PART II

Regional Issues in Agricultural Development

Chapter 3

CHANGING FARM SIZE AND AGRICULTURAL DEVELOPMENT IN EAST ASIA

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When labor is abundant relative to land in the early stage of economic development, labor-intensive methods of cultivation are socially efficient. In such cultivation systems, no major indivisible inputs are used and, hence, there is no major source of scale economies. Roughly speaking, a farm of 1–2 hectares can be managed efficiently by family labor consisting of a few workers. Beyond that scale, hired labor must be employed. However, the monitoring cost of hired labor arises, which increases more than proportionally with the cultivation size (Feder 1985; Otsuka, Chuma, and Hayami 1992; Hayami and Otsuka 1993). This explains why the family farm dominates in agriculture in most countries in the world (Berry and Cline 1979; Eastwood, Lipton, and Newell 2010). Thus, the optimum farm size in low-wage economies is bound to be small because of the limited availability of family labor and the costly substitution of capital for labor. This situation was predominant in East Asia (that is, Northeast and Southeast Asia), which justifies the dominance of relatively small operational sizes.

In the process of the economic development in East Asia, which accompanies the continuous increases in the real wage rate, the comparative advantage of the economy in most Asian countries has been shifting from agriculture to nonagricultural sectors. A part of the reason could be the small farm size, predominant in this region, which requires labor-intensive cultivation (Estudillo and Otsuka 2016). Farm size expansion, however, is difficult to realize due to the imperfection of land markets (Otsuka 2007). As a result, high-income countries or economies in East Asia, for example, Japan and the Republic of Korea, have been increasing imports of grains.

The striking feature of East Asia is its historically unprecedented rapid and successful industrialization, realized outside European and North American continents, which transformed the economies, including agriculture. A large part of the rural population had a chance to migrate to urban sectors that are highly able to absorb surplus labor from rural origins. As a result, the real wage rate and therefore the opportunity cost of family labor in

agriculture also increased continuously. Labor abundance disappeared in most of East Asian agriculture. To reduce the labor cost, farmers need to substitute machines for labor. To operate machines more efficiently, farm size must be expanded. Since large machines are indivisible, scale advantages arise. Thus, larger farms become more efficient than smaller farms, and so the land must be transferred from the smallholder farmers to the larger farmers.

In light of these emerging challenges, the second section of this chapter overviews historical paths taken by agriculture in the region following Hayami and Ruttan (1985, Chapter 5). We cover both Northeast Asia (China, Japan, and the Republic of Korea) and Southeast Asia (Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Thailand, and Viet Nam). The third section summarizes what changes industrialization (and income growth) has brought to agriculture and food demand structure in East Asia. In other words, the section describes the emerging challenges in detail. The fourth section examines technological, institutional, and market innovations that have recently emerged in response to the challenges mentioned above. The final section is the conclusion of this chapter.

Productivity Growth in Agriculture

In this section, we follow Chapter 5 of Hayami and Ruttan (1985) to overview long-term changes experienced by East Asian countries. Asian paths in Hayami and Ruttan (1985) are characterized by continuous efforts to increase land productivity by intensifying labor and other input use, especially through biochemical technological innovations, given that the initial condition was that the majority of farmers were small family-based cultivators including owner and tenant farmers. Arable land per person, land-labor ratio, and the average farm size were generally small under high population density (though there are some differences in the initial factor endowment between Northeast Asia and Southeast Asia). As described in the next section, rapid and successful industrialization in this region has absorbed a large share of the labor force, which has resulted in a shortage of labor in agriculture. The rapidly rising real wage makes it necessary to substitute for labor. Divergence from historical paths observed in the past has been recently confirmed in Japan and is expected to happen soon in many other countries in the region.

Factor Endowment

First, we characterize factor endowments in the region by looking at changes in arable land per person residing in rural areas and the average farm size.

TABLE 3.1 Agricultural land in square kilometers per person (rural population)

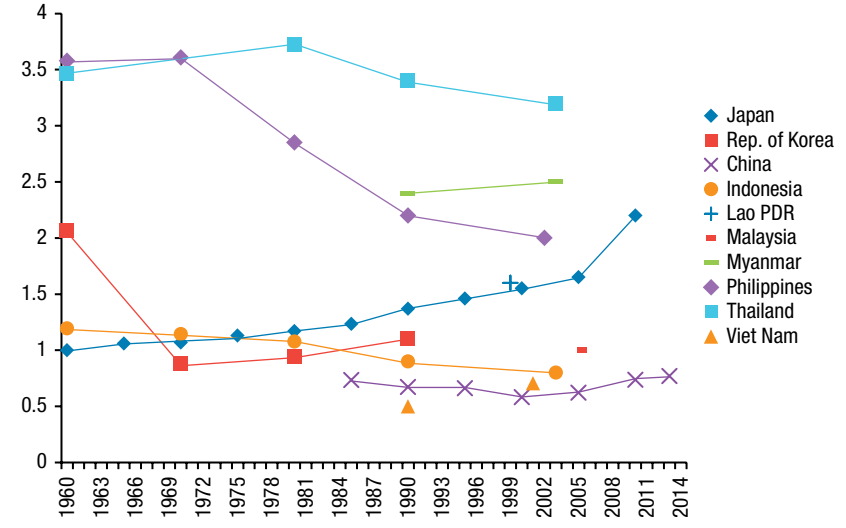
Country	1961	1980	2000	2016
Japan	0.002093	0.002178	0.001941	0.005798
Rep. of Korea	0.001147	0.001362	0.002060	0.001907
China	0.006225	0.005404	0.006447	0.008856
Cambodia	0.006677	0.004395	0.004821	0.004378
Indonesia	0.005027	0.003308	0.003845	0.004794
Lao PDR	0.007764	0.005625	0.004343	0.005809
Malaysia	0.005091	0.006205	0.007964	0.011231
Myanmar	0.006049	0.004093	0.003212	0.003692
Philippines	0.004089	0.003586	0.002768	0.002161
Thailand	0.005147	0.005459	0.004592	0.006625
Viet Nam	0.002200	0.001562	0.001446	0.001958

Source: Data from World Bank (2019).

