Chapter 6

POLICY OPTIONS FOR MODERNIZING THE MILLING SECTOR

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As noted in the previous chapter, investments to expand the large milling sector should not come at the cost of ignoring the smaller milling sector. Serious attention should also be given to revitalizing this sector to help meet a broader demand base for cheaper rice while maintaining rural employment and income opportunities among this dominant group of millers and paddy traders in the country.

Another key observation in Chapter 5 was the distinctive quality differences in the final products generated by each rice milling sector. Such product differentiation implies a more complex story about comparative advantage and efficiencies between the small- and larger-scale milling sectors that produce distinctive standard- and premium-quality rice types using a different mix of technologies. Smaller de-huskers use rubber-roller technology, with either electric- or diesel-powered motors, resulting in varying degrees of quality in the final product (broken grains, discoloration, foreign debris, etc.). Medium-to-larger-scale millers use more modern and capital-intensive technologies involving parboiling, drying, milling, de-stoning, and sorting stages, resulting in a more consistent, premium-quality rice grain. This is the grain that is more apt to compete with imports. The mix of technologies, degree of capital intensiveness, scale of operations, and so forth is not only about labor and capital costs but very much a story about adequate access to paddy throughout the year, especially for the larger-capacity mills. Additionally, energy costs (fuel and electricity), transportation costs, marketing and transaction costs, and prices can all greatly affect the profit margins and viability of the modern and larger-capacity milling plants. Improving the quality of domestic rice in order to compete more effectively with imports will therefore depend on how profitable the medium-to-larger milling sector can still be if it upgrades and expands production of premium-quality rice in Nigeria.

The objective of this chapter is to assess the potential for transforming and modernizing the domestic rice milling sector in Nigeria using a mathematical programming model. More specifically, it seeks to address a number of key policy questions: Are there differential abilities and efficiencies among existing mill types (small to large) to supply the domestic market? Given these differences, what is the likely path for transforming the sector into a modernized agro-industry in order to better compete with imports and meet domestic demand? What would be the welfare implications, especially for rural employment? To answer these questions, a survey of the literature, field data, and use of a spatial equilibrium rice milling model were adopted.

The chapter begins by providing an overview of the rice milling model adopted here, including data sources and model assumptions. Details of the model—including its mathematical derivation, parameter assumptions, and validation—are provided in Appendix E. A number of policy scenarios are introduced in the model to test for each milling sector's ability to become more competitive and meet local demand for both premium and standard rice varieties. Results are measured as changes in quantity supplied, volume of imports, and employment. Findings are that the small-to-medium-scale sector is the most resilient to policy shifts and global price changes. Even with zero tariffs, these enterprises are able to stay in business and employ a larger pool of labor. The large-scale enterprises, on the other hand, require higher tariffs to stay in business and are more likely to shift to milling imported brown rice under a zero tariff policy regime. A final concluding section discusses the policy implications of these model results and how they answer the key policy questions raised above.

Introducing a Rice Milling Model for Nigeria

To assess the viability of modernizing the milling sector in Nigeria, and especially the optimal strategy for doing so, a rice milling model (RMM) for Nigeria was developed using mathematical programming techniques to reflect as much as possible the underlying economic structure of the rice milling industry in Nigeria. Adopting this approach is appropriate for a number of reasons.

First, poor data availability makes an ex ante simulation type approach more desirable. Second, the location of agro-industries is uniquely challenged by spatial constraints in accessing raw materials and product markets. Finally, the RMM is especially suitable for analyzing the recent policy focus of expanding the milling industry's large-scale subsector. The model provides empirical estimates of this policy's economic viability and implications for raising the quality of milled rice and employment in the industry relative to alternative policies that also promote improvements in either the small and medium mill subsectors or both.

The RMM builds on the literature of industrial location, industrial clusters, and industrial organization theories, studies that generally analyze the optimal scales, numbers, and locations of processing plants, given a spatial distribution of access to raw input sources, transportation and input costs, and output markets. Their application to agriculture is especially suitable because of the spatial nature of agriculture as a supplier of raw and perishable inputs to agro-industries. Fewer "traditional" location-allocation applications in agriculture have been applied in recent times (Lucas and Chhajed 2004).[1] This is despite a growing interest in the analysis of supply chains and industrial clustering. As large multinational firms become more dependent on multiple resource and input suppliers in the production process, the optimization of the complete supply chain becomes critical in maximizing the firm's profits. Optimizing the supply chain involves choosing the number, location, capacity, and types of industrial plants and/or warehouses; from whom and in what quantity to buy raw inputs; the type and volume of products to produce and which markets to target; as well as amounts to hold in inventory. Industrial organization theory introduces many of the real-world challenges typically ignored in a perfectly competitive world, such as the presence of transaction costs, imperfect information, and barriers to entry. The agglomeration effect is also important in explaining industrial clustering—for instance, lowering the cost of producing or marketing a product in a particular location due to economies of scale (Mccann and Sheppard 2003; Jones and Woods 2002). In Nigeria, the agglomeration effect can be particularly useful in explaining the appearance of milling clusters of small- and medium-scale operators in a number of states, for example.

Because of an interest in determining the optimal scale and mix of the milling industry, this chapter builds on earlier empirical work and adopts the industry profit-maximization model, as in Durham and Sexton (1996). With this model, it is possible to assess the optimal scale mix and efficiencies across the different milling sectors and to provide empirical estimates of the Nigerian rice milling industry's ability to raise the output of quality milled rice and employment in the country. Just as importantly, accessing sufficient quantities of a higher-quality (or premium) paddy variety becomes critical in this regard. While the largest cost share of milled rice is paddy, whose price is

1 One exception is econometric studies that test for the factors influencing agro-industry location in food processing in the United States, for example. The work has typically framed the problem as a profit-maximization one—relating profit to the difference between revenues (local price and quantity sold) and costs of raw inputs and plant operations, all of which vary across space. Brown, Florax, and Mcnamara (2009) provide a good review of this literature.

affected by transport costs from the farm to the mill, transport costs to product markets are expected to be just as large because destinations are typically not the same as the paddy source. Rice marketing or trader costs in Nigeria appear to be quite high, as illustrated in Chapter 5.

