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Agro-processing, food prices, and COVID-19 shocks

Evidence from Myanmar's rice mills

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ABSTRACT

The COVID-19 pandemic has stressed global agri-food systems at a critical time. Poverty rates have increased and food security is a growing concern for the most vulnerable. Even in the advanced stages of the pandemic, the shocks to many sectors of agri-food systems are not well understood. This paper assesses the impacts of COVID-19 on the processing sector of Myanmar's agri-food system.

We focus on the milling of rice, which is the country's most important staple and accounts for more than half of calories consumed. Rice serves as the country's leading export commodity as well. Using unique data collected via phone interviews with more than 400 medium- and large-scale rice mills, we highlight the following major findings:

- COVID-19 has caused disruptions for medium- and large-scale rice mills, including lower milling throughput, employee layoffs, and less credit availability than in normal times.
- Our analysis of prices during the pandemic compared with prices a year prior reveals significant resilience in the rice processing sector. Overall, milling margins increased slightly during the pandemic, but there was important heterogeneity by rice variety.
- For the locally preferred, aromatic, and more expensive rice variety, rice and paddy prices did not significantly change during the pandemic. This is possibly due to the reduced purchasing power of local consumers.
- However, for the exported rice variety, rice prices increased significantly. This increase is linked to increases in rice prices in international markets. Importantly, the increased rice prices were mostly passed through to producers in higher prices for their paddy.
- Similarly, higher rice prices achieved by more modern mills were passed through to farmers.
- Our results also highlight the immense importance of the sales of byproduct–broken rice and rice bran–to the overall profit margins of rice mills, which allows mill operators to sustain negative paddy-to-rice margins.

1. INTRODUCTION

The COVID-19 pandemic has stressed global agri-food systems at a critical time. Global gross domestic product shrunk by 4.4 percent in 2020 (IMF 2020), pushing an estimated 88 to 115 million people into extreme poverty, the first increase in 20 years (World Bank 2020b; Laborde et al. 2020). This raises tremendous food security concerns and places heightened importance on agri-food systems, which are responsible not only for food supplies but also for the incomes and livelihoods for a large share of the global population. There are multiple demand and supply pathways through which COVID-19 could impact agri-food systems. Lower household incomes from lost jobs could shock demand. Supply disruptions could manifest through restrictions on imports, exports, and transportation restrictions, as well as through exchange rate shocks, reduced access to credit, and higher energy costs (Swinnen and McDermott 2020; Laborde et al. 2020). Whereas modeling exercises of COVID-19 impacts on agri-food systems have been conducted for several countries, empirical assessments are still limited.

One sector that has received little empirical attention is agro-processing (Bene et al. 2021), which accounts for 80 percent of global food sales and is increasingly important in lower income countries (World Bank 2008).[1] This paper addresses the impacts of COVID-19 on agro-processors in Myanmar. We use data collected through telephone surveys with medium- and large-scale rice millers to assess the impact of COVID-19 on milling margins by comparing paddy, rice, and milling byproduct prices before and during the pandemic.

In the rice supply chain, rice millers are a crucial group of actors, adding significant value to the product, which benefits both consumers and producers (Minten et al. 2012; Reardon 2015). Mills process raw paddy into rice, which is the single most important processed food in Myanmar by a wide margin, with average per capita consumption at 170 kg per year (USDA 2020a). Rice is also an important export commodity (Diao et al. 2020). Myanmar was the sixth biggest rice exporter worldwide in 2018[2] with thousands of tons exported through both official and unofficial trade each year (USDA 2020a). From a production perspective, rice is Myanmar's most important crop, accounting for more than 30 percent of the value of all crops produced (CSO 2019). The far-reaching upstream and downstream influences of rice milling highlight the importance of understanding COVID-19's impacts on the sector.

Previous research on the impact of COVID-19 on agri-food systems shows that agricultural supply was not largely affected in the short term as there were enough global stocks of food and other agricultural produce available when the pandemic hit (Torero 2020). Yet, in the medium term, shocks to factor markets, e.g., labor and inputs, and to transportation, e.g., international trade and logistics can increase costs (Laborde et al. 2020, Hirvonen et al. 2021), leading to increased food prices and decreased farm returns. Nordhagen et al. (2021) document the widespread impacts of COVID-19 on small and medium enterprises in the agri-food system. In Myanmar, there have been shocks at almost every link in the agricultural supply chain, from input retailers to consumers (Boughton et al. 2021). The research literature also shows that COVID-19 shocks have increased food prices in some contexts, including. significant, if modest, price increases for raw foods in urban areas of India during a national lockdown (Narayanan & Saha 2021) and large price increases for some vegetables both in urban settings in Ethiopia (Hirvonen et al. 2021) and during lockdowns in China (Ruan et al. 2021).

The research described in this paper makes three main contributions. First, we analyze the effect of the COVID-19 shock on the processing sector and assess the influence of international trade, local demand changes, and local processing margins on rice and paddy prices using modeling and

[1] Lusk et al. (2020) illustrate the large impacts of COVID-19 on the beef and the pork sectors in the US.

[2] https://knoema.com/atlas/topics/Agriculture/Trade-Export-Value/Rice-exports

empirical assessments. Second, despite the global importance of rice, there are very few studies based on surveys of rice mills, a crucial node in the value chain. Moreover, when surveys have been done, few authors have tried to analyze mill processing margins, despite their importance for producers and consumers alike.[3] We propose a more complete method of looking at these margins by incorporating into these analyses consideration of rice quality and the value of byproducts, often ignored in other studies. Third, Myanmar's agricultural sector, especially processing, has been the subject of few updated studies and surveys. Ours is among the first to shed light on the importance of rice milling within the sector.

Our data reveal significant disruptions from the COVID-19 pandemic, including lower milling throughput, employee lay-offs, and less credit availability than in normal times. We further note that raw paddy prices paid by mills for varieties linked to export markets, such as the *Emata* variety, slightly increased during the COVID-19 pandemic, mirroring international rice price increases over the same period. Prices of the locally preferred aromatic and more expensive rice, the *Pawsan* variety,[4] did not show such increases, perhaps due to reduced domestic purchasing power in Myanmar. Despite the challenges facing the mills due to COVID-19, we find significant resilience in the sector with relatively small changes in processing margins and changes in rice prices during the pandemic being mostly transmitted to producers.

We also offer some important insights on the rice milling sector. We find that modern mills pay higher prices to their suppliers and, due to extra processing, sell rice at higher prices than their competitors. We also observed that their margins and the prices to suppliers and buyers were affected in similar ways by the COVID-19 pandemic. We further illustrate the importance of byproducts for milling margins. Paddy-to-rice milling margins–excluding marketed byproduct values–are negative. Thus, without byproduct sales higher margins between producer and consumer prices would be required to assure the profitability of the mills. Expansion of marketing opportunities for byproducts, such as for use as feed in the rapidly growing aquaculture and poultry sector in the country, might have spillover effects and contribute to lower paddy-to-rice processing margins, thereby lowering rice prices for consumers and raising paddy prices received by farmers.

These results have several implications. First, access to international rice markets has seemingly contributed to price stability in local markets, indicating the importance of continued safe trade during global shocks. Second, monitoring crucial nodes in the value chains through inexpensive phone interviews has allowed efficient tracking of the performance of a large sector of Myanmar's economy that has strong links to producers and consumers alike. Similar surveys could be conducted with other local processors as well as with processing nodes in other countries. Third, modernization of mills is associated with higher prices for farmers and should be encouraged in Myanmar's agricultural policies through further relaxation of restrictions on investments in agro-processing and rice trade.