Table 3.1 shows agricultural land per rural population from 1961 to 2016. In 1961, Japan and the Republic of Korea in Northeast Asia had relatively small amounts of arable land per rural population. Countries in Southeast Asia, except Viet Nam, had relatively large amounts of arable land per rural population. China had a relatively large area of arable land per rural population. Interestingly, we observe a clear contrast between the above two groups. While the second group (Southeast Asia) decreased arable land over time, the first group marginally increased arable land or maintained the same level over time. In Japan, arable land per rural population was almost the same in 1961 and 2000, but it increased after 2000. China and the Republic of Korea experienced an increase in arable land over time, largely due to fast and large-scale urbanization. In contrast, the countries in Southeast Asia, except Malaysia, monotonically decreased arable land per rural population in 1961 to 2000, although the initial size differed across countries (the largest size was observed in Cambodia, Lao PDR, and Myanmar, the smallest in Viet Nam). Except for the Philippines, however, all of them experienced a slight increase after 2000. In East Asia, there was a turning point in agricultural land per rural population around 2000, and since then the emerging trend has been toward increase.

Figure 3.1 shows changes in the average farm size in the region. Though the initial size differs between Northeast and Southeast Asia and many countries showed decreasing trends until 2000, Japan clearly showed an increase in the average size recently. Farm size expansion has also been taking place in China since the early 2000s through land rental markets (Huang and Ding

FIGURE 3.1 Changes in farm size (hectares) in East Asia, 1960 to 2014



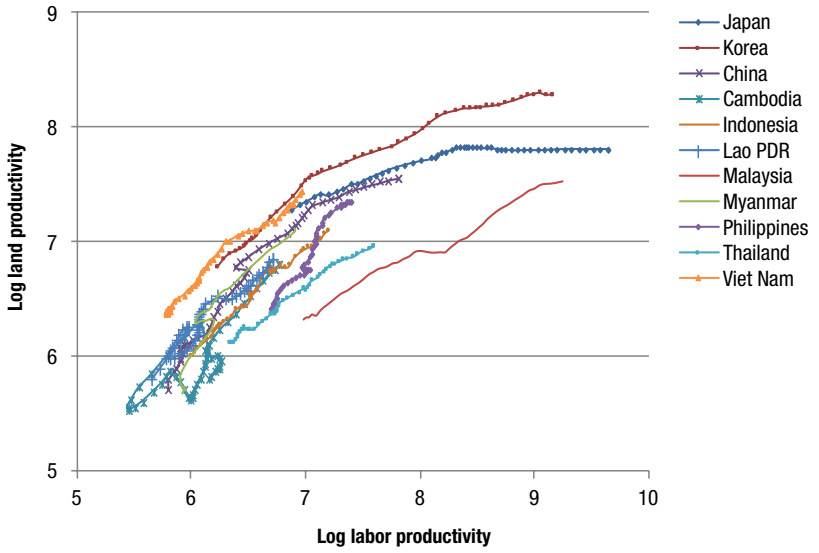
Source: FAO (2010); for China, Huang and Ding (2016); for Japan, Ministry of Agriculture, Forestry and Fisheries (various years), https://www.maff.go.jp/e/data/stat/index.html.

2016). The decreasing trend in the Philippines and Thailand was especially clear after 1980.

Obviously, whether farm size increases in Asia is a serious issue. The average operational farm size was already small in the 1970s, ranging from 1 hectare in Indonesia and Japan to 3 or 4 hectares in the Philippines and Thailand. It has declined in subsequent periods in all these countries, except in Japan and China, because of rapid population growth in rural areas. Farm size increased in Japan and China, but it is far below the average farm size in high-income economies in Europe and North America where farms of more than 100 hectares are common. If small farms continue to dominate and become a major constraint on large-scale mechanization in high-wage Asian economies, the continent could become a gigantic importer of food grains. This has already happened in high-income economies in Asia, such as Japan and the Republic of Korea (Otsuka 2013). In an attempt to address this issue, the Chinese government has started facilitating land consolidation through the rental market and introduced subsidies for mechanization. Therefore, the farm size in China is expected to increase much faster than generally assumed.[1]

1 It is noted that China food grains (rice and wheat) consumption has been declining and will fall more rapidly in the coming decades. The recent projections show that China may not need to

FIGURE 3.2 Output per worker versus output per hectare of agricultural land in East Asia, 1961 to 2014



Source: Data from USDA (2019).

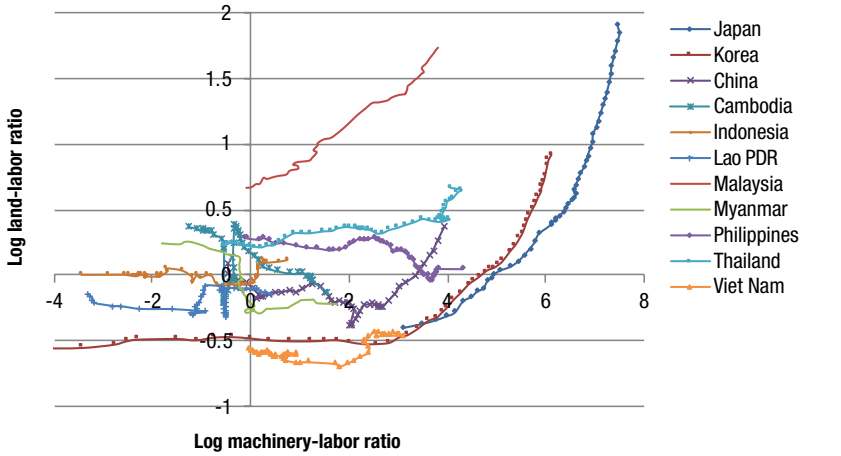
Note: Gross agricultural output in 2005 US dollars per the number of economically active adults in agriculture is on the *x*-axis; gross agricultural output in 2005 US dollars per total agricultural land in hectares of rainfed cropland equivalents is on the *y*-axis. They are both log transformed. The period covered for Japan is 1961–2000.