Referred to as the RMM for Nigeria, the mathematical programming model compares three industry scales for milling rice in Nigeria in order to determine the optimal scale mix for producing rice more efficiently and to become more competitive with imports. Both transport and marketing costs are explicitly included in the model. Basically, the model determines the optimal location and competitiveness of different types of mills across regions (small, medium, and large scale), subject to supply, capacity and storage constraints, exogenous market prices, production technology, resource costs, and transportation and marketing costs.

The RMM for Nigeria can be considered a two-commodity, spatially oriented optimization model with an objective of maximizing industry profits across three miller sectors based on current scale technologies, two differentiated paddy rice varieties (common and superior quality) and corresponding types of milled rice (standard and premium quality), and two production seasons. "Superior paddy varieties" refers to the most preferred rice seed for milling premium-quality rice among medium- and large-scale millers, such as FARO 54. "Common paddy varieties," on the other hand, refers to both traditional and other older improved rice seeds that are considered inferior for milling purposes and thus produce standard-quality rice. These are only milled by the small milling sector. The geographic unit of analysis is the state level, for all 37 states in the six geopolitical zones listed in Table E.7 in Appendix E. Figure 1.1 in Chapter 1 shows the location of all 37 states on a map. The model is calibrated to 2010 base-year quantities of total paddy production by state and milled rice output at the national level, as well as—given current levels of input and output prices—operating costs, transportation costs between state capitals, and production capacities and resources in each state. Prices are assumed to be exogenous to the model, while quantities of paddy and milled rice are treated as decision variables. The price of milled premium rice is explicitly linked to the world price (inclusive of global shipping, off-loading, and other port fees at Lagos), the rice import tariff, and any inland transportation and marketing costs. The price of premium rice faced by the medium-scale sector is assumed to lie halfway between the large- and small-scale miller prices. This assumption reflects the fact that medium-scale operators produce better-quality rice than small millers but less than the large industrial millers.

Although local paddy can be purchased from any state subject to transportation and marketing costs, this is limited to the superior paddy rice preferred by medium- and large-scale operators to produce premium-quality milled rice. The superior paddy is also assumed to capture a price premium over more common varieties, as evident from Chapter 5. The small milling sector, on the other hand, is assumed to purchase paddy only within their respective state—and then, typically, the common paddy variety to produce standard-quality milled rice. This is reasonable considering that the smaller milling sector mostly services local producers and consumers. Consequently, output is differentiated between premium and standard milled rice types. Only the medium- and large-scale millers produce the premium rice that is more comparable with imports. Therefore, to account for any changes in output as prices are made to adjust to tariff or world price changes, inverse supply functions of both paddy varieties demanded by each of the milling sectors are introduced into the model to allow prices to also adjust accordingly.

All the data and underlying assumptions are based on various secondary sources and the author's own fieldwork. Among the secondary data sources, production data were taken from the National Agricultural Extension and Research Liaison Services (NAERLS 2009) for the 2009 production season, while prices were annual averages from the National Bureau of Statistics (NBS) for 2010 and 2012 (for paddy, local rice, and imported). To be consistent with the price data, a base tariff rate of 50 percent in 2010 was used. Nigerian Agricultural Transformation Agenda (ATA) documents were relied on in defining the country's national objectives and targets for improving the milling sector.

The primary data are based on the author's own field visits to four major rice-producing states (Niger, Kano, Benue, and Kwara; see Figure 1.1 in Chapter 1 for the locations of states) in 2012 and 2013, as described in Chapter 5. As highlighted before, there are very poor data on the rice post-harvest sector, aside from rapid appraisals. The only exception is a 2002–2003 study undertaken by the Africa Rice Center and Nigerian partners (Lançon et al. 2003b). Consequently, estimation of both fixed and operational cost data relied heavily on the data collected from the field visits, including milling capacity and technologies, production costs (material, labor, and other inputs), output, and prices. These data contributed to defining the model's set of parameters in its objective (profit), production technology, and resource constraint functions. Parameter estimates for the small- and medium-scale mills were compared with those of Lançon et al. (2003a) to ensure their accuracy, as the latter involved a much larger sample. As much as possible, therefore, model parameters were estimated based on both past data and field observations by the author. As noted earlier, the model was calibrated to a baseline year of 2010 with a 50 percent tariff rate for rice imports. The baseline year of 2010 was chosen to be consistent with the price and tariff data and partially because state- and national-level production figures were not expected to change as much from the NAERLS data collected in the 2009 harvest season. Although the data used come from various sources and relate to various years, every effort was made to update to the base year where possible.

Upon validating the results of the model to the base-year levels of output, a number of policy scenarios were introduced to test for each milling sector's ability to become more competitive and meet local demand for both the premium and standard rice varieties. Further details of the model, data assumptions, and model calibration and validation are provided in Appendix E. The policy scenarios introduced in the model and corresponding results are reported by milling sector and region in the following section.