2. BACKGROUND

Processed food consumption

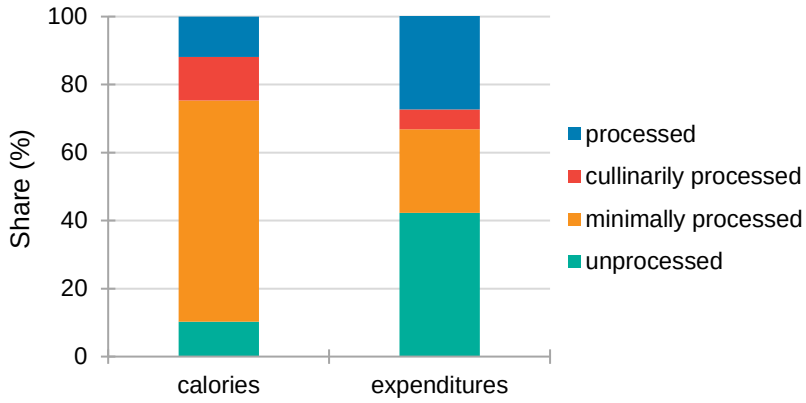
In case studies conducted in Bangladesh, Nepal, Indonesia, and Vietnam, Reardon et al. (2014) showed that the average share of processed foods in consumption was 59 percent in rural areas and 73 percent in urban areas. They also found that this processing share rises with income levels and that the importance of this sector is increasing globally.

[3] For exceptions, see Reardon et al. (2014) and Minten et al. (2013). Hayami et al. (1999) and Chung et al. (2016) looked at mill margins based on key informant interviews in the Philippines and Malaysia, respectively. Timmer (1974) looked at rice marketing margins, but only at the aggregate level.

[4] Throughout the paper, Pawsan refers to the Ayeyarwady variants of Pawsan rice rather than the more regionally specific Shwebo Pawsan.

To assess the importance of the consumption of processed foods in Myanmar, we rely on the classification of Monteiro et al. (2019) to split foods groups into four distinct processing categories: unprocessed, minimally processed, culinary processed, and processed foods using data from the consumption module of the nationally representative Myanmar Poverty and Living Conditions Survey conducted in 2015 (MoPF and World Bank 2017).[5] While processed foods make up on average only 10 percent of calories consumed, they contribute 28 percent of the value of food of Myanmar consumers (Figure 1). However, most foods eaten in Myanmar fall under the category of minimally processed foods, which are foods that are altered by industrial processes but do not include added salt, sugar, oils, fats, or other food substances. Such foods make up almost two-thirds of calories consumed, but represent only one-quarter of expenditures, indicating that relatively lower-value products go through this process. Rice milling falls in the minimally processed category as harvested paddy must be converted into milled rice for human consumption.

Figure 1. Importance of processed foods in diets in Myanmar, by percent share of calories consumed and household expenditures on food



Source: Authors' calculations based on MoPF and World Bank (2017)

Myanmar's rice sector

Myanmar's rice milling sector has undergone dramatic change and modernization since the industry was liberalized in 2003, particularly under the civilian government from 2010 to 2020 (Okamoto 2005). However, medium- and large-scale mills, which are classified as having a daily throughput capacity greater than 15 tons, accounted for just 12 percent of all rice mills in Myanmar in 2018 (USDA 2020a). Yet, in terms of total rice produced, these medium- and large-scale mills are becoming increasingly important, as the number of small-scale mills is declining (USDA 2020a).

Rice, as a major commodity in agricultural production and food consumption, is central to Myanmar's agricultural policymaking. It was estimated in 2017-18 that paddy accounted for 35 percent of all land cultivated in Myanmar–17.9 million out of 50.5 million total acres (CSO 2019). Average annual rice consumption is estimated to be 170 kg per person per year, which is one of the highest rates in the world (USDA 2020a). In 2015, rice made up 19.7 and 14.2 percent of total food expenditures in rural and urban households, respectively, and contributed to even higher shares of calories consumed–52 and 61 percent, respectively (Boughton et al. 2020).

Total paddy production in 2017-18 was estimated to be 25.6 million tons. Most was used for domestic consumption, though rice is also an important source of foreign exchange for Myanmar. While official statistics put rice exports at 2.2 million tons in 2019, it is generally acknowledged that export levels are higher. USDA (2020a) estimated rice exports in 2018-19 to be 2.7 million tons, making rice one of Myanmar's most important agricultural export products. Most exported rice goes

[5] We thank Kristi Mahrt for these calculations.

to China, though there is increasing diversification in recent years with more exports going to Europe, Africa, and other countries in Southeast Asia (Dorosh et al. 2019; Diao et al. 2020). The main exported rice variety is Emata, a long-grain, slender, and translucent rice (World Bank 2014b).[6] Myanmar consumers consider Emata to be lower quality than the locally preferred Pawsan variety, which is a fine-quality aromatic variety with lower yields (Dorosh et al. 2019; Proximity Designs 2016). Pawsan is not in demand outside of Myanmar, so exports of the variety are negligible.

COVID-19 in Myanmar

Myanmar has been severely impacted by the COVID-19 crisis. Though the case load remained low prior to September 2020, the economy has been severely affected. A major impact has been the decline in remittance incomes, which had been important for a significant–but relatively wealthier–share of the population (World Bank 2020a). Poor households also were affected by the pandemic through job insecurity and low availability of savings (World Bank 2020a). Headey et al. (2020) finds that both quantitative and qualitative measures show severe and widespread income losses due to COVID-19. Thirty-five percent of respondents in their surveys stated that their household failed to earn any income in September 2020. The authors estimate that the prevalence of income-based poverty at the USD 1.90 per day poverty line increased from 16 percent in January to 63 percent in September 2020. In a national phone survey in June 2020, the World Bank (2020c) further found that 18 percent of households were facing difficulties in securing an adequate diet.

Headey et al. (2020) modeled the impact of COVID-19 related disruptions on Myanmar's economy from both international, e.g., lower agricultural exports and workers' remittances, and domestic sources, e.g., COVID-19 prevention measures, such as stay-at-home orders and temporary business closures. They find that the strict lockdowns combined with much-reduced levels of international remittances and agricultural exports resulted in a sharp increase in severe poverty, from 9.8 percent pre-COVID-19 to 31.6 percent in the period of most extreme disruptions. Similarly, Boughton et al. (2021) document the impact of COVID-19 in different parts of Myanmar's agri-food system and show persistent financial stress for a high proportion of households and agri-food system businesses.

The COVID-19 pandemic also affected the rice sector in different ways. First, after the COVID-19 pandemic, a food reserve scheme was set up by the government where exporters were required to provide 10 percent of their planned exports at a low price to these food reserves (World Bank 2020a; USDA 2020b). Second, rice exports were affected as borders were closed at multiple locations and export quotas were established (USDA 2020b). However, international rice trade has since re-started (Htoon 2020). Finally, transport between regions became more difficult during lockdowns, leading to less rice trade through the Yangon rice wholesale market–which served as a clearing center of rice for the country–and more direct trade from rice producing regions to border crossings (Htoon 2020).