Productivity Growth

This subsection characterizes productivity growth, both partial and total, following Hayami and Ruttan (1985). Figure 3.2 shows the relationship between output per worker (horizontal axis) and output per agricultural land (vertical axis), both of which are log transformed. First, overall, countries in the region followed the so-called Asian path, described in Hayami and Ruttan (1985), in which land productivity increases faster than labor productivity in the early period followed by fairly rapid growth of labor productivity, even after the mid-1980s. The clearest case is the Republic of Korea. The two economies of the Republic of Korea and Japan started almost from an identical path (initial condition), whereas development stages were different across them. Second, divergence is clearly detected in Japan away from this path; labor productivity

import significant food grains, but imports of soybean, maize, edible oils, sugar, and dairy will rise in the future (Huang et al. 2017).

FIGURE 3.3 Land-labor ratio and machine use per worker, 1961 to 2014



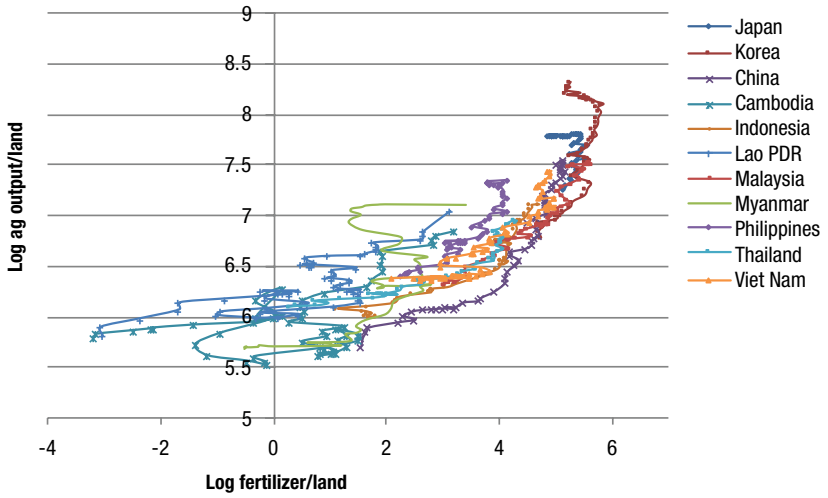
Source: Data from USDA (2019).

Note: Metric horsepower of machinery per the number of economically active adults in agriculture is on the *x*-axis; total agricultural land in hectares of rainfed cropland equivalents per the number of economically active adults in agriculture is on the *y*-axis. Both are log transformed. The period covered for Japan is 1961–2000.

keeps increasing while land productivity remains constant. That is, Japan is approaching the European path, described by Hayami and Ruttan (1985), which is closely related to an increase in farm size and mechanization. Third, Malaysia follows a unique path; labor productivity is clearly higher than other countries at the same level of land productivity. Although the analysis is descriptive and not rigorous, trends observed in Figure 3.2 seem largely consistent with the Hayami-Ruttan induced innovation hypothesis.

Figure 3.3 shows the relationship between land-labor ratio (vertical axis) and machine use per worker (horizontal axis), both of which are log transformed. First, Japan, the Republic of Korea, and Viet Nam seem to follow a similar path (starting from a nearly identical land-labor ratio), though machine use in Viet Nam clearly is still at the early stage relative to Japan and the Republic of Korea. Machine use per worker in Viet Nam is comparable to that of many countries in Southeast Asia. Second, Malaysia stands alone in starting from a very high land-labor ratio and achieving high machine use per worker (almost the same level of land-labor ratio as in Japan). Third, other countries, including China, fall between the above two cases. In China, an

FIGURE 3.4 Land productivity and fertilizer input per hectare, 1961 to 2014



Source: Data from USDA (2019).

Note: Metric tons of fertilizer per total agricultural land in hectares of rainfed cropland equivalents is on the *x*-axis; gross agricultural output (2005 US dollars) per total agricultural land in hectares of rainfed cropland equivalents is on the *y*-axis. Both are log transformed. The period covered for Japan is 1961–2000.

increase in machine use per worker recently seems to happen with an increase in land-labor ratio. In the Philippines, Indonesia, and Thailand, machine inputs per worker increased while land per worker has been relatively constant. Nonmonotonicity observed in Cambodia and Myanmar seems to be related to data problems.

According to Figure 3.3, the land-labor ratio is significantly related to machine use per worker, which can be interpreted as a proxy for mechanical technology. Interesting observations are that land-labor ratio is higher in Malaysia compared with machine use per worker, and it is lower in Japan and the Republic of Korea compared with machine use per worker. These observations suggest that Japan and the Republic of Korea failed in expanding land area per worker because of the protective agricultural policies, which deter the exodus of the rural population. It seems that not only factor endowment, but also other factors affect the mechanization.

Figure 3.4 shows the relationship between fertilizer use per agricultural land area (horizontal axis) and output per agricultural land area (vertical axis), both of which are log transformed. According to this figure, land productivity

is consistently and almost completely explained by fertilizer use per agricultural land area. Fertilizer use per agricultural land area can be interpreted as a proxy for biological-chemical technology. Strikingly similar paths across East Asian countries suggest that similar biological-chemical technologies, represented by fertilizer-using and high-yielding Green Revolution–type technologies of wheat and rice, have been developed and diffused in this region, beginning in Japan before World War II and transferred to tropical Asia primarily in the 1970s and 1980s (see Chapter 11). The elasticity of land productivity growth to fertilizer input is relatively low when fertilizer input level (per land area) is still low (below 4 log transformed), but land productivity growth appears to accelerate in response to fertilizer inputs once fertilizer use is intensified. This observation suggests that fertilizer-using and land-saving technology is developed in the process of economic development that accompanies growing scarcity of land. In other words, consistent with the Hayami-Ruttan induced innovation hypothesis, fertilizer-using technology is developed to save an increasingly scarce factor of production, that is, land. In this context, Japan, the Republic of Korea, China, Viet Nam, Indonesia, the Philippines, and Malaysia are all above the threshold. In Myanmar, Cambodia, and Lao PDR, land productivity increased without intensification of fertilizer use, which is somewhat puzzling.

