プロジェクト報告

The Asian Green Revolution at a crossroads due to increasing labor shortage: the case of rice farming in the Philippines[1)]

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1. Introduction

Rapid growth in the industrial and service sectors has triggered many Asian countries' economic "take-offs." This has accelerated the economic migration of laborers from rural areas to cities and industrial zones. Consequently, the Green Revolution, led by a combination of seed-fertilizer technology and labor-intensive crop care, is facing challenges due to increasing rural labor shortage (Viswanathan et al., 2013; Briones and Felipe, 2013). Thus, for economically sustainable farming under such circumstances, a structural change toward labor-saving farming—that is, simultaneous mechanization and farm size enlargement in the agricultural sector—is needed. As Timmer (1988) has argued in his landmark article, such structural change is unavoidable in the course of economic development, and thus, unless it proceeds smoothly, economic growth could be hampered, possibly resulting in the so-called middle income trap.

However, the detailed process of such change and, consequently, strategies to ensure it are not yet well understood. In fact, the reality tells us that it is difficult to

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find the cases of successful agricultural transformation, to draw lessons. An example of failure is Japan's high-cost rice farming, unsuccessful partly due to the difficulty in farm enlargement[2]. Podhisita (2017) has pointed out problems related to such enlargement and mechanization in Thailand. Meanwhile, Huang et al. (2015) have shown that changes toward mechanization and farm enlargement have stared in China following introduction of new institutional arrangements by the government.

For a better understanding of the agrarian structural change under increasing labor shortage, we have to examine the labor and farm land markets and mechanization—all three are related to each other and equally important. The purpose of this paper is to present descriptive statistics on the changing nature of rice farming with particular focus on labor market and land market outcomes and mechanization under increasing labor shortage. To this end, long-term farm household panel data from the Philippines, a country experiencing increasing labor shortage, has been used.

2. Study site and data

The Philippines, cynically labeled "sick man of Asia," has been experiencing economic growth since the early 2000s. The average annual GDP growth rate, which was 4.5% between 2000 and 2009, rose to 6.4% in the 2010–2019 period, led by the growth of the service and manufacturing sectors (World Bank, 2020). Accordingly, rural laborers have been moving from the agricultural to the industrial and service sectors, leading to increasing agricultural labor scarcity.

The data set used for this study is the Central Luzon Loop Survey (hereafter, the Loop Survey). The use of "loop" in the name stems from the survey's sampling feature: selection of sample farm fields along the loop of the national highway passing through six provinces (Figure 1). Randomization of the sample was achieved by specifying the fields to be observed at specific kilometer posts along the main highway (e.g., the 50th, 60th, 70th, etc.). The survey was initiated in 1966 by the International Rice Research Institute and conducted every four to five years,

2) Takahashi (2012) investigated the obstacles underlying the structural transformation in Japan.

completing 13 rounds by 2015–16. The most important feature of the data is that these were collected from the same fields despite their operators changing. Hence, this data set provides long-term plot-level panel data. A comprehensive documentation of the Loop Survey from 1966 (1st round) to 2012 (12th round) can be found in the work by Moya et al. (2015).

The following are the study site's agroecological features. The area is known as the rice bowl of the country, having a distinct wet season (hereafter, WS) and dry season (hereafter, DS) —the WS begins in May or June and ends in October, and the DS begins in November and ends in March or April. The introduction of irrigation systems and adoption of low-lift pumps and shallow tube wells have made DS rice farming possible[3]. In the latest survey round (2015–16), 85 sample farmers cultivated rice in the WS, and 50 of them cultivated it in the DS as well by employing irrigation techniques. In the WS, crop losses are common because of flooding, typhoons, and insect and disease outbreaks, while the DS includes periods characterized by a lack of water because of drought.

The following are the study site's socioeconomic features of 2015–16. The average household size was 4.7 persons, with 3.1 of working age (14–65) and 2.3 female, and the average farm size was 2.2 ha (median being 1.6 ha). The average age and schooling years of the household head were 57.1 and 9.4 years respectively. Similar to other Southeast Asian countries, hiring laborers for rice farming was common—the total person days for WS rice cultivation per ha were 47, out of which hired labor accounted for 87%, while these figures for the DS were 41 and 92% respectively.