3. CONCEPTUAL AND EMPIRICAL FRAMEWORK

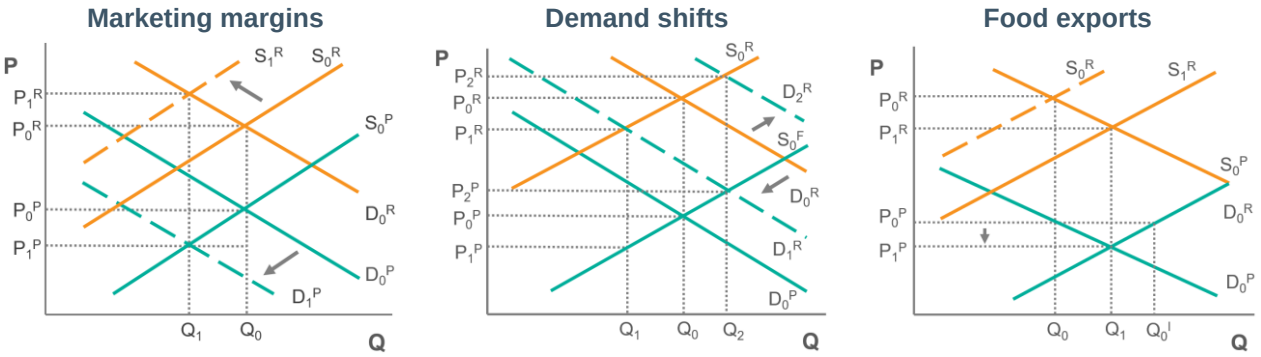
Conceptual framework

To understand the impact of COVID-19 on rice markets, we rely on simple supply, derived supply, demand, and derived demand frameworks (Gardner 1975; Tomek and Robinson 1990). We consider three scenarios (Figure 2). The first two assess the impacts of COVID-19 in the case of autarky. In the third scenario, we add a rice export scenario. In all three scenarios, the S_0 (supply), D_0 (demand),

[6] Myanmar uses the Beale classification system to group rice varieties based on paddy length and ratio of length and breadth. The categories are Emata, Ngasein, Letywezin, Meedon, and Byat (World Bank 2004b). Pawsan varieties fall under the Meedon classification.

P_0 (prices), and Q_0 (quantity) refer to before the COVID-19 pandemic. Superscripts P and R refer to the situation for paddy (farm prices) and milled rice (consumer prices), respectively.

Figure 2. COVID-19 impacts on marketing margins, demand shifts, and food exports



Source: Authors

The marketing margins scenario looks at the case of increasing processing margins. Such increases could stem from higher labor costs, as milling is labor-intensive and laborers may be less willing to work at the mill during the pandemic; higher procurement costs, due to fewer trucks being available for paddy procurement due to increased health risks and mobility restrictions; higher interest costs (Htoon 2020); less competition as fewer mills are operating; and lower values for byproducts due to reduced demand for livestock feed. In this scenario, we see a shift downward of the derived demand curve for paddy and an upward shift for the derived supply of rice. This leads to a higher rice price (P_1^R) and a lower paddy price (P_1^P) than in the situation before the COVID-19 pandemic (P_0^R, P_0^P). In such a scenario, less paddy will be procured and less rice will be consumed.

In the demand shift scenario, we consider a case of COVID-19 related disruptions in demand. First, if there is a downward shift in demand from D_0^R to D_1^R caused by a decline in the purchasing power of consumers (e.g., see Headey et al. (2020)), rice prices would decline to P_1^R and paddy prices would consequently decline to P_1^P. Second, if demand shifts upward due to increased demand for the government's COVID-19 food reserve stock (World Bank 2020a; Htoon 2020) or due to a shift away from high-value to staple products (Laborde et al. 2020), local rice and paddy prices would be pushed up to P_2^R and P_2^P, respectively.

Finally, the food exports scenario illustrates that paddy prices will be reduced in the case of restrictions on international borders for rice exports. Rice prices will also decline to P_1^R and local consumption would go up from Q_0 to Q_1.

These frameworks indicate the possible different forces at play in rice markets during the COVID-19 pandemic in Myanmar and illustrate the heterogeneous effects on prices that can be found for paddy (at the producer level) and rice (at the consumer level), depending on the type and magnitude of shifts in supply or demand. Multiple forces act upon supply and demand at the same time, so the impact of COVID-19 is ultimately an empirical question. Moreover, these models are simplified frameworks. More complete models should take into consideration time lags in supply and demand, risk, price expectations, changing market power, and quality and spatial factors (see, e.g., Wohlgenant 2001; Gardner and Rausser 2001; McCorriston 2002). However, the simple models in Figure 2 show how the COVID-19 pandemic may affect prices.

Empirical methods

To evaluate the impact of the COVID-19 crisis and associated policy responses on rice product prices and miller margins, we use a difference-in-difference (DiD) econometric specification that compares the prices of the three main marketed rice outputs–head rice, broken rice, and rice bran–

to the input–paddy–both before and during the pandemic. By framing the price changes of each output relative to paddy, we can determine if milling margins changed during the crisis. We make these DiD comparisons using the following fixed effect model:

$$p_{ijt} = M_i + \beta_1 Post_t + \beta_2 HeadRice_j + \beta_3\left(Post_t * HeadRice_j\right) + \beta_4 BrokenRice_j + \beta_5\left(Post_t * BrokenRice_j\right) + \beta_6 Bran_j + \beta_7\left(Post_t * Bran_j\right) + \beta_5\left(Post_t * BrokenRice_j\right) + \beta_8 PctBroken_{ijt} + \varepsilon_{ijt} \quad (1)$$

where p_{ijt} is the dependent price variable for mill i at time t with j indexing the type of rice product–either paddy, milled rice, bran, or broken rice. M_i is the mill fixed effect which captures all time invariant characteristics for each mill. There are three indicators for each main product produced by milling processes: $HeadRice_j$ for milled rice, $BrokenRice_j$ for broken rice, and $Bran_j$ for rice bran. $Post_t$ is an indicator variable equal to one if the price observation is after the COVID-19 policies had been put in place in Myanmar. $PctBroken_{ijt}$ is the percentage of broken rice in head rice sold, which is an important determinant of the milled rice price, but is not relevant to paddy, broken rice, or bran and, therefore, takes a value of zero for those prices.

There are several estimators of interest. β_1 will capture the change over time in prices that millers paid for paddy. β_2 will show the average rice margin–the price that millers receive for their milled rice minus what they paid for paddy–before the pandemic. Similarly, β_4 and β_6 will show the price differences before the pandemic between paddy and broken rice and bran, respectively. The change in milled rice margins after the pandemic is shown by β_3. If β_3 is positive (negative), then the change in milled rice prices was greater (less) than the change in paddy prices. β_5 and β_7 will show the same relationship but for broken rice and bran prices relative to the change in paddy prices. Lastly, β_8 will show the relationship of the percentage of broken rice to milled rice prices.

The mill fixed effects control for important determinants of prices that do not vary over time, including mill location, that is, the proximity to paddy production zones and to rice sales locations; machinery and equipment used to mill rice, which determine rice quality and production efficiency; and management skill and education. Our price data also hold the variety of rice fixed across type j and time t at the mill level. Thus, the fixed effects also control for varietal differences in prices. While controlling for these effects produces better average estimates of the effects of COVID-19 on millers, there may be important differences in the observed changes in prices across some of these parameters. To evaluate some of these impacts, we first estimate equation (1) as a simple DiD model without mill fixed effects but with important covariates. Then, to take the analysis further, we estimate the mill fixed effects DiD model for different subsets of our mill sample defined across important covariates, such as rice variety and mills with modern or traditional machinery.

