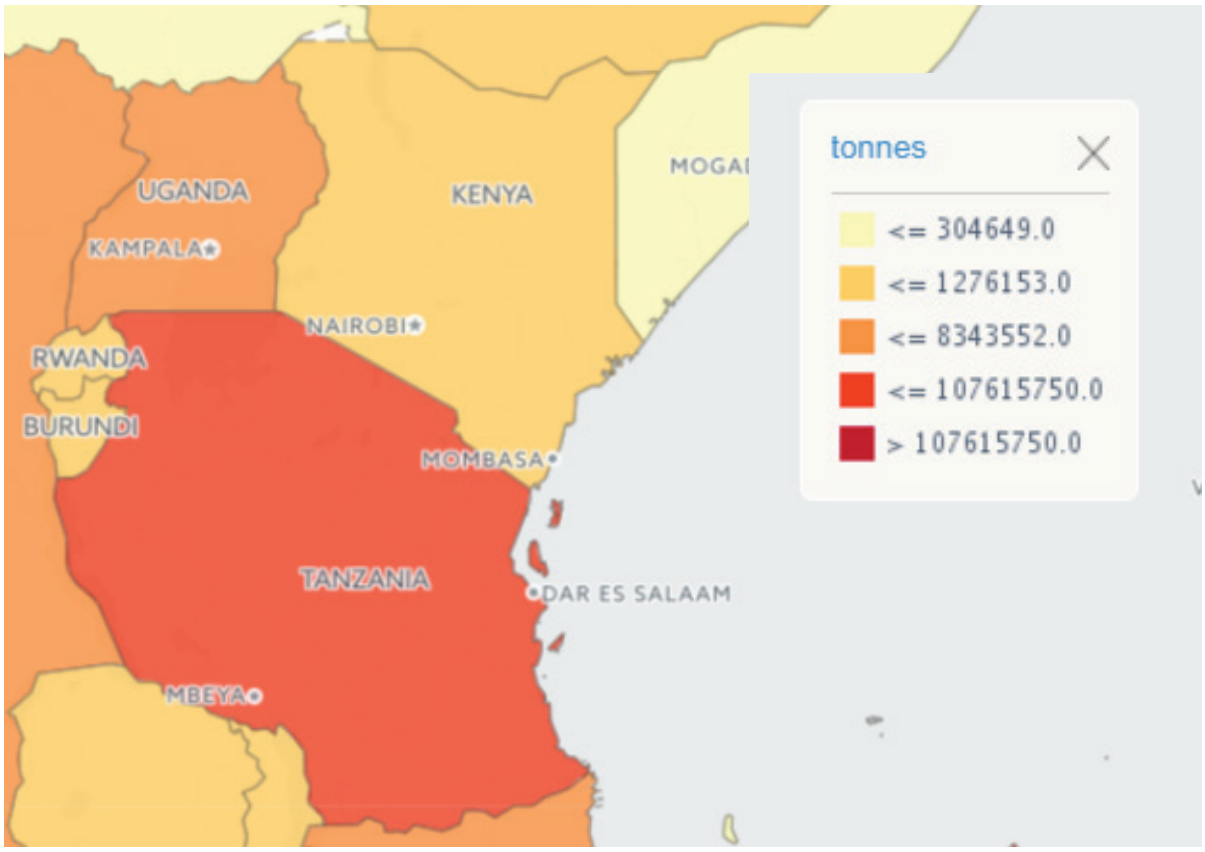
$PG_{wh} = P_{wh} - RP_{wh}$ $\qquad$ $PG_{fg} = P_{fg} - RP_{fg}$

Nominal rate of protection: when expressed as a ratio of their corresponding reference price, price gaps at wholesale and farm gate levels are referred to as the NRPs. The NRPs allow to measure the level of price incentives/disincentives to production and thus to assess the effects of the policies and the economic environment affecting the output market of a value chain. The **nominal rates of protection** at wholesale (NRP_{wh}) and at farm gate (NRP_{fg}) levels are defined by the following equations:

$NRP_{wh} = \frac{PG_{wh}}{RP_{wh}}$ $\qquad$ $NRP_{fg} = \frac{PG_{fg}}{RP_{fg}}$

Annex 2 Additional figures and tables

Figure 7 Paddy rice production in the EAC



Note: amounts in the legend are total paddy production levels (in tonnes) for 2005-14 (sum).