Table 3.2 compares average annual total factor productivity (TFP) growth rate estimates in East Asia (Nin-Pratt 2018). First, China shows outstanding performance after 1980. In crop production, Viet Nam had the highest TFP growth after 1980, while Malaysia shows high TFP growth in livestock before and after 1980. Many countries in Southeast Asia had also experienced high TFP growth in 2001 to 2008. High TFP growth observed in Southeast Asia before 1980 by some studies (for example, Dias Avila and Evenson 2010) is not confirmed in Table 3.2, which implies that the Green Revolution was not mainly driven by TFP growth, but associated with intensive utilization of inputs such as fertilizers. See Pingali (2012) for more about the Green Revolution. Fan and Brzeska (2010, Sections 4 and 5) reviewed TFP in Northeast Asian countries, which points to the importance of institutional and policy reforms in determining TFP.

In sum, countries in the region followed the so-called Asian path, described in Hayami and Ruttan (1985), that is, land productivity increasing faster than labor productivity in the early period, but Japan seems to divert from the path by rapidly increasing labor productivity, approaching the European path, which is closely related to an increase in farm size

TABLE 3.2 Average TFP growth rate for different periods

Country	1961–1970	1971–1980	1981–1990	1991–2000	2001–2008	2009–2014
Japan	0.00090	0.00496	0.00680	0.00445	0.01168	0.00059
Rep. of Korea	–0.02684	–0.00528	0.00864	0.02373	0.00791	0.00709
China	0.00736	–0.00299	0.03125	0.03284	0.02181	0.01261
Cambodia	–0.02254	–0.03897	–0.00997	0.02180	0.01478	0.01118
Indonesia	0.00103	–0.00068	–0.00966	–0.00144	0.02579	0.00416
Lao PDR	–0.02425	–0.01032	0.00039	0.02613	–0.01723	0.02890
Malaysia	0.00492	0.00575	0.00692	0.01058	0.03615	–0.01082
Myanmar	–0.03009	0.00050	–0.00060	0.01963	0.05342	–0.04323
Philippines	–0.01365	0.00943	–0.00363	0.00159	0.02047	–0.00095
Thailand	–0.01397	0.00106	–0.02145	0.01070	0.01740	0.01304
Viet Nam	–0.01498	0.00882	0.01395	–0.00395	0.02036	0.01051

Source: Nin-Pratt (2018).
Note: TFP = total factor productivity.

and mechanization in recent years. Many countries in Southeast Asia had favorable land endowments in the initial conditions, but more recently both land-labor ratio and machine use per worker increase together in these countries following the cases of Japan and the Republic of Korea due to significant labor shortage common in the region.

Agricultural Growth, Urbanization, and Food Demand

In this section, we discuss details of recent economywide changes highly relevant to agriculture, including the development of nonagricultural sectors, intersectoral and interregional labor mobility, and changes in factor prices. The fastest and most successful industrialization experienced in this region inevitably accompanied rapid urbanization and created scarcity of labor in rural areas and therefore increased real rural wages. In rural areas, nonagricultural sectors also developed and absorbed labor from agriculture. As a result, the opportunity cost of farming has dramatically increased in the region. Income growth has contributed to large poverty reduction (though the head counts of the poor are large in this region due to its large population size) and transformation of food demands.

Industrialization, Urbanization, Employment, and Poverty Reduction

Declining shares of agriculture in gross domestic product (GDP) and employment occurred very rapidly in Northeast Asia. Rural labor was absorbed by nonagricultural sectors largely located in urban areas and newly created local cities and towns. Table 3.3 shows the share of the population that was urban from 1960 to 2018. Except in Japan where the share was already above 60 percent in 1960, the shares ranged between 8 and 30 percent in 1960. The Philippines had the highest share, 30 percent, and Lao PDR had the lowest share, 8 percent, in the region. By 2010, Japan reached above 90 percent, followed by the Republic of Korea, 82 percent. Since the share in the Republic of Korea was about 28 percent in 1960, the speed of that country's urbanization was very fast.

When the countries are grouped by percentage of urban population, there are three groups in the region. The first group consists of high-income countries, that is, Japan, the Republic of Korea, and Malaysia, in which more than 75 percent of the population was urban by 2018. The second group, China, Indonesia, the Philippines, and Thailand, had 45 to 60 percent of the population in urban areas in 2018. The last group consists of low-income countries, that is, Viet Nam, Myanmar, Lao PDR, and Cambodia, where the share of urban population was around or below 35 percent in 2018. Since the share of urban population is correlated with the share of employment in agriculture, the table likely indicates that these countries went through a declining share of population engaged in agriculture with the development of economies.

Rapid industrialization and urbanization in the region have increased stress on natural resources, particularly fresh water, which is essential to agricultural production. Table 3.4 shows freshwater withdrawal by sectors: agricultural, industrial, and municipal (domestic) use. The share of agriculture is relatively low in Japan (67 percent), the Republic of Korea (55 percent), China (66 percent), and Malaysia (22 percent). Indonesia and the Philippines remain at 81–82 percent, and the rest of Southeast Asian countries are at about 90 percent. Except in Malaysia, the share of agriculture is inversely correlated with industrial development and urbanization in the region. The issue of increasing water scarcity will be discussed in Chapter 20.