Using the Rice Milling Model: Policy Scenarios and Results

Potential effects of a number of policies and strategies, either proposed under the ATA or for future consideration, are considered in the RMM. Brown rice milling is permitted under all the policy scenarios but limited to the large-scale milling sector. Policies are either trade related (e.g., the introduction of rice import tariffs) or public investment related. For the latter, this includes (1) technology or research and development (R&D)–related investments to improve access to superior-quality paddy and the productivity of paddy production and (2) investments to improve market efficiencies through lowering of both marketing and transportation costs. More specifically, the policy scenarios introduced in the model include the following:

S1 **Trade policy (trade).** Introduction of a change in import tariff. Base is with a 50 percent tariff in place. Two additional tariffs are introduced: (i) a reduction to 0 percent tariff, and (ii) an increase to 100 percent tariff.

S2 **Technology policy (science and technology, S&T).** Investing in R&D and irrigation to promote superior-quality paddy varieties and productivity growth in overall paddy production. The scenario in the model involves increasing by 50 percent the adoption of superior-quality varieties and expansion of current irrigation area in states producing more than 50,000 metric tons (MT). Tariffs are kept at their base.

S3 **Marketing improvement (markets).** Lowering high transportation and marketing costs through improved performance (e.g., by increased investments in road infrastructure, transportation, and communications). Tariffs are kept at their base.

S4 **All combined (all).** The combined effect of all three scenarios is also considered (i.e., S1 + S2 + S3).

Aside from evaluating these policy effects under the current state of milling capacities and technology in the country, I also consider their effects under a number of investment strategies targeted to improve each of the three milling sectors, either separately or collectively, in order to expand their capacities or improve their efficiencies. Overall, four milling strategies are considered:

M1 **Large-scale strategy.** Expanded milling capacity (doubling the number of large-scale mills, increasing them from 17 to 34, as under the ATA plan).

M2 **Medium-scale strategy.** Improving further processing (de-stoning and polishing) for premium rice (by a 20 percent increase in milling costs), plus gaining a price premium of 10 percent more in milled rice prices.

M3 **Small-scale strategy.** Doubling milling costs (because small mills' operating costs are so low they would need to at least double to produce a notable improvement in processing) and capturing a price premium of 10 percent more in milled rice prices from further processing (e.g., de-stoning) for standard rice.

M4 **Comprehensive strategy.** Combining all three strategies (M1 + M2 + M3).

Evaluating the three policy effects under each of these strategies will help weigh the benefits and costs for choosing one over the other. The benefits and costs are measured in terms of changes in total milling output from the base year by miller sector and type of rice; changes in the mix of miller types from the base year with respect to their contribution to total national output; changes in the mix of premium- versus standard-quality rice produced in the domestic rice economy; and changes in employment by the rice milling industry from the base year by miller sector and type of rice.

Tables 6.1 and 6.2 summarize the results with respect to the effect of a round of policy shocks on total rice output. From Table 6.1, it is clear that the variant of policy scenario S4—which includes combined investments in rice

TABLE 6.1 Effect of policies on national output by types of miller and rice (million MT)

Policy Scenarios		By type of miller (scale)					By type of rice		
		Large[b]	Large[b]	Med	Small	Total	Premium	Standard	Total
Scenario	Tariff (%)[a]	Brown	Local only				Brown & local	Local	All
		Output (million MT)							
Base	*50*	*0.6*	*0.5*	*0.3*	*2.3*	*3.1*	*1.4*	*2.3*	*3.7*
S1 – Trade	0	1.1	0.0	0.2	2.3	2.5	1.3	2.3	3.6
	100	0.0	0.7	0.6	2.3	3.6	1.3	2.3	3.6
S2 – S&T	50	0.6	0.5	0.5	2.4	3.4	1.6	2.4	4.0
S3 – Markets	50	1.0	0.1	0.6	2.8	3.5	1.7	2.8	4.5
S4 – All	50	0.9	0.2	0.6	3.2	4.0	1.7	3.2	4.9
	0	1.1	0.0	0.6	3.2	3.8	1.7	3.2	4.9
	100	0.0	0.9	1.0	2.6	4.5	1.9	2.6	4.5
		Percent change from base (%)							
S1 – Trade	0	83.3	–100.0	–33.3	0.0	–19.4	–7.1	0.0	–2.7
	100	–100.0	40.0	100.0	0.0	16.1	–7.1	0.0	–2.7
S2 – S&T	50	0.0	0.0	66.7	4.3	9.7	14.3	4.3	8.1
S3 – Markets	50	66.7	–80.0	100.0	21.7	12.9	21.4	21.7	21.6
S4 – All	50	50.0	–60.0	100.0	39.1	29.0	21.4	39.1	32.4
	0	83.3	–100	100.0	39.1	22.6	21.4	39.1	32.4
	100	–100.0	80.0	233.3	13.0	45.2	35.7	13.0	21.6

Source: Rice Milling Model results.

Notes: [a]Base year includes a 50 percent tariff. [b]For large millers, they have an option to mill brown rice (large brown) or local paddy rice (large local only). Notice that a complete switch occurs when tariffs are removed or raised to 100 percent (favoring brown rice for the former and local paddy for the latter). MT = metric tons. S&T = science and technology.

TABLE 6.2 **Effect of policies on shares in national output by types of miller and rice (percent of total rice output)**

Policy Scenario		Type of miller (scale)					Type of rice	
Scenario	Tariff (%)[a]	Large brown[b]	Large local[b]	Med	Small	Total[c]	Premium	Standard
Base	*50*	*16.2*	*13.5*	*8.1*	*62.2*	*100.0*	*37.8*	*62.2*
S1 – Trade	0	30.6	0.0	5.6	63.9	100.0	36.1	63.9
	100	0.0	19.4	16.7	63.9	100.0	36.1	63.9
S2 – S&T	50	15.0	12.5	12.5	60.0	100.0	40.0	60.0
S3 – Markets	50	22.2	2.2	13.3	62.2	100.0	37.8	62.2
S4 – All	50	18.4	4.1	12.2	65.3	100.0	34.7	65.3
	0	22.4	0.0	12.2	65.3	100.0	34.7	65.3
	100	0.0	20.0	22.2	57.8	100.0	42.2	57.8

Source: Rice Milling Model results.