Source: FAOSTAT (2016) and authors' computations.

Table 1 Share of rice within total food purchases in Rwanda, for different geographic areas, income groups and rice types

	National				Urban				Rural			
	2010/11		2013/14		2010/11		2013/14		2010/11		2013/14	
	Aggregate spending (RWF billions)	Food budget share (%)	Aggregate spending (RWF billions)	Food budget share (%)	Aggregate spending (RWF billions)	Food budget share (%)	Aggregate spending (RWF billions)	Food budget share (%)	Aggregate spending (RWF billions)	Food budget share (%)	Aggregate spending (RWF billions)	Food budget share (%)
Local rice	27.8	*3.9*	32.1	*3.7*	7.9	*3.3*	8.1	*2.3*	19.9	*4.1*	24.1	*4.6*
Imported rice	22.5	*3.1*	41.2	*4.8*	12.6	*5.3*	23.4	*6.8*	10.0	*2.1*	17.8	*3.4*
All rice	50.3	*7.0*	73.3	*8.5*	20.4	*8.6*	31.5	*9.2*	29.9	*6.2*	41.8	*8.0*

Source: NISR, 2012, 2015b and authors' computations.

Table 2 Summary of data sources for NRP computation

Series	Source	Notes
Border prices	UN Comtrade (2016)	The border price was taken as the unit value of Pakistani rice imports to Rwanda. It was obtained by dividing the yearly monthly value in US$ by the monthly imported quantity of Pakistani rice and converting the result in RWF using historical exchange rates from OANDA (2016). For 2005–09, no monthly disaggregation of trade flows was available, therefore yearly import prices given on UN Comtrade (2016) were used.
Quality adjustment factors	MINAGRI (2016b)	Quality adjustment factors were computed as the ratio of monthly local and Asian rice prices as given in the E-Soko database. Such detailed prices were only available for 2011–15, hence ratios for 2005–10 were assumed equal to the 2011 values of the ratio.
Access costs border-wholesale	World Bank (2011), Shippers Council of East Africa (2015)	The access costs include transport and inventory costs as well as freight forwarding fees. Access costs for 2005–10 were estimated by assuming that the real costs remained constant over 2005–2011 and estimating nominal amounts using the Consumer Price Index for Rwanda found on WDI (2016). As no monthly cost estimates were available, costs were assumed constant throughout the year.
Wholesale prices	EAGC (2016)	Only yearly averages were accessible; therefore, the same yearly average price was used for all months in a given year. 2005 was not available.
Access costs rural market-wholesale	MINAGRI (2016)	Access costs between rural markets and wholesale were estimated by computing monthly average price differentials between retail prices in Kigali and retail prices in rural markets for each province but the Northern Province (negligible production), assuming the difference arises from these costs. Averages were smoothed using an exponential fit to obtain series of estimated costs.
Prices on rural markets	MINAGRI (2016b)	On some markets, prices were missing for October, November and December 2015. In such cases, prices were estimated by taking the average of the 9 preceding months.

Note: Once the monthly series were obtained, averages were taken to convert them into 'periodical' series (see section 3.2 above).

Source: Compiled by authors as referenced in the table.

Table 3 Income elasticities for selected food products, by location and income groups, 2010–11 and 2013–14

	2010–11 (EICV3)					2013–14 (EICV4)				
	National	Urban	Rural	Rural poor	Rural non-poor	National	Urban	Rural	Rural poor	Rural non-poor
Local Rice	1.45	0.60	1.57	1.35	1.45	1.04	0.37	1.25	1.19	1.07
Imported Rice	1.94	1.43	1.96	1.37	1.73	1.89	1.11	1.66	1.31	1.62
Other cereals	1.00	0.69	1.17	1.10	1.03	1.07	0.66	1.04	1.22	1.01
Beans	0.45	0.38	0.49	1.06	0.56	0.63	0.50	0.67	1.04	0.74
Roots and tubers	0.65	0.37	0.68	1.12	0.75	0.67	0.39	0.66	1.02	0.83
Animal Products	1.41	1.18	1.66	1.28	1.58	1.42	1.27	1.31	1.22	1.26

Source: Authors' computations using EICV datasets (NISR 2012, 2015b)

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