In Figure 3.5, we examine the relationship between shares of GDP and employment in agriculture in the period from 1961 to 2015. Both shares tended to simultaneously decrease over time, though there are variations across countries. The Republic of Korea showed the largest changes in both

TABLE 3.3 Share of urban population (%) in East Asia, 1960 to 2018

Country	1960	1970	1980	1990	2000	2010	2018
Japan	63.3	71.9	76.2	77.3	78.6	90.5	91.7
Rep. of Korea	27.7	40.7	56.7	73.8	79.6	81.9	81.5
China	19.5	17.4	19.4	26.4	36.2	50.0	59.2
Cambodia	10.3	16.0	9.9	15.5	18.6	19.8	23.4
Indonesia	14.6	17.1	22.1	30.6	42.0	49.9	55.3
Lao PDR	7.9	9.6	12.4	15.4	22.0	33.1	35.0
Malaysia	26.6	33.5	42.0	49.8	62.0	70.9	76.0
Myanmar	19.2	22.8	24.0	24.6	27.0	31.4	30.6
Philippines	30.3	33.0	37.5	48.6	48.0	45.3	46.9
Thailand	19.7	20.9	26.8	29.4	31.4	44.1	49.9
Viet Nam	14.7	18.3	19.2	20.3	24.4	30.4	35.9

Source: Data from World Bank (2019).

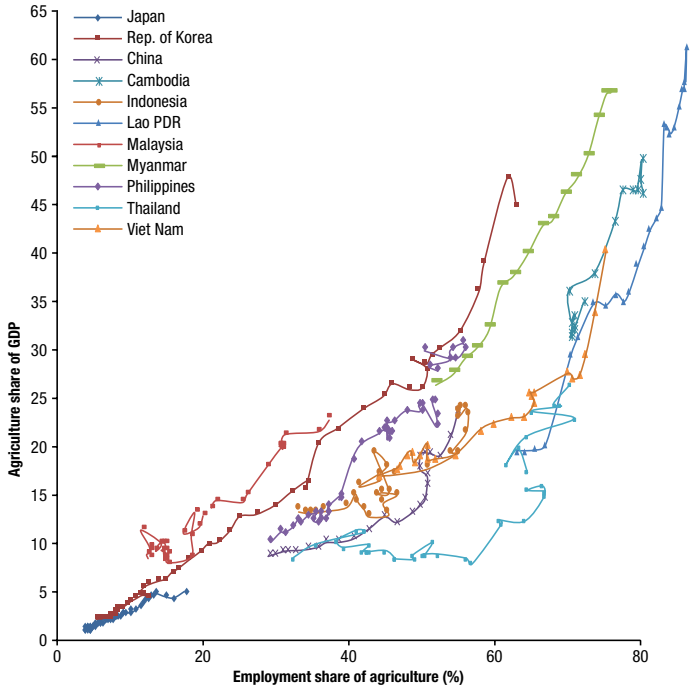
TABLE 3.4 Freshwater use by sectors in East Asia in the early 21st century

Country	Agricultural ($100\ m^3$/year)	Industrial ($100\ m^3$/year)	Municipal ($100\ m^3$/year)	Total ($100\ m^3$/year)
Japan	54.4 (2009)	11.6 (2009)	15.4 (2009)	81.5 (2009)
Rep. of Korea	16.0 (2003)	4.5 (2002)	6.9 (2005)	29.2 (2005)
China	385.2 (2015)	133.5 (2015)	79.4 (2015)	598.1 (2015)
Cambodia	2.0 (2006)	0.0 (2006)	0.1 (2006)	2.2 (2006)
Indonesia	92.8 (2000)	24.7 (2005)	14.0 (2005)	113.3 (2000)
Lao PDR	3.2 (2005)	0.2 (2003)	0.1 (2003)	3.5 (2005)
Malaysia	2.5 (2005)	4.8 (2005)	3.9 (2005)	11.2 (2005)
Myanmar	29.6 (2000)	0.5 (2005)	3.3 (2000)	33.2 (2000)
Philippines	67.1 (2009)	8.3 (2009)	6.2 (2009)	81.6 (2009)
Thailand	51.8 (2007)	2.8 (2007)	2.7 (2007)	57.3 (2007)
Viet Nam	77.8 (2005)	3.1 (2005)	1.2 (2005)	82.0 (2005)

Source: Data from FAO (2018).

GDP and employment shares. Starting from low levels of GDP and employment shares, the paths of Japan and Malaysia also overlap that of the Republic of Korea. A similar path is followed by the Philippines, Indonesia, China, and Viet Nam. In contrast, Thailand showed a unique pattern, in which the share of GDP decreased first while that of employment stayed relatively constant. This indicates that the share of nonfarm income of agricultural households increased. Subsequently the employment share started decreasing,

FIGURE 3.5 GDP share and employment share of agriculture (%) in East Asia, 1961 to 2015



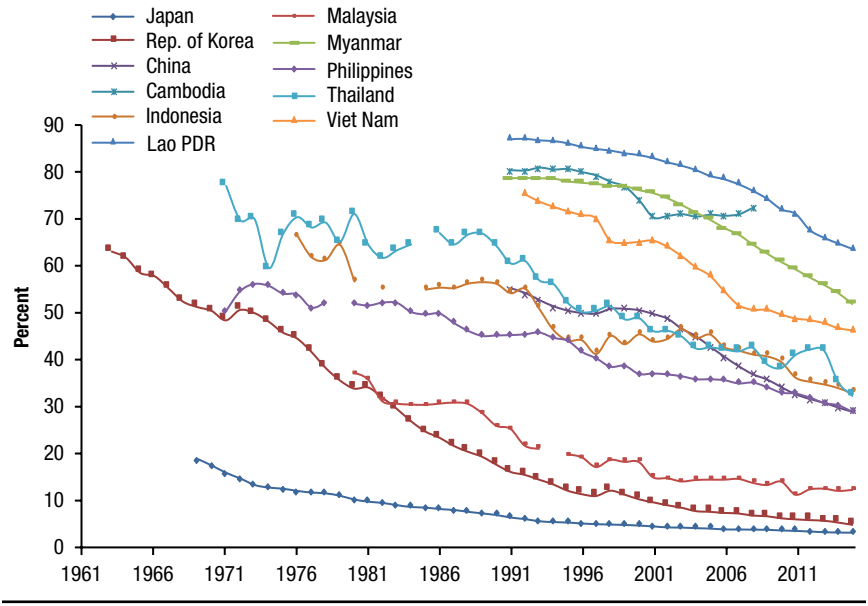
Source: Data from World Bank (2019).