4. DATA

To learn about the effects of COVID-19 on Myanmar's rice processing, we conducted interviews with rice millers starting in July 2020 and continuing monthly through November. Due to the unnecessary risks of COVID-19 transmission through face-to-face interviews and the transportation restrictions that limited mobility, the interviews were conducted via telephone. A sample of 657 rice mills was randomly selected from a listing of 1,025 medium- and large-scale rice mills–defined by a milling capacity of 15 tons per day or higher–provided by the Ministry of Commerce and the Myanmar Rice Federation[7]. The sample covers six townships in three regions–Ayeyarwady, Bago, and Yangon–which collectively account for 45 percent of the monsoon rice produced in Myanmar.

[7] The sample was first used for an in-person study conducted by the International Growth Centre (IGC) in collaboration with the Ministry of Commerce (MOC) in 2019.

The phone surveys were designed as a panel across five monthly interview rounds. Each of the 657 sampled mills was called each round. However, the number of interviews fluctuated across rounds due to mill closures, unavailable or unreachable phone numbers, and interview refusals. The number of completed interviews for each of the five rounds varied between 371 and 447.

The primary objective of the phone surveys was to understand how rice millers had been impacted by the COVID-19 crisis. Each questionnaire had two parts. The first was a set of fixed questions common across surveys. These questions concerned COVID-19 disruptions to business activities, e.g., transportation restrictions affecting paddy purchases or rice sales; business responses to those disruptions, e.g., adoption of safety measures or hiring fewer employees; and prices of paddy, rice, and byproducts–rice bran, broken rice, and rice husks–for each mill's highest volume variety. The second part of each questionnaire was more dynamic and included detailed questions on important topics that emerged during the pandemic, such as on credit and finance.

In the third round of interviews, conducted in September, we also sought information on how prices of rice, paddy, and byproducts had changed during the pandemic. We asked millers to report current (2020) prices and the prices from one year prior (2019). We captured detailed price information only for the rice variety with the highest throughput in the 30 days prior to interview. Other relevant data collected for this study include detailed information on byproduct uses (collected in the October survey) and milling outputs and conversion rates of paddy into milled rice and byproducts (collected in the November survey).

5. RICE MILLING IN MYANMAR

We have a sample of 252 mills with detailed price data in September 2020 and recall to September 2019. The main monsoon rice paddy production region of Ayeyarwady has the most mills (146) followed by Bago (66) and townships around Yangon (40), the major urban center in Myanmar (Table 1). The average daily throughput of these mills was 27 metric tons. Daily throughputs were relatively stable over the course of the survey, suggesting that variations in total throughput–most often linked with seasonality in production–come from changes in the number of days that mills are operating rather than changes in production when operational. Most medium- and large-scale mills own important value-added machinery, including driers (63 percent) and whiteners (84 percent) (Table 1). Less than half of the sample owned a mist polisher (49 percent) or a color sorter (46 percent), two key machines in modern milling processes. However, 63 percent own at least one of these machines–we define these as "modern" mills. On average, the interviewed mills employ seven permanent and 16 temporary workers, who are overwhelmingly male. All mills buy paddy and sell milled rice, though 53 percent of mills also generate revenue by milling on commission by collecting a set fee per unit milled (typically defined by bags of milled rice output).

Table 1. Mill descriptives and variable definitions

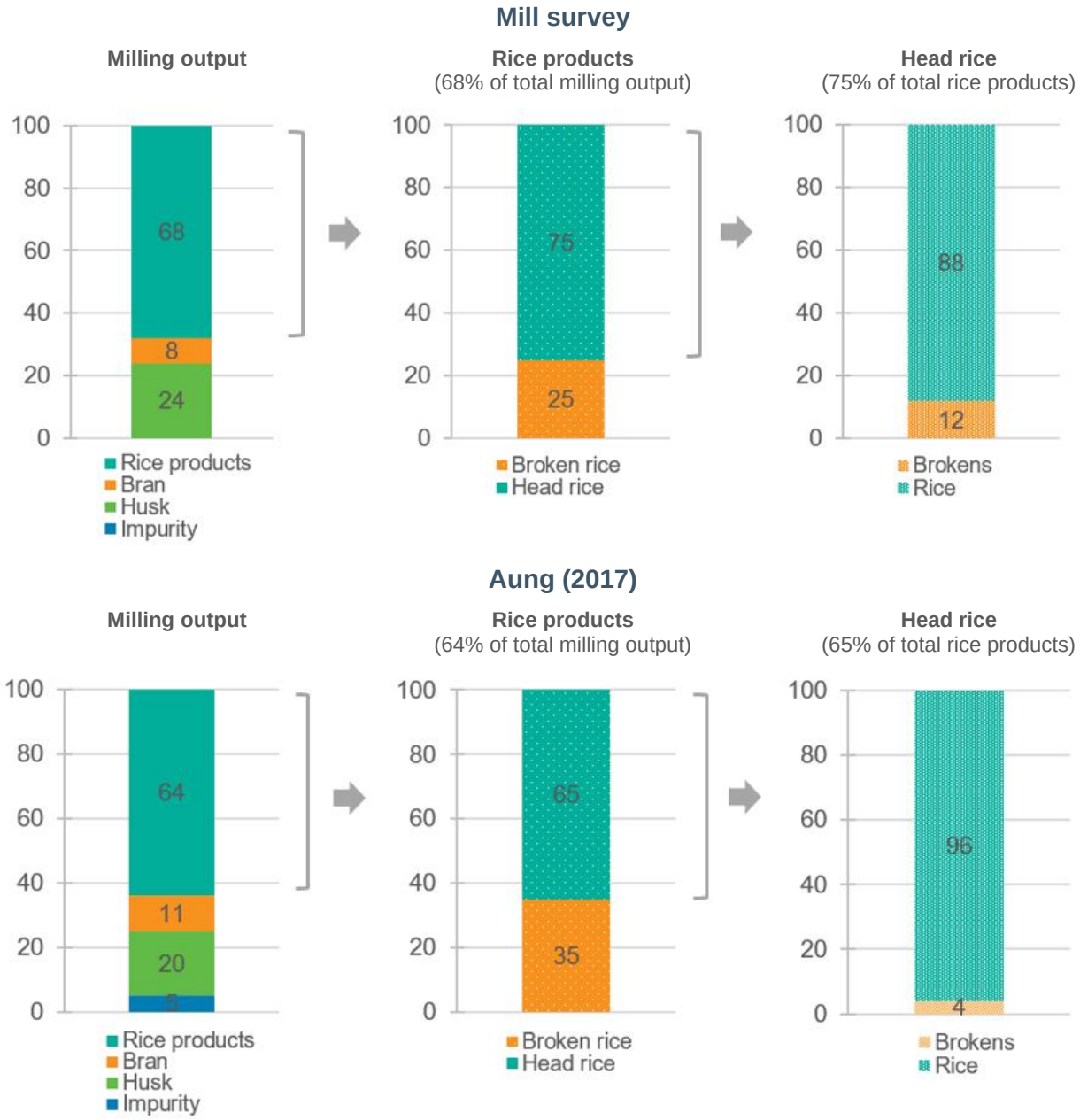
	# or % share	Definition
Price data sample (# of operating mills)	252	Operating mills were those milling paddy into rice in the 30 days prior to interview in September
Ayeyarwady	146	
Bago	66	
Yangon	40	
Average daily rice throughput (MT/day)	26.7	Average daily milled rice throughput in the days that mills operated in August
Machinery (share of mills that own, %)		
Drier	63	Share of mills that own a drier
Mist polisher	49	Share of mills that own a mist polisher
Color sorter	46	Share of mills that own a color sorter
Bucket lift	89	Share of mills that own a bucket lift
Whitener	84	Share of mills that own whitener
Modern mill	63	Modern mills are those owning either a mist polisher or color sorter
Traditional mills	37	Traditional mills are not modern
Employees (mean #)		
Permanent - Male	6	Number of permanent male employees
Permanent - Female	1	Number of permanent female employees
Temporary - Male	15	Number of male temporary or casual workers hired by the mill in the week prior to interview
Temporary - Female	1	Number of female temporary or casual workers hired by the mill in the week prior to interview
Processing on commission (%)	53	Share of mills that processed paddy on commission, as a service for traders or households