3. Changes in rice farming

Table 1 shows the adoption of labor-saving technologies and the area planted with

3) The completion of the Pantabangan Dam in 1975 and the establishment of the Upper Pampanga Integrated Irrigation System represented the first major irrigation project in the region. The Casecnan Irrigation and Hydroelectric Plant, which commenced in 2002, diverts water from the Casecnan and Taan rivers of Nueva Vizcaya to the Pantabangan Reservoir through a 25-km long tunnel in the Nueva Ecija province—this has further enhanced the expansion of irrigated area in the region. In the last two decades, the adoption of low-lift pumps and shallow tube wells has been the major source of irrigation expansion, particularly in the dry season.

rice from 1966 to 2016, revealing four features. First, small-scale mechanization proceeded rapidly after the Green Revolution and was completed in the early 1990s. The adoption rate of the power tiller (hand tractor) and small thresher reached almost 100% in the early 1990s; the latter's dropped to 45% in the 2015 WS and to 54% in the 2016 DS because of the adoption of the combine harvester in those years.

Second, the adoption of the combine harvester has just begun—the government promoted it as a replacement for manual harvesting, and its utilization increased from 0% to about 40% from 2011 to 2016; however, it is not the dominant equipment yet, and hence, harvesting still largely depends on manual work.

Third, crop establishment also relies on manual laborers—it can be done either through transplanting or direct seeding, with the latter—broadcasting seeds directly on a field—being a labor-saving method introduced in this area in the 1980s; it is, however, appropriate only for plots with suitable water control because otherwise the germination of seeds cannot be synchronized. Hence, as shown in Table 1, the boom in direct seeding's adoption during the introduction period notwithstanding, it is no longer widely used, particularly in the WS (only 10% in the 2015 WS) when water control is more difficult. At the same time, the transplanting machine has not been used either, as a substitute for manual transplanting in the study site, at least until the latest survey round. Thus, crop establishment continues to be a labor-intensive activity.

Fourth, the area planted with rice has remained almost unchanged at slightly more than 1 ha in the WS and slightly less than 1.5 ha in the DS, implying inactive land sales or rental market.

Hence, in summary, mechanization is still limited to a few activities (i.e., land preparation and threshing), and enlargement of the cultivated area has not yet been realized at the study site. In other words, agricultural transformation has reached only the halfway mark.

What is the impact of these features on rice farming performance? Figure 2, which shows paddy yield's long-term trend (kg/ha) in Panel A and its coefficient of variation in Panel B, indicates a stagnant yield growth since the late 1900s (in particular, in the WS) and increasing variations in the 2010s. Note that the adoption of hybrid rice varieties, which have a potential yield of about 10–14 t/ha compared with latest inbred varieties' 6–10 t/ha, has continued since 2011, and 11% of farmers in the WS and 37% in the DS cultivated the hybrid varieties in 2015–16. However, the actual yield did not increase in 2015–16. Taken together with the increasing coefficient of variation, the recent trend indicates that the potential yield has not been realized, fully or stably, in the fields.

4. Concluding remarks

It is possible to point out two possible reasons for the yield stagnation and fluctuation. First, given the increasing labor shortage and limited progress in mechanization, rice farmers rely more on unfamiliar laborers from outside their villages, making labor management difficult. Second, many sources indicate that natural disasters such as floods and insect outbreaks have been increasing in the Philippines (Laborte et al., 2015). In addition, in Central Luzon, floods have become more severe due to newly constructed factories and roads hampering smooth flow of water to drains. Thus, natural and man-made disasters have hindered yield increase in the area. Future studies could investigate whether the increasing labor management difficulty, limited progress in mechanization, and unchanged farm size are relevant factors for yield stagnation even after controlling for the negative effects of disasters.