Note: S&T = science and technology. Numbers might not always add up to 100 because of rounding. [a]Base year includes a 50 percent tariff. [b]For large millers, they have an option to mill brown rice (large brown) or local paddy rice (large local). Notice that a complete switch occurs when tariffs are removed or raised to 100 percent (favoring brown rice for the former and local paddy for the latter). [c]Total includes large brown as well as the three local rice types.

R&D (referred to in the table as "S&T") and improved market performance (referred to here as "markets") but does not include a tariff change—has major effects on overall output. Local production of rice can potentially rise from 3.1 to 4.0 million MT at the current 50 percent base tariff rate. Simply increasing the tariff rate to 100 percent (policy scenario S1) does not produce as much, rising to 3.6 million MT, although higher than S2 for S&T alone and S3 for markets alone. There are several reasons for this. First, prices do not rise as much as the increase in the tariff—a result that is also validated from actual price data in Chapter 7. Moreover, while prices for premium rice in the large-scale sector rise by a 0.7 fraction of the tariff change in the model, prices for the bulk of standard and premium rice flowing from the medium milling sector were assumed to rise much more slowly (about 20 percent of the change in tariff). Paddy prices were also assumed to increase at about the same rate as the rise in standard rice prices. A reasonable assumption, this also implies a weak supply response in paddy production based on the previous findings in Chapter 4. Finally, the higher tariff simply replaces brown rice milling with milling of local paddy only in the large-scale sector.

A rise in premium rice prices due to the higher 100 percent tariff benefits local rice milling by raising the price margin between paddy and milled rice for both large- and medium-scale operators. As a result, as shown in S1 in Table 6.2, both sectors respond with higher output from milling local paddy—although only the smaller medium-scale sector is adding anything to total output. For the large-scale sector, its share of milled rice actually declines from 28.9 (16.2 plus 12.7) in the base to 20.2 percent (from both brown and local) as the sector shifts away from milling any imported brown rice. Alternatively, increasing investments in either R&D (paddy S&T) in S2 or market improvement (markets) in S3 also produces a higher supply response in the medium milling sector, which almost doubles its output under the current tariff regime (50 percent tariff base). For the large-scale sector, improved markets (e.g., through lowered transportation costs) in S3 actually favor the milling of imported brown rice when there has been no change in the tariff regime, as millers farther from the port of entry face lower transportation costs. The smaller milling sector seems to benefit more from the combined effect of both R&D and market improvements, as in S4, with its share of output rising above 65 percent (Table 6.2) regardless of whether the current tariff is removed or not. Increasing tariffs to 100 percent, on the other hand, reduces the sector's share from 63.3 in the base to 58.5 percent. The higher favorable prices for rice producers and millers benefit all (see increased output volumes in Table 6.1), but especially the medium- and larger-scale millers, who are able to increase their shares of national output. The combined effect of the high tariff and investments in R&D and markets naturally produces a greater supply response, especially from the medium- and large-scale sectors (or for milled premium rice). The increase in the supply of superior-quality varieties from R&D and adoption, lowered transportation and marketing costs, together with more favorable rice prices, drives such a response. I will come back to this later.

Another way to evaluate which milling sector benefits or is more resilient to a policy shock is to examine their resulting industry shares in the national total after the shock. Table 6.2 summarizes this for both miller types and the rice type on aggregate. In the base case, the large sector contributes about 29 percent to total rice milled in the country (this is including brown rice). The medium-scale sector is the smallest, contributing only about 8 percent to total rice in the country, with the rest of the rice (the more inferior standard rice) coming from the small milling sector (about 63 percent). Again, the introduction of a 100 percent tariff regime makes only a very little dent on the supply of local rice, either premium or standard. While large millers switch completely to local paddy milling, they simply replace the brown rice they would otherwise mill under a lower tariff regime. This is also a sector whose total milling capacity is constrained in the model by the actual number of mills and locations where they are situated in the country. For example, the bulk of milling brown rice occurs in Lagos (estimated to have about six large rice mills).

Altogether, the shares of local premium rice do not rise much with either higher tariffs or improvements that lower transportation and marketing costs unless there are significant investments to expand production of higher-quality premium varieties (S2 and S4 row). The lower costs not only result in lower mill gate prices for paddy but for brown rice, too. The result is that many of the large millers switch to brown rice milling, even in northern Nigeria.

The effects of the different policies on output and industry shares among types of rice millers and types of rice can vary widely at the subnational level, especially given the spatial nature of the model. Table 6.3 shows the policy effects on regional output. Because much of the production of rice in Nigeria occurs in the North Central, North East, and North West zones (for Nigeria's six geopolitical zones, see the footnote in Figure 1.1), a majority of the increase in total output comes from these three regions. All three also benefit more from policies focused on increasing, through S&T investment, productivity and growth in the supply of quality rice paddy than under the higher tariff regime: in S4, with the base tariff, total output rises by between 37 and 57 percent. The

TABLE 6.3 Effect of policies on zonal output by types of rice

Policy Scenario		Zone					
Scenario	Tariff %[a]	NC	NE	NW	SE	SS	National
		Quantity (million MT)					
Base	50	0.97	0.77	1.04	0.40	0.01	3.63
S1 – Trade	0	0.96	0.76	1.03	0.40	0.01	3.59
	100	1.02	0.89	1.19	0.40	0.04	3.63
S2 – S&T	50	1.06	0.91	1.14	0.40	0.01	3.96
S3 – Markets	50	1.23	0.95	1.38	0.46	0.04	4.51
S4 – All	50	1.36	1.01	1.63	0.49	0.04	4.98
	0	1.33	1.06	1.64	0.43	0.01	4.91
	100	1.15	1.22	1.34	0.49	0.04	4.44
		Percent change from base (%)					
S1 – Trade	0	−1.0	−1.3	−1.0	0.0	0.0	−1.1
	100	5.2	15.6	14.4	0.0	300.0	0.0
S2 – S&T	50	9.3	18.2	9.6	0.0	0.0	9.1
S3 – Markets	50	26.8	23.4	32.7	15.0	300.0	24.2
S4 – All	50	40.2	31.2	56.7	22.5	300.0	37.2
	0	37.1	37.7	57.7	7.5	0.0	35.3
	100	18.6	58.4	28.8	22.5	300.0	22.3

Source: Rice Milling Model results.