Source: Mill survey

To produce milled rice from paddy, millers feed paddy through several machines to remove undesirable portions of the paddy, which make the rice not only ready for human consumption but also more refined and attractive. The milling process inevitably produces several byproducts which themselves are often marketable, though not for direct human consumption.

In the November round of phone interviews, we asked millers how much of each product they typically produce from milling 100 baskets of paddy. Figure 3 gives an overview of the products produced during the milling process and compares data collected from our phone surveys with benchmark estimates from Myanmar in Aung (2017). According to our phone surveys, about 24 percent of the paddy weight is lost when husks are removed in the first milling stage. A further 8 percent is removed as rice bran. Rice products (head rice and broken rice) account for 68 percent of the original paddy weight. Head rice is the final product sold to consumers. Broken rice is the recovered broken rice grain, which is sold as a byproduct. Head rice also contains some share of broken rice, typically between 5 and 25 percent depending on quality and the targeted market. Exact conversion ratios from paddy to rice might differ depending on rice varieties, quality of the mill, and preferences by consumers (Aung 2017). Consequently, there are several differences in our data relative to those of Aung (2017).

Figure 3. Breakdown of rice milling outputs, comparison between mill phone survey results and Aung (2017) estimates



Sources: Aung, 2017; Mill survey

First, our sample of mills achieves higher yields of rice products and of head rice, though our estimates are still in line with conversion rates observed in other major rice producing countries (World Bank 2004a). The mills in our study also recover a higher share of husks, though our estimates may contain impurities which were not separately captured in our survey, but are noted in Aung (2017). Furthermore, the mills in our study recover lower rates of rice bran and broken rice. The latter is due to a higher share of broken rice passed through into head rice–12 percent on average for our sample, but only 4 percent in Aung (2017). The amount of broken rice in head rice varies by rice variety and intended market. The two main varieties in our data are Pawsan varieties, which typically have 5 to 10 percent broken rice in head rice, and Emata varieties, which typically have 10 to 20 percent broken rice.

With nearly a 50/50 split between marketable head rice and byproducts produced by the milling processes, recovering and selling byproducts is essential to mill's bottom lines–71 percent of mills

reported that byproduct sales were “very important” to their business. To better understand the importance of rice byproducts and how they are used in Myanmar, we asked millers whether they sold each byproduct and what the end uses were in 2019. The various uses for each product are presented in Table 2.

Table 2. Milled rice byproduct uses in 2019, percent of mills reporting

	Bran (%)	Broken rice (%)	Husks (%)
Mills selling	91	92	10
Conditional share selling to different uses			
Fish feed	99	15	0
Livestock feed	96	92	18
Fertilizer	9	0	28
Animal bedding	0	0	24
Fuel - parboiling	9	14	51
Fuel - other	8	14	71
Noodle making	5	61	9

Source: Mill survey

Nearly every mill sells bran and broken rice–91 and 92 percent, respectively. However, only 10 percent sell husks. Both bran and broken rice are most commonly sold as feed. Bran almost exclusively goes to fish and livestock feed, with other uses being reported by fewer than 10 percent of millers. Broken rice is mostly used to feed livestock, and much less so for fish. There is an important quality distinction within broken rice. Larger, more complete pieces of broken grain are typically sold for further processing into human foods–61 percent of mills reported selling broken rice for noodle production. Rice husks have a much smaller market than bran and broken rice and are used mostly as a low-cost fuel source. Yet, they have other non-market uses. Resourceful mills will also burn their own rice husks to operate driers or compost the husks for use as a fertilizer.

6. COVID-19 IMPACTS ON RICE MILLING

We begin our analysis by exploring the COVID-19 impacts reported by millers, which provide an overview of how mills perceive COVID-19 to have affected their businesses. We then move on to detailed explorations of the price effects of the crisis.

Reported impacts

Mills reported large business disruptions due to COVID-19 and corresponding policy responses implemented to mitigate its tremendous health burden. In the August survey round, 44 percent of the millers interviewed reported disruptions to buying paddy caused by transportation restrictions. However, the downstream effects in selling rice were less pronounced as only 26 percent reported disruptions (Table 3). This likely reflects the highly localized implementation of transportation restrictions in Myanmar as millers had a more difficult time with transport in the upstream sections of the rice supply chains, i.e., in connections to farms in rural, rice production regions, than they did in the downstream sections, i.e., to commodity exchange centers and wholesale markets in urban areas.

Table 3. Share of rice mills reporting operations changes and disruptions due to COVID-19

Share of mills reporting operations changes, August 2020 compared with August 2019 (%)				
	Decrease	Same	Increase	Mean change
Rice throughput	51	46	3	-18
Demand for credit from farmers	1	86	13	4
Expected annual revenue	79	17	4	-28
Share of mills reporting business disruptions in August 2020 (%)				
Transport restrictions in selling rice	26			
Transport restrictions in buying paddy	44			
Applied for COVID-19 relief loan	38			
Reduced the number of employees	38			
Reduced mill operating days	46			
Closed for at least one week	19			

Source: Mill survey

Millers also stated that they experienced disruptions to business operating days; 19 percent closed for at least one week and 46 percent otherwise reduced operations. Reduced activity led to a reduction in employed staff for 38 percent of millers. Twenty-three mills were completely closed due to COVID-19 in the 30 days prior to the August interviews.

The net effects of these challenges appear to be lower rice throughput and decreased revenues. Only 3 percent of mills reported higher daily rice throughput in August 2020 compared to 2019, while 51 percent reported a year-on-year decline. Overall, 79 percent of millers expected their total annual revenue in 2020 to be lower than in 2019, with an average expected change of a 28 percent decline. Only 4 percent of millers expected their revenues to increase. There were also increases in demand for credit, both by mills–38 percent of millers applied for a government COVID-19 relief loan in August, the first month that loans were made available to agribusinesses–and by farmers–13 percent of mills reported an increased demand for credit provision.