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Table 1 : Adoption of labor-saving technologies from 1966 to 2016 (%)

Wet Season	1966	1970	1974	1979	1982	1986	1990	1994	1999	2003	2008	2011	2015
Animal	96	90	98	72	67	90	89	75	74	56	59	52	63
Power tiller (2W)			17	47	56	58	85	93	96	99	99	100	99
Big Tractor (4W)	11	42	36	30	24	14	18	16	28	26	31	30	31
Rotavator							2		2			4	16
Manual Threshing	13	26	51	46	10	4							
Small thresher	0	0	5	21	73	96	100	100	100	100	100	100	55
Big thresher	87	74	44	31	17								
Combine harvester	0	0	0	0	0	0	0	0	0	0	0	0	45
Direct Seeding				1	16	15	22	24	21	14	7	8	10
Transplanting	100	100	100	100	90	95	85	81	80	87	94	92	90
Area plated to rice (ha.)	1.91	2.12	1.86	1.23	1.05	1.40	1.12	1.21	1.17	1.22	1.16	1.22	1.20
Dry Season	1967	1971	1975	1980		1987	1991	1995	1998	2004	2007	2012	2016
Animal	100	100	79	53		69	98	77	67	58	65	65	78
Power tiller (2W)	6	0	43	79		88	90	100	93	100	100	100	100
Big Tractor (4W)	47	62	43	9		6	2	9	17	17	18	8	28
Rotavator												15	2
Manual Threshing	24	31		37		3							
Small thresher			36	44		98	100	100	100	100	100	100	54
Big thresher	71	69	64	20									
Combine harvester	0	0	0	0		0	0	0	0	0	0	0	46
Direct Seeding				9		48	71	63	54	63	57	30	43
Transplanting	100	100	100	91		59	33	41	48	41	44	73	57
Area plated to rice (ha.)	1.49	1.88	1.53	1.38		1.32	1.23	1.18	1.12	1.33	1.21	1.32	1.46
Throughout seasons													
Farm size (ha.)	2.09	2.54	2.60	1.89	1.78	1.81	1.81	1.70	1.59	1.90	1.45	1.94	2.20
Sample size	95	62	59	148	135	120	108	100	85	116	107	95	85

Note : the sum of direct seeding and transplanting can be greater than 100 because some farmers practice both in multiple plots.

Figure 1 : Location of survey site

Panel A:

Paddy Yield Trend

Panel B:

Coefficient of variation of paddy yield

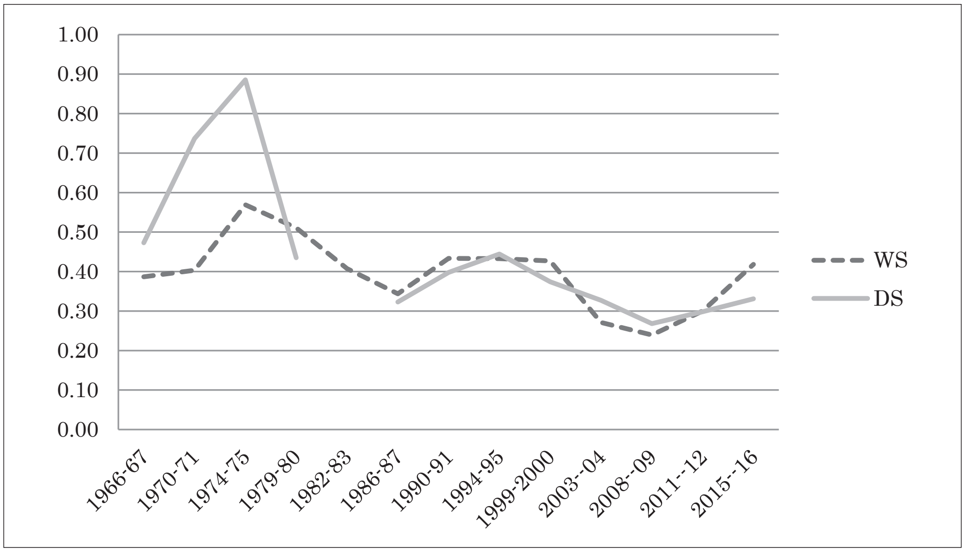

Figure 2: Paddy yield trend and the coefficient of variation from 1966 to 2016