Note: NC = North Central zone; NE = North East zone; NW = North West zone; SE = South East zone; SS = South South zone; SW = South West zone. MT = metric tons. S&T = science and technology. [a] Base year includes a 50 percent tariff.

South West region is particularly sensitive to higher tariffs, as millers in this region are unable to switch to local paddy. Instead, they would have to purchase it from excess paddy producing states such as Niger and Benue.

The changing mix in the operating scale of the rice milling industry can have important implications on employment outcomes within each miller sector. To estimate employment by milling type, calculations were made based on the average of field observations with regard to the number of full-time persons employed by each milling type's capacity during peak operations and calculated as the number of employees per maximum MT capacity that can be produced in a single year. For large-scale milling operations, this is 0.002 for milling imported brown rice (i.e., 400 employees/[24 MT/hr * 24hrs * 330 days/yr]) and 0.003 for milling local paddy (i.e., 400 employees/[18 MT/hr * 24 hrs * 330 days/yr]); for medium-scale operations, this is 0.005 (i.e., 20 employees/[2 MT/hr * 8 hrs * 270 days]); and for small-scale operations, this is 0.017 (i.e., 10 persons/[0.5 MT/hr * 8 hrs * 150 days]).

National employment in the rice milling sector for large-, medium-, and small-scale mills adds up to a very rough figure of about 43,000. For our purposes, however, the accuracy of this absolute number is not as important because we are only interested here in the proportional change and direction (up or down) in employment due to different policy scenarios.

Table 6.4 reports the change in total employment due to each policy scenario introduced in the model by each miller type and by rice type (premium or standard). Table 6.5 shows the shares of labor employed by milling type. In total, it is estimated that the small milling sector employs over 90 percent of

TABLE 6.4 Effect of policies on change in employment by miller and rice type (percent change from base)

Policy		Miller type (scale)			Type of rice		
Investments	Tariff %[a]	Large[b]	Med	Small	Premium	Standard	Total
S1 – Trade	0	–9.2	–20.2	–1.4	–13.0	–1.4	–2.4
	100	–18.8	104.3	0.3	23.5	0.3	2.4
S2 – S&T	50	2.2	83.6	3.5	30.2	3.5	5.9
S3 – Markets	50	–7.6	109.9	22.1	32.8	22.1	23.1
S4 – All	50	–3.0	123.2	40.7	40.4	40.7	40.6
	0	–9.2	104.9	40.0	30.0	40.0	39.1
	100	–5.8	247.2	12.9	81.2	12.9	19.1

Source: Rice Milling Model results.

Note: S&T = science and technology. [a]Base year includes a 50 percent tariff. [b]Large here includes both brown and local paddy rice milling. The reduction in employment for large scale under the 100 percent tariff is primarily because of the closure of large mills in Lagos, as they find it unprofitable to mill local paddy as a substitute for brown rice after tariffs rise to 100 percent.

TABLE 6.5 Effect of policies on changes in employment shares by miller type (as percent of national employment in the rice milling industry)

Policy		Miller type (scale)		
Investments	Tariff %[a]	Large[b]	Medium	Small
Base[a]	50	6.0	3.1	90.9
S1 – Trade	0	5.6	2.6	91.8
	100	4.8	6.3	89.0
S2 – S&T	50	5.8	5.4	88.8
S3 – Markets	50	4.5	5.4	90.1
S4 – All	50	4.1	5.0	90.9
	0	3.9	4.6	91.5
	100	4.7	9.2	86.1

Source: Rice Milling Model results.

Notes: S&T = science and technology. Totals across miller types may not always equal 100 because of rounding. [a]Base year includes a 50 percent tariff. [b]Large here includes both brown and local paddy rice milling.

the labor force in the country's rice milling industry. The medium milling sector employs the least—although the position of the lowest-employing sector can quickly shift from the medium- to the large-scale sector as policies affect millers' operations. An important implication of this is that any small change in output within the small milling sector has more significant effects on overall employment. The other sector most affected by small changes in output is the medium sector, simply because of its higher dependence on labor per metric ton of output than the large sector. In fact, Table 6.4 shows that much of the gain in employment is experienced by the medium sector, as the production of premium rice rises following increases in R&D investments and improved markets; employment more than doubles as a result, although this is still a small rise as a share of the total employed in the industry (from 3 to 5 percent, as shown in Table 6.5).