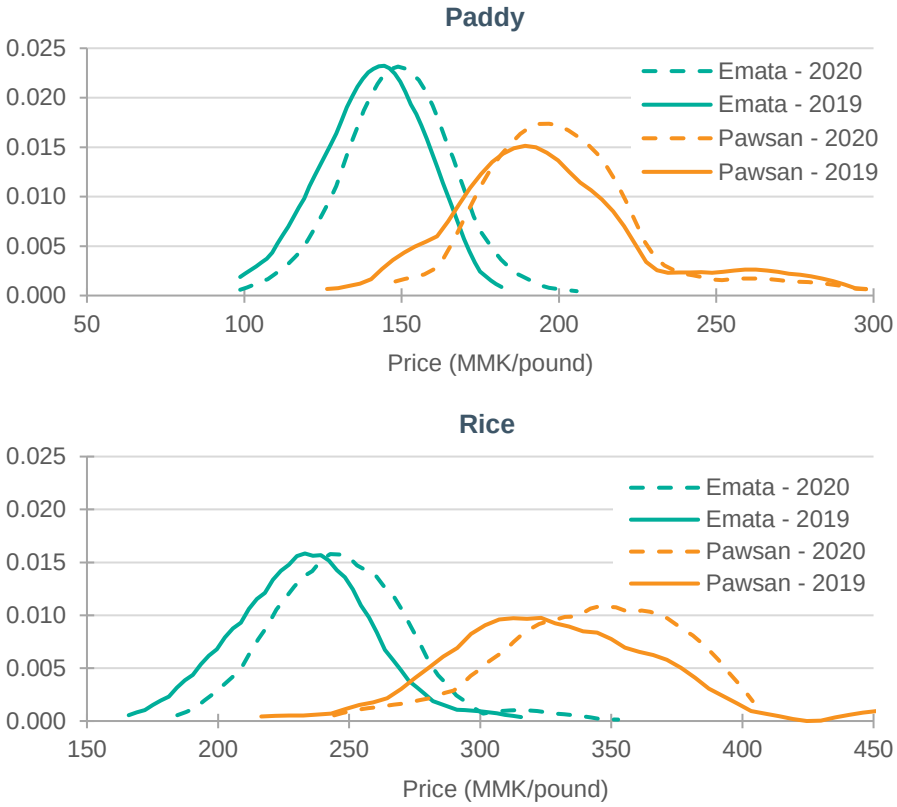
Impacts on prices and margins

Graphical analysis

To explore the impacts of COVID-19 on prices, we begin with simple kernel density estimations of prices in 2019 and 2020 for the two most common varieties in our data, Emata and Pawsan (Figure 4). There are five main takeaways.

- There was considerable variation in both paddy and rice prices, indicating important sources of price variability to explore further.
- Rice prices were generally higher in 2020 compared to 2019. The price increases appear to pass through to paddy prices, which were also higher.
- Varietal differences matter tremendously. Pawsan receives significantly higher prices than Emata.
- Pawsan price distributions show greater variance than the Emata price distributions. With no export market as an anchor point for Pawsan, the prices for this domestic market variety are subject to greater fluctuations (World Bank 2014b).
- Despite the differences in price levels, the distributions and changes across years are largely similar for both Pawsan and Emata. Thus, although prices have increased during the COVID-19 pandemic, there is no noticeable increase in price variations at the mill level.

Figure 4. Paddy (top) and rice (bottom) price distributions for Pawsan and Emata varieties, 2020 and 2019 (MMK per pound)



Note: Kernel density estimations.
Source: Mill survey

To provide a more complete picture of COVID-19's impact on rice mills, we calculate gross milling margins for 2020 and 2019 and compare the changes for Emata and Pawsan varieties. Gross milling margins are calculated to account for the values of paddy input, rice output, and each marketed byproduct using the following equation:

$$Margin_{ijt} = \left(P_{ijt}^{rice} * \overline{C_j^{rice}}\right) + \left(P_{ijt}^{broken} * \overline{C_j^{broken}}\right) + \left(P_{ijt}^{bran} * \overline{C_j^{bran}}\right) + \left(P_{ijt}^{husk} * \overline{C_j^{husk}}\right) - \left(P_{ijt}^{paddy} * 4600\right) \quad (2)$$

with the margin for mill *i*, variety *j,* and year *t.* Each price (*P*) is from reported data at the mill level and is set to zero for mills that did not sell. Each conversion rate (*C*) represents the average amount of each product produced from 100 baskets of paddy at the variety level[8]. We assume the same conversion rates between 2019 and 2020. Milling equipment is typically used for many years without much decline in efficiency, and mills were presumably less likely to have invested in new equipment during the pandemic. The value of paddy input is the mill-variety-year price multiplied by 100 baskets, which we assume to have a dry input weight of 46 pounds–the official Myanmar conversion rate.

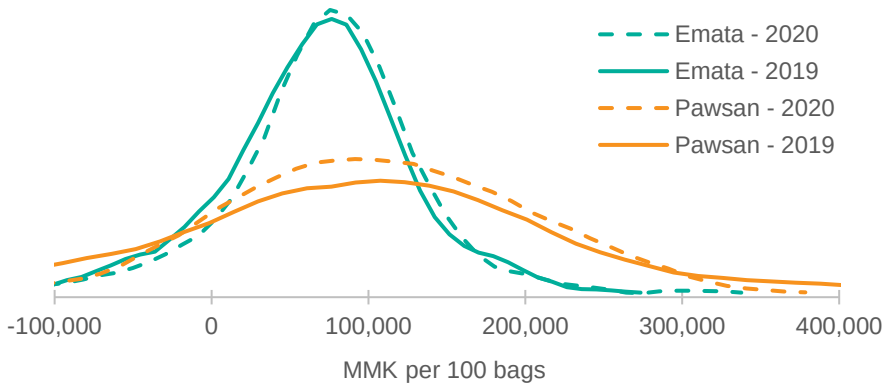
We found three key results in our analysis of gross milling margins (Figure 5).

- Gross margins for both Emata and Pawsan are higher in 2020 than 2019. This suggests that on a per-unit-milled basis at the mill-level, challenges presented by the COVID-19 crisis have not had substantial negative effects on milling margins.

[8] We use the average conversion rates for two reasons. First, the conversion rate data were collected in a different survey round (November) than our price data (September) and the samples do not align perfectly. Second, there were several unrealistic responses that suggested some millers did not understand the question properly or that there was an error in conversion rates among units during data collection.

- Gross margins for Pawsan shows a much wider variance than Emata. The wider paddy and rice price variations for Pawsan pass through to total margins, while byproduct sales do little to reduce and may increase variance.
- Margins for the more expensive Pawsan variety are higher, as noted in other settings for higher quality rice (Minten et al. 2013).