Note: The database includes 2015 because the recent data include forestry and fishery together with agriculture for value-added percent of GDP. GDP = gross domestic product.

which brought Thailand back to a situation comparable to the Philippines and Indonesia.

Figures 3.6 and 3.7 show changes in employment and GDP shares, respectively, from 1961 to 2015, to confirm the decreasing trends in these shares. In employment share, Japan, the Republic of Korea, and Malaysia were the first to reach a very low level. The speed of the decrease in the Republic of Korea is remarkable, as its initial condition was comparable to that of many Southeast Asian countries. The second group, consisting of the Philippines, Thailand, Indonesia, China, and Viet Nam, still keep the share of employment in agriculture between 30 and 50 percent. In Indonesia, the Philippines, and Thailand the reduction in employment (share) accelerated after 1980. The employment share in the rest of the countries, namely, Cambodia, Lao PDR, and Mayanmar, seems to remain relatively high. In Figure 3.7, aside from Japan, we clearly observe two groups: the Republic of Korea, China, Indonesia,

FIGURE 3.6 Changes in employment share of agriculture (%) in East Asia, 1961 to 2015

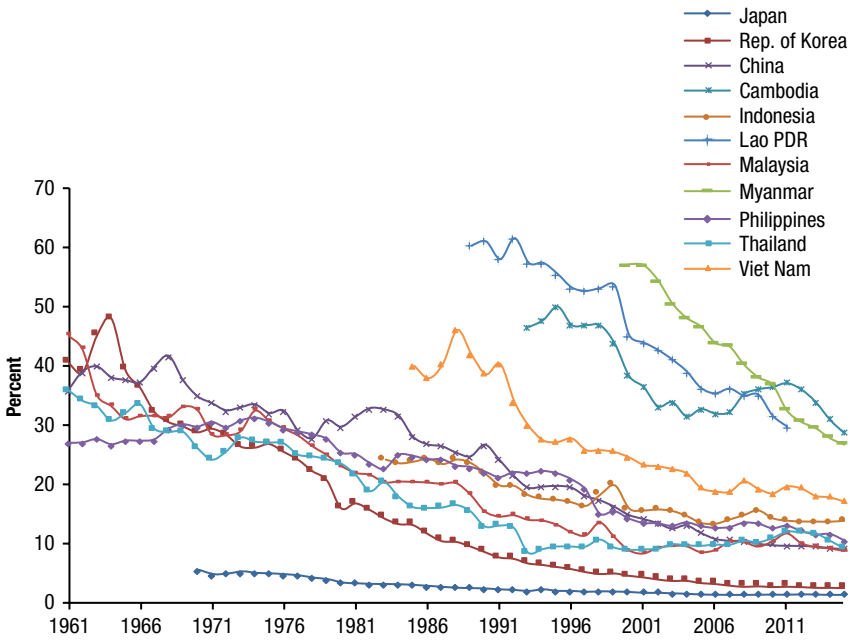


Source: Data from World Bank (2019).

the Philippines, Thailand, Malaysia, and Viet Nam as the first group, and Cambodia, Lao PDR, and Mayanmar as the second group. The first group started from 25–45 percent in 1961 and reached 10–15 percent in 2015. Note that the path of the Republic of Korea recently converged with the path of Japan, which started from an exceptionally low share of GDP in 1961. The second group still maintains about 30 percent of the GDP share in agriculture.

Along with successful industrialization, this region has experienced the above-mentioned transformation of the agricultural sector in the economy and unprecedented income growth and poverty reduction. Figures 3.8 and 3.9 show changes in the poverty gap and the head count ratio of poverty in rural areas, respectively. Both graphs clearly show a reduction of poverty level as well as its convergence. China, Indonesia, and Viet Nam showed remarkable reductions in their poverty gaps. Although international comparability in the head counts remains questionable, as they use national-level thresholds, overall all countries in which the statistics are available experienced a relatively fast reduction of rural poverty. Therefore, there seems to be no question that a decrease in the share of GDP and employment in agriculture was associated with a reduction of rural poverty.

FIGURE 3.7 Changes in GDP share of agriculture (%) in East Asia, 1961 to 2015



Source: Data from World Bank (2019).

Note: The database includes 2015 because the recent data include forestry and fishery together with agriculture for value-added percent of GDP.