Turning to the milling technology and expansion strategies, four different strategies are introduced to test for their effect on total output, employment, and shares of the premium versus the standard varieties of local rice. Results are summarized in Tables 6.6 through 6.8. The first strategy is the large-scale one that involves introducing the 17 new large integrated mills proposed under the ATA strategy for rice. The three largest rice-producing zones (North Central, North East, and North West) naturally gain the largest share of new mills. Among current capacities, the South West is dominated by mills that mostly process brown rice. Although capacity utilization in the base case is about 96 percent in the large-scale sector, the introduction of 17 new mills results in a much lower capacity utilization ratio of 58 percent. This may explain the small effect on total output illustrated in Table 6.6: with no tariff change, brown rice milling and paddy rice milling increase only 0.7 and 3.4 percent, respectively, in the large sector (S1 row, column under the large-scale strategy and base 50 percent tariff, and with no change in paddy productivity and improvement of markets). Despite the expanded milling activities in the large-scale sector, total rice output in the country changes little due to a limited supply of superior local paddy varieties. The superior varieties are demanded by both medium- and large-scale millers, so that an increase in the capacity of large-scale milling under the ATA strategy simply diverts the paddy away from medium-scale millers (notice the 3.5 percent decline in output for this milling sector in Table 6.6). All in all, milled output of premium-quality rice (produced by the medium- and large-scale sectors only) turns out to increase by only 0.6 percent.

At the current tariff rate, combining the large-sector strategy with improvements in paddy rice productivity and markets seems to have negligible effects on output (S4, with no tariff change and with S&T and markets). While large-scale millers actually increase output of milled brown rice by 9.4 percent, they decrease their milling of local paddy by 12.7 percent. While this may seem counterintuitive at first glance—one would expect the milling of local paddy to increase as the supply of paddy increases—the lowered transportation and marketing costs allow more large millers to partially shift to milling imported brown rice, as moving it from the port of Lagos becomes cheaper. Moreover, brown rice milling is cheaper because it does not require any parboiling and is not constrained by limited supplies during lean seasons, as is the case for local paddy.

Rice import tariffs can have significant effects on the large-scale sector. The biggest increase in large-scale output of premium rice actually occurs when tariffs are removed and a productivity change in paddy and improved market performance also occur (S4 scenario in Table 6.6 under large-scale strategy and a zero tariff rate). Production of premium-quality rice increases by 36.3 percent compared to a higher tariff of 100 percent, when it increases by only 18.0 percent. Evidently, with zero tariffs, most large millers switch to imported brown rice milling, adding a significant amount of premium rice in the marketplace and above the total supply of local paddy. The smaller milling sector contributes the most to the increase in total local rice under zero tariffs—an increase of 25.6 percent.

Examining across the four strategies in Table 6.6, a medium-scale strategy has a similar positive response in supplying premium-quality rice as does a

TABLE 6.6 Effect of different miller strategies on total output by miller and rice type (percent change from base)

		M1. Large–scale strategy			M2. Medium–scale strategy			M3. Small–scale strategy			M4. Comprehensive strategy		
	Sector	$\tau=0\%$	$\tau=50\%$*	$\tau=100\%$	$\tau=0\%$	$\tau=50\%$*	$\tau=100\%$	$\tau=0\%$	$\tau=50\%$*	$\tau=100\%$	$\tau=0\%$	$\tau=50\%$*	$\tau=100\%$
S1. No S&T and markets	*L–brown*	*40.7*	*0.7*	*–16.2*	*13.9*	*3.1*	*–16.2*	*13.9*	*0.4*	*–16.2*	*40.7*	*3.9*	*–16.2*
	L–local	–12.7	3.4	21.5	–12.7	–3.4	3.9	–12.7	–1.7	7.5	–12.7	–4.7	11.5
	Med	–1.6	–3.5	–3.7	–5.2	5.1	15.8	–1.6	–0.2	8.2	–5.2	3.7	8.2
	Small	–0.3	0.3	0.1	1.2	–1.2	0.1	1.7	3.1	0.2	3.2	2.3	0.1
	Total local	*–14.6*	*0.2*	*17.9*	*–16.7*	*0.5*	*19.8*	*–12.6*	*1.2*	*15.9*	*–14.7*	*1.3*	*19.8*
	Premium	26.5	0.6	1.7	–4.0	4.8	3.5	–0.4	–1.5	–0.5	22.8	2.8	3.5
	Standard	–0.3	0.3	0.1	1.2	–1.2	0.1	1.7	3.1	0.2	3.2	2.3	0.1
S4. With S&T and markets	*L–brown*	*40.7*	*9.4*	*–16.2*	*13.9*	*7.9*	*–16.2*	*13.9*	*9.9*	*–16.2*	*40.7*	*12.3*	*–16.2*
	L–local	–12.7	–12.7	24.7	–12.7	–6.8	6.5	–12.7	–8.7	10.2	–12.7	–9.5	11.7
	Med	8.3	–5.2	9.5	–1.1	9.6	31.3	1.7	8.6	17.5	–2.5	8.8	21.2
	Small	25.6	1.2	4.1	32.2	25.7	0.6	43.9	37.6	12.6	48.0	38.1	8.1
	Total local	*21.2*	*–16.7*	*38.3*	*18.4*	*28.5*	*38.4*	*32.9*	*37.5*	*40.3*	*32.8*	*37.4*	*41.0*
	Premium	36.3	–8.6	18.0	0.1	10.8	21.6	2.9	9.8	11.6	25.6	11.5	16.7
	Standard	25.6	1.2	4.1	32.2	25.7	0.6	43.9	37.6	12.6	48.0	38.1	8.1

Source: Rice Milling Model results.