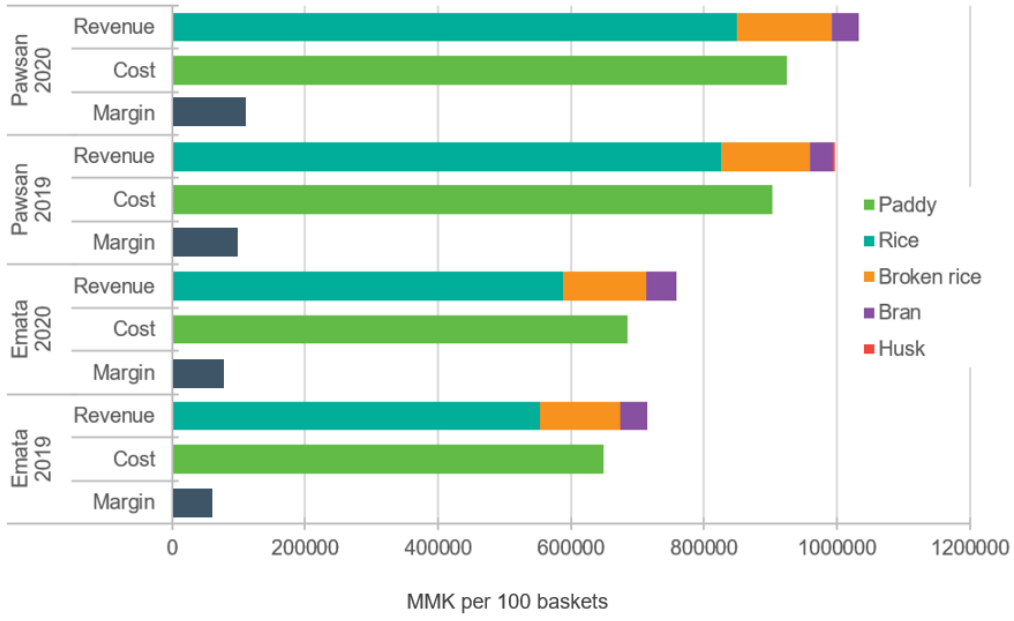
Figure 5. Gross milling margins for Emata and Pawsan varieties, 2020 and 2019 (MMK per 100 bags)



Kernel density plots. Source: Mill survey

Figure 6 presents the average output revenues and paddy costs for Emata and Pawsan by year. The importance of byproduct sales is immediately evident. The revenue from rice sales alone is less than the paddy cost in each case. Thus, without the ability to market byproducts, milling paddy-to-rice margins would need to increase, putting downward pressure on paddy prices paid to farmers and upward pressure on milled rice prices to consumers.

Figure 6. Average milling paddy costs, revenues, and margins in MMK per 100 baskets of paddy, Pawsan and Emata varieties for 2020 and 2019



Source: Mill survey

After rice, broken rice is the main contributor to margins. Pawsan revenues from broken rice are slightly higher than those for Emata. This is not because prices are higher–they are statistically

similar. Rather, it is because more broken rice is recovered from Pawsan varieties as the final consumer head rice is sold with a lower percentage of broken rice in it than is the case for Emata varieties. Bran is the third leading contributor to milling margins, but with total values of about one-third of broken rice for Emata and one-quarter of broken rice for Pawsan. The value of husks is negligible.

Confirming the results in Figure 5, milling margins increased in 2020 from 2019 for both varieties. Pawsan margins were higher than those for Emata by about 45 percent.

Multivariate regression analysis

While the graphs give an idea of overall changes in prices and margins, we explore further variations using the regression framework presented in Section 3. To begin, we present three specifications in Table 4: (1) a simple pooled model without variety and regional controls; (2) a pooled model including variety and regional controls; and (3) a mill fixed effect model. Prices are expressed in MMK per pound.

Table 4. Impact of COVID-19 on prices and margins of medium- and large-scale rice mills in Myanmar, MMK per pound

Dependent variable: Price (MMK per pound)	(1) Simple pooled model	(2) Pooled model with variety and regional controls	(3) Mill fixed effect model
Constant (paddy, 2019)	150.619***	158.929***	150.185***
	(2.156)	(4.918)	(1.692)
Post (paddy, 2020)	7.343**	7.219***	7.335***
	(2.946)	(2.182)	(1.154)
Head rice	134.295***	128.525***	130.499***
	(5.657)	(4.557)	(5.475)
Post x Head rice	5.415	5.421	5.517***
	(4.857)	(3.864)	(1.496)
Broken rice	10.241***	10.336***	10.993***
	(2.620)	(2.311)	(2.490)
Post x Broken rice	2.227	2.182	1.968
	(3.609)	(3.183)	(1.380)
Bran	-37.119***	-37.660***	-36.494***
	(3.103)	(2.945)	(3.470)
Post x Bran	9.158**	9.252**	9.097***
	(4.449)	(4.238)	(1.751)
pctBroken	-3.551***	-2.949***	-3.111***
	(0.382)	(0.304)	(0.519)
Bago Region		-5.360***	
		(1.692)	
Yangon Region		(2.942)	
		(2.505)	
Pawsan variety		17.671***	
		(5.182)	
Emata variety		-11.834**	
		(4.711)	
Mill fixed effects	No	No	Yes
Observations	1713	1713	1713
R-squared	0.692	0.778	0.803

Note: Heteroskedasticity robust standard errors in parentheses. Constant in mill fixed effect model represents the average of the fixed effects; * p<0.10, ** p<0.05, *** p<0.01.
Source: Mill survey

The constant is the average of fixed effects and reflects the average paddy price in 2019, which is estimated to be 151 MMK per pound in specification 1. The post coefficient reveals change in paddy prices in 2020 and shows a significant increase of about 7 MMK per pound paid to farmers. In the base period, rice prices were 89 percent higher than paddy prices, as shown by the positive estimate of the head rice dummy of 134 MMK per pound. Any increases in rice prices during the pandemic were passed through to producers in the form of higher paddy prices. The paddy-to-rice margins did not significantly change during the COVID-19 crisis in specifications 1 and 2–measured by the interaction of the *head rice* and *post* dummy. However, the result is significant in specification 3, though its contribution is small to overall rice prices (just 2 percent of the 2020 rice price). Thus, paddy-to-rice margins show modest, if any, changes linked to COVID-19.

Table 4 also shows interesting effects on byproduct prices. Intuitively, head rice is the most valuable product from rice milling and receives the highest price per pound of all the outputs, demonstrated by the head rice coefficient being much greater than those for broken rice and bran. Moreover, the differences between paddy and broken rice were not significantly affected by the COVID-19 pandemic. The broken rice price also increased to a similar extent as the main head rice product and both results are insignificant. The small and insignificant price changes for broken rice relative to paddy indicate that demand from the noodle making and livestock feed sectors–the two major markets for broken rice (Table 2)–were not significantly disrupted by the COVID-19 pandemic. However, there are larger effects for bran prices. Bran receives a much lower price per pound than the other products, and even significantly lower than paddy. Yet, the bran prices significantly increased by 9 MMK per pound more than paddy prices during the pandemic. This suggests some substantial demand changes from fish farms, the main market for bran, along with livestock feed (Table 2). Conversations with industry experts suggest that there may have been feed substitution effects driving the demand increase. Fish farmers may have increased the share of low-cost bran in their feeding programs, substituting away from higher priced pellets and mixed feeds, many of which are imported. The price increases for byproducts relative to paddy might have helped mills to keep changes in processing margins low and allow them to pay higher prices to farmers for their paddy during the COVID-19 pandemic.

The regressions reveal further insights on Myanmar's rice market. The share of brokenness in the head rice leads to significantly lower prices, as has been shown in numerous other settings (World Bank 2014a; Minten et al. 2014). A one percent increase in brokenness reduces the price of head rice by approximate 3 MMK by pound. We also see that the Pawsan variety commands a significant premium over Emata rice, ceteris paribus. Pawsan varieties receive a price 30 MMK per pound of paddy greater than Emata varieties and about 18 MMK greater than those of other rice varieties (the default in the regression) that do not fall under the Pawsan or Emata classification, the most common of which is the Ngasein variety.