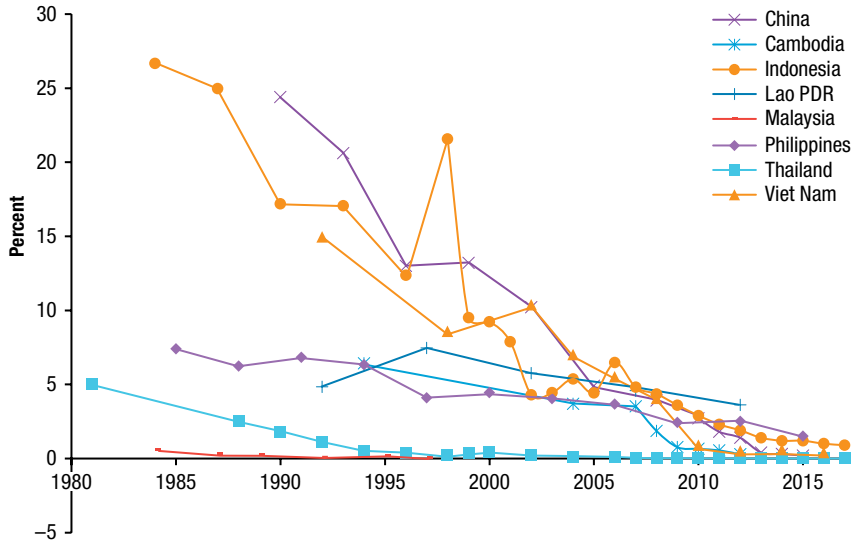
Production Side—Labor Shortage

Successful industrialization not only led to the large-scale transformation of the agricultural sector through a reduction in its contribution to GDP and employment (which also resulted in a substantial reduction in the poverty level), but also created a serious labor shortage and thus a rapid increase in real wages. As reported in Wiggins and Keats (2014), rural wages in the region have been increasing fast recently.

In this context, whether or not the Lewis turning point has been passed is an interesting empirical issue. It is known that Japan and the Republic of Korea passed the Lewis turning point around 1960 and 1975, respectively (Minami 1968; Bai 1982). More recently, Thailand, China, and Indonesia appeared to have passed the turning point (Zhang, Yang, and Wang 2011). Viet Nam seems to be approaching the turning point relatively quickly.

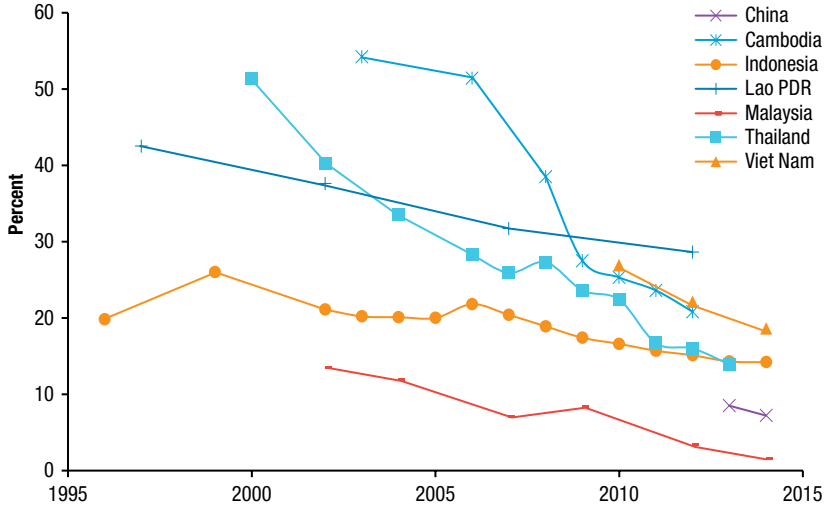
Figure 3.10 shows changes in rural real wages in six provinces in China: Heben, Hubei, Jilin, Jiangxi, Shandong, and Sichuan (Wang, Yamauchi, and

FIGURE 3.8 Poverty gap (%) at $1.90 a day (2011 PPP) in East Asia, 1980 to 2017



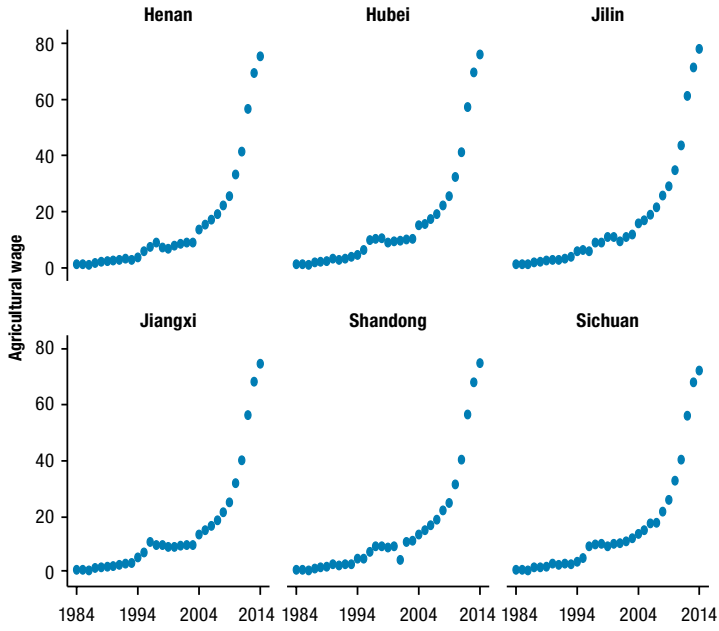
Source: Data from World Bank (2019).
Note: PPP = purchasing power parity.

FIGURE 3.9 Rural poverty head count (% in rural population) in East Asia, 1995 to 2015



Source: Data from World Bank (2019).

FIGURE 3.10 Real agricultural wages in selected provinces in China: 1984 to 2014



Source: Wang, Yamauchi, and Huang (2016).

Huang 2016). Strikingly, an acceleration of rising real wages after 2000 seems to be common in most provinces. How to tackle labor shortage (and rising real wages) is an emerging issue after 2000, which is consistent with the turning point reported for China (Zhang, Yang, and Wang 2011).

Outflow of labor from agriculture also involves intergenerational issues. In some countries, such as the Republic of Korea, China, and Japan, farmers cannot find successors to take over their farming, which exacerbates the labor shortage problem but promotes farm size expansion in the long run.

Demand Side—Food Demand and Nutrition Transition

This subsection discusses nutrition transitions (Popkin 2002a, 2002b, 2006) in the context of East Asia (Kelly 2016). Diets dominated by starchy, low-variety, low-fat, and high-fiber foods are being replaced by consumption of processed foods higher in fats, sugars, and salt and, in some cases, accompanied by rises in diet-related noncommunicable disease (NCD). The issue of nutrition transition is discussed in Chapter 10.