Note: S&T = science and technology. L-brown and L-local refer to large brown and large local, respectively. *Note that $\tau=50$ percent is really the base period tariff; therefore, for the large-sector strategy, the change in output is measuring the effect of introducing 17 new mills without any change in tariffs. For the medium- and small-sector strategies, under the same $\tau=50$ percent tariff, the output changes reflect improvements in their current milling technologies, with no tariff change, but with alternative S1 and S4 scenarios (S&T here stands for improved paddy varieties). Changes from base are weighted by the share of the sector in total output.

large-scale strategy, especially under a protective tariff regime of 100 percent. The medium milling sector strategy with 100 percent tariff and no changes in paddy production of market improvements (S1) would have the effect of increasing output of the premium-quality rice by 3.5 percent compared with only 1.7 percent under the large-scale strategy of adding 17 new large mills. Under a small-scale strategy, on the other hand, the small sector would raise national output of local rice by only 1.2 percent with no change in tariffs, while adding little to increase the output of premium rice. Higher tariffs under this strategy mainly benefit the large- and medium-scale sectors. Altogether, rice output for both premium and standard rice types increases the most under a comprehensive strategy that invests in all three milling sectors, with improvements in paddy productivity and markets (S4) and with zero tariffs. National output of premium-quality rice would increase by 25.6 percent, while the supply of standard-quality rice would increase by 48.0 percent. However, much of the increase in premium rice is derived from the milling of brown rice. Ensuring sufficient growth in the supply of domestically produced premium-quality rice would occur under a more liberal tariff regime (zero tariffs) that permits the milling of brown rice. The milling of local paddy is otherwise unprofitable for a majority of large millers at zero tariffs.

Disaggregating the effects on output by zones mostly reflects the distribution of major rice-producing regions. The exception is the South West zone: this zone's output most consistently and dramatically fluctuates as tariffs change. Table 6.7 illustrates this by showing a typical 10 to 11 percent reduction in its contribution to national output at the 100 percent tariff level. The explanation for this is the going out of business of several mills, as the milling of brown rice is no longer profitable at this tariff level. This occurs as other regions, especially in the three northern zones (NC, NE, and NW), expand their large-scale milling of local paddy, with some regions even reaching maximum capacity utilization.

The effect on employment across the various strategies can also be examined. Table 6.8 reports the estimated effects of each strategy on employment, weighted by each sector's share in total employment in the country's milling industry. Naturally, employment rises as output rises in most cases. As in the case of increased output, for example, the effects on employment are greatest in S4, with increased R&D investments and market efficiencies. Within S4, a comprehensive strategy that focuses attention on all the sectors, combined with zero tariffs and permitting the milling of brown rice, produces the greatest employment effects. Because the removal of tariffs from the base of 50 percent can also be similarly viewed as a reduction in the global rice price

TABLE 6.7 Effect of different miller strategies on total output by zone (percent change from base)

		M1. Large-scale strategy			M2. Medium-scale strategy			M3. Small-scale strategy			M4. Comprehensive strategy		
	Zone	$\tau=0\%$	$\tau=50\%$*	$\tau=100\%$	$\tau=0\%$	$\tau=50\%$*	$\tau=100\%$	$\tau=0\%$	$\tau=50\%$*	$\tau=100\%$	$\tau=0\%$	$\tau=50\%$*	$\tau=100\%$
S1. No S&T and markets	NC	6.2	0.8	3.2	–0.2	1.8	4.5	–0.1	0.8	1.4	6.2	1.8	5.7
	NE	3.2	0.2	1.8	–2.0	–0.2	4.8	0.0	0.2	3.3	1.2	–0.1	4.7
	NW	6.0	–0.2	5.6	–0.5	1.5	5.3	1.4	0.3	4.1	7.7	2.8	4.8
	SE	9.5	0.0	1.3	0.0	0.3	–0.8	0.0	0.1	0.0	9.5	0.4	–1.3
	SS	0.1	0.1	0.8	0.1	0.1	0.8	0.1	0.2	0.8	0.1	0.2	0.8
	SW	1.3	0.0	–10.9	–0.3	0.0	–11.0	–0.1	0.1	–9.8	1.4	0.1	–11.0
S4. With S&T and markets	NC	16.0	10.6	6.6	12.8	10.4	9.5	11.7	13.2	6.7	18.3	13.7	9.6
	NE	11.4	6.7	10.4	4.5	6.8	12.5	12.1	12.1	12.4	12.8	12.1	10.3
	NW	22.8	16.1	11.1	14.3	16.2	9.6	18.4	16.6	8.6	27.0	16.8	12.7
	SE	10.2	4.0	3.7	0.7	2.4	0.6	4.6	4.5	2.6	13.8	6.2	2.3
	SS	0.1	0.8	0.8	0.1	0.8	0.8	0.1	0.8	0.8	0.1	0.8	0.8
	SW	1.4	0.1	–10.4	–0.1	0.1	–10.8	–0.1	0.1	–7.1	1.4	0.1	–10.9

Source: Rice Milling Model results.

Note: NC = North Central, NE = North East, NW = North West, SE = South East, SS = South South, SW = South West. S&T = science and technology. *Note that $\tau=50$ percent is really the base period tariff; therefore, for the large-sector strategy, the change in output is measuring the effect of introducing 17 new mills without any change in tariffs. For the medium- and small-sector strategies, under the same $\tau=50$ percent tariff, these are improvements in their current milling technologies, with no tariff change, but with alternative S1 and S4 scenarios (S&T here stands for improved paddy varieties). Changes from base are weighted by the share of the sector in total output.

TABLE 6.8 Effect of different miller strategies on total employment in the milling industry by miller and rice type (percent change from base total)