To explore these varietal effects further, we estimate the preferred mill fixed-effect model separately for Pawsan and Emata varieties in models (1) and (2) of Table 5. The differences in marketing channels for these two important varieties underscore some interesting differences in estimated effects. First, comparing coefficients in a fixed-effects model again shows paddy prices for Pawsan to be 43 percent higher on average than Emata in 2019. Interestingly, Emata paddy prices increased significantly during COVID-19. Rice prices increased further as the paddy-to-rice margin estimates increased significantly. To frame it differently, more than 50 percent of the head rice price increase for Emata was passed on to farmers. The price increase of Emata seems linked with international market developments, as international rice prices grew over the period studied – the Food and Agriculture Organization rice price index was 108.6 in November 2020 compared with 102.5 in November 2019. For Pawsan, the estimated changes in both paddy-to-rice margins and paddy prices paid to farmers were not statistically different from zero. One possible reason that

Pawsan did not enjoy similar price increases as Emata is a decline in purchasing power from lower incomes in the local market (Headey et al. 2020; World Bank 2020c). Local consumers may have substituted away from the higher-priced Pawsan rice varieties, offsetting any potential price increasing factors.

Table 5. Impact of COVID-19 on prices and margins of medium- and large-scale rice mills in Myanmar, split sample estimations by rice variety and mill technology

	Rice variety		Modern/Traditional mills	
Dependent variable: Price (MMK per pound)	(1) Emata	(2) Pawsan	(3) Modern	(4) Traditional
Constant (paddy, 2019)	139.590***	199.798***	153.491***	144.568***
	(1.291)	(5.989)	(2.402)	(2.190)
Post (paddy, 2020)	8.327***	3.693	7.154***	7.585***
	(1.217)	(3.997)	(1.534)	(1.755)
Head rice	108.488***	147.810***	132.974***	123.439***
	(3.797)	(8.387)	(6.839)	(9.429)
Post x Head rice	6.392***	6.098	5.560***	5.590**
	(1.306)	(4.534)	(1.928)	(2.423)
Broken rice	21.411***	-40.095***	8.870***	14.589***
	(1.996)	(6.886)	(3.293)	(3.819)
Post x Broken rice	0.637	7.680*	1.311	3.216
	(1.545)	(3.990)	(1.777)	(2.222)
Bran	-24.173***	-99.246***	-38.105***	-33.754***
	(2.919)	(10.148)	(4.728)	(4.949)
Post x Bran	7.215***	16.446***	10.941***	5.973*
	(1.854)	(4.570)	(2.033)	(3.255)
pctBroken	-1.484***	-2.582***	-3.458***	-2.329***
	(0.317)	(0.955)	(0.695)	(0.816)
Mill fixed effects	Yes	Yes	Yes	Yes
Observations	1,407	306	1,143	673
R-squared	0.813	0.908	0.773	0.785

Note: Mill fixed effects in each regression. Constant represents the average of the fixed effects. * p<.1, ** p<.05, *** p<.01
Source: Mill survey

For byproducts, varietal differences are much less important. Although the coefficients for broken rice and bran as well as their interactions with post are much different, these reflect levels and changes relative to paddy. Broken rice in both varieties sold at around 160 MMK per pound in 2019. For bran, the 2019 price estimates were 115 MMK per pound of Emata and 101 MMK per pound of Pawsan. The changes in both broken rice and bran prices were similar across varieties. Again, the coefficients show differences; both byproducts show larger and significant changes for Pawsan, but these are relative to paddy prices, which did not change for Pawsan but did for Emata. Emata broken rice prices rose by 9 MMK per pound in 2020 and bran prices rose by 16 MMK. For Pawsan, the changes were 11 MMK and 20 MMK per pound, respectively. These byproduct results have two important implications. First, byproduct prices played an important role in millers' financial viability during the pandemic, particularly for Pawsan, which did not show paddy-to-rice margin increases. Second, byproduct prices are affected by the differentiated output markets for Emata and Pawsan that drive differences in paddy and rice prices.

Models (3) and (4) in Table 5 compare modern and traditional mills with separate fixed-effects estimations. Modern mills can achieve higher rice quality, controlling for variety, through use of polishers and color sorters, which translates to margins of about 10 MMK per pound higher than traditional mills. A substantial portion–about 50 percent–of the higher prices modern mills receive for head rice is passed through to farmers in higher paddy prices. In terms of price changes during the

pandemic, both modern and traditional mills show similar patterns. The exception is in bran prices, for which modern mills enjoyed a greater price increase above paddy price changes than did traditional mills.

Linking these results to the model scenarios presented in Section 3 (Figure 2), we find that food exports continued in an important way during the pandemic and that global rice price increases have contributed to price increases during COVID-19 for Myanmar's exported rice variety, Emata. We also note that changes in paddy-to-rice marketing margins have been small and, in the case of the locally traded Pawsan variety, insignificant. Margin changes have not been a major explanation for price changes in the paddy and rice markets. In the case that rice prices went up, these changes were largely transmitted to farmers through higher paddy prices. Local demand changes also had an apparent effect. The more expensive, locally preferred rice has seen insignificant paddy and rice changes relative to 2019, which are likely linked to the significant increase in poverty rates caused by the pandemic (Headey et al. 2020; World Bank 2020a, 2020c).

7. CONCLUSION

The pandemic has led to substantial disruptions to agri-food systems around the world. In this paper, we explore disruptions to Myanmar's agri-food system, focusing on changes in prices and processing margins for rice mills during the crisis using data collected from rice mills through phone interviews. Rice mills play crucial roles in rice value chains, though their exact functions are often not well understood. Other research suggests that mill profitability in Myanmar has been seriously affected by the pandemic, jeopardizing their roles in the value chain (World Bank 2020a).

We find that Myanmar's rice mills were not exempt from the general COVID-19 disruptions experienced in the country – mills experienced lower overall throughput, employee lay-offs, and less credit availability at the mill level. Yet, despite these challenges, the processing sector has been surprisingly resilient and milling margins have been relatively little affected. In the case that there were margin increases, they were relatively small and did not contribute in an important way to consumer price changes and were mostly passed through to farmers as higher prices for their paddy. For the Emata rice variety linked to export markets, we find that international price increases were met with local price increases. There were no significant price increases for the locally preferred and more expensive Pawsan rice variety, which may have experienced a drop in demand. We also find that modern mills were able to achieve higher rice prices – a large share of which was passed through to farmers as higher prices for their paddy. Lastly, our results further underscore the overall importance of byproducts to rice millers. Stability in byproduct markets helped millers' bottom lines and further contributed to their ability to pass any rice price changes on to producers.

The research points to several important implications for policy and future research:

- It was feared that international trade disruptions due to the COVID-19 pandemic–as were seen in the food crisis of 2008 (Torero 2020)–may exacerbate global food security problems. These trade restrictions have seemingly been less than expected, which has contributed to stable exports for Myanmar and stable prices for consumers and producers. This suggests the importance of international trade during such global shocks.
- Updated representative information–especially in times of shocks–on important sectors such as the rice sector is often hard to come by. Monitoring of crucial nodes in value chains through high-frequency inexpensive telephone interviews has allowed for efficient, innovative, and timely surveillance, which shed light on a large sector of Myanmar's economy that has widespread links to producers and consumers. Similar survey set-ups should be pursued in other sectors and countries.

- Modernization of mills is associated with higher prices for farmers and should therefore be encouraged. This can be prompted through further relaxation of restrictions on investments in agro-processing and on international trade in the sector.

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