		M1. Large–scale strategy			M2. Medium–scale strategy			M3. Small–scale strategy			M4. Comprehensive strategy		
	Sector	τ=0%	τ=50%*	τ=100%	τ=0%	τ=50%*	τ=100%	τ=0%	τ=50%*	τ=100%	τ=0%	τ=50%*	τ=100%
S1. No S&T and markets	*L–brown*	*7.4*	*0.1*	*−2.9*	*2.5*	*0.6*	*−2.9*	*2.5*	*0.1*	*−2.9*	*7.4*	*0.7*	*−2.9*
	L–local	−3.1	0.8	5.2	−3.1	−0.8	0.9	−3.1	−0.4	1.8	−3.1	−1.1	2.8
	Med	−0.6	−1.4	−1.5	−2.1	2.0	6.3	−0.6	−0.1	3.3	−2.1	1.5	3.3
	Small	−0.4	0.4	0.1	1.8	−1.7	0.1	2.5	4.5	0.3	4.7	3.4	0.1
	Total local	*−4.1*	*−0.2*	*3.8*	*−3.4*	*−0.5*	*7.3*	*−1.2*	*4*	*5.4*	*−0.5*	*3.8*	*6.2*
	Premium	3.7	−0.4	0.8	−2.6	1.8	4.3	−1.2	−0.4	2.1	2.2	1.0	3.1
	Standard	−0.4	0.4	0.1	1.8	−1.7	0.1	2.5	4.5	0.3	4.7	3.4	0.1
S4. With S&T and markets	*L–brown*	*7.4*	*1.7*	*−2.9*	*2.5*	*1.4*	*−2.9*	*2.5*	*1.8*	*−2.9*	*7.4*	*2.2*	*−2.9*
	L–local	−3.1	−3.1	6.0	−3.1	−1.6	1.6	−3.1	−2.1	2.5	−3.1	−2.3	2.8
	Med	3.3	−2.1	3.8	−0.4	3.8	12.5	0.7	3.4	7.0	−1.0	3.5	8.5
	Small	36.9	1.8	6.0	46.3	37.0	0.9	63.1	54.0	18.2	68.9	54.8	11.6
	Total local	*37.1*	*−3.4*	*15.8*	*42.8*	*39.2*	*15*	*60.7*	*55.3*	*27.7*	*64.8*	*56*	*22.9*
	Premium	7.6	−3.5	6.8	−1.0	3.6	11.1	0.1	3.1	6.5	3.3	3.4	8.3
	Standard	36.9	1.8	6.0	46.3	37.0	0.9	63.1	54.0	18.2	68.9	54.8	11.6

Source: Rice Milling Model results.

Note: S&T = science and technology. L-brown and L-local refer to large brown and large local, respectively. *Note that τ=50 percent is really the base period tariff; therefore, for the large-sector strategy, the change in output is measuring the effect of introducing 17 new mills without any change in tariffs. For the medium- and small-sector strategies, under the same τ=50 percent tariff, the output changes reflect improvements in their current milling technologies, with no tariff change, but with alternative S1 and S4 scenarios (S&T here stands for improved paddy varieties). Changes from base are weighted by the share of the sector in total output.

of 50 percent, this scenario could be particularly relevant given the current downward trend in global rice prices.

Conclusion

Chapter 5 emphasized that improving the quality of domestic rice in Nigeria in order to compete more effectively with imports will depend on how much the country's milling industry can be transformed to increase its productivity and expand production of premium-quality rice. The objective of this chapter is to assess whether this is feasible and how it could be done given the current technology mix and scale of the different miller types in Nigeria. More specifically, it seeks to address a number of key policy questions: Are there differential abilities and efficiencies among existing mill types (small to large) to supply the domestic market? To what extent does increasing tariffs help the industry? This is accomplished through the development and application of a simulation model representing the rice milling industry in Nigeria—the RMM.

The empirical analysis in this chapter further validated the importance of having sufficient access to quantities of superior-quality paddy among the large- and medium-scale millers in order to increase the supply of premium-quality local rice in Nigeria. Results also show that the reduction in transportation and marketing costs can play a critical role in both the location and mix of milling types by affecting the prices of paddy and final rice product. The exception is the large-scale sector, which is likely to switch to milling brown rice if tariffs are low enough (or even absent) and the cost to ship it overland from Lagos becomes cheaper. This is particularly true for large millers farther away from paddy producers, but it is just as relevant for all millers whenever the seasonal supply of paddy is at its lowest.

Import tariffs are shown to be particularly important for protecting the large-scale sector. At zero tariffs, these enterprises would go out of business unless they are able to substitute for milling imported brown rice. The option to mill brown rice offers large-scale millers a way to manage production risks associated with inadequate and infrequent supplies of superior-quality paddy, as well as fluctuations in the price of imported rice. The price risk comes from either a reduction in the tariff rate or a fall in global prices. As the model results show, the large sector faces the risk of going out of business if the tariff is removed altogether and the miller is not allowed to mill brown rice. This is because the milling of imported brown rice does not require any parboiling and therefore offers a profitable alternative at very low tariff rates. Moreover, when facing the same tariff rates, the ratio between the price for imported brown rice and imported milled rice tends to change little across the country, as both types of rice experience the same transportation costs from the port of Lagos. Price movements for both types of rice in world markets generally move in the same direction as well. Hence, millers can be assured a positive return most of the time.

In contrast, findings show the small-to-medium-scale sector to be more resilient to policy shifts and global price changes. These enterprises are able to stay in business even with zero tariffs. It is also a sector that has more to gain from improvements in paddy productivity, markets, and processing technologies. Although the small-scale sector cannot compete directly with imports, it plays a critical role in supplying a cheaper alternative for poorer consumers. Moreover, larger employment effects for the whole milling industry are shown to occur following improvements and expansion in the small milling sector. After all, this is a sector that currently employs over 90 percent of the total number of people employed in the industry (that is, across all three milling types). The medium-scale sector, on the other hand, offers a more immediate potential for improving productivity and product quality. Like the large-scale sector, it could serve a similar purpose of helping increase the competitiveness of local rice with imports.

Finally, model results also show that a comprehensive strategy that includes targeted investments among all three milling sectors and a policy regime of zero tariffs has the potential to contribute the most to output and employment. The modeling exercise also shows, however, that for such a strategy to be successful in meeting the demand for premium-quality rice, the milling of imported brown rice should be allowed. Allowing brown rice milling is necessary if large-scale millers are to remain in business under a zero tariff regime.