As described above, most of East Asia has experienced high income growth through rapid industrialization in recent decades, which is reflected in increased consumer purchasing power. This is a main driving force for the nutrition transition from complex carbohydrate consumption to more fat, salt, sugar, and processed-food consumption. This is apparent in higher-income countries, though we are beginning to observe such a change in lower-income countries (Drenowski and Popkin 1997; Popkin, Adair, Ng 2012). Another important factor relevant in the context of East Asia is, as emphasized previously, the rapid pace of urbanization. The opportunity cost of home cooking tends to be high in urban settings, especially when family size is much smaller than rural counterparts and many women work outside the home (Pingali 2007). Urbanization and nutrition will be discussed further in Chapters 9 and 10.

The existing studies seem to identify some common elements of the manifestation of the nutrition transition in East Asia. First, the most common change in the region is a dramatic increase in the proportion of dietary energy derived from oils and fats, mainly oilseed based, replacing complex carbohydrate sources (Kelly 2016). For example, in China, annual vegetable oil consumption per capita has increased from 1 kilogram in 1963 to 11 kilograms in 2003 (Kearney 2010). Second, the predominant rice-based diets are also transformed, with more wheat consumption. There seems to be a pattern: with rising incomes, people tend to increase rice consumption first when income increases, and then the dependence on rice decreases afterward. For example, in China, rice consumption increased rapidly in the 1960s and 1970s from 172 grams per capita per day in 1963 to 260 in 1983 before falling again to 213 in 2003. In the same period, wheat consumption increased from 71 grams per person per day to 167 (Kearney 2010). Third, consumption of meat has also been increasing as part of the nutrition transition. The largest change here has been seen in pork and poultry consumption. In China, for example, from 1990 to 2014 pork consumption more than doubled, from 15 to 31 kilograms per capita per year, and poultry consumption rose from 2 kilograms to 11.5 kilograms per capita per year during the same period.

Finally, we observed a dramatic increase in consumption of processed, packaged, and convenience foods, which overlaps the above-mentioned changes. In China, consumption of processed foods increased from 20 kilograms per capita annually in 1999 to over 80 kilograms per capita in 2012, and in Thailand it rose from 60 to 110 kilograms during the same period. In Thailand and the Philippines, soft drink consumption was particularly high

and approached high-income-country level, and in Malaysia and Indonesia processed high-fat foods were most prevalent. In higher-income Asian countries such as Japan, consumption of processed foods has stopped increasing since the 1990s, but it is growing fastest in the upper-middle-income countries such as Thailand and China (Baker and Friel 2014).

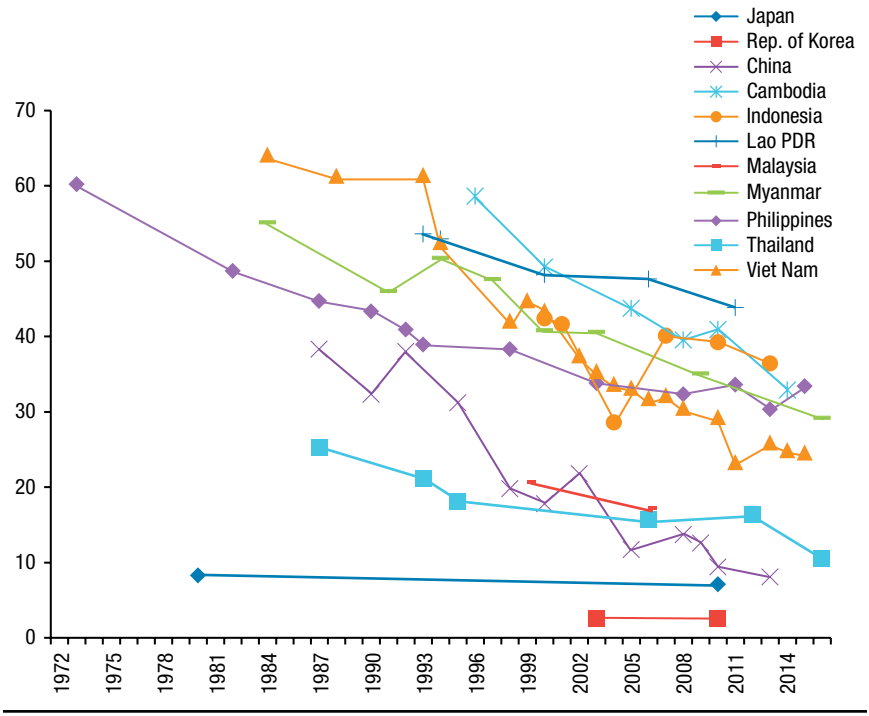
While malnutrition has been receding in Asia overall, owing to rapid and successful economic growth, rates of overweight and obesity are rising rapidly, particularly in Southeast Asia (Chopra, Galbraith, and Darnton-Hill 2002; Popkin 2006). For example, from 1980 to 2008, prevalence of adult overweight and obesity combined increased from 12 to 39 percent in Thailand, from 15 to nearly 50 percent in Malaysia, and from 5 to around 25 percent in Indonesia (Stevens et al. 2012). In Southeast Asia, the burden of diet-related disease, including diabetes, cardiovascular disease, and diet-related cancers, is also quickly rising.

By focusing on the population of children under age 5, Figures 3.11 and 3.12 contrast prevalence of stunting to prevalence of overweight. Figure 3.11 shows that the prevalence of stunting has been decreasing over time in all countries, which reflects a substantial improvement of nutrition intake among young children as well as pregnant women in the region.

In contrast, the prevalence of overweight has had an upward trend in recent years. This is consistent with recent trends observed in adult obesity in Thailand, Malaysia, and Indonesia (reported above). Thailand and Indonesia reached an alarming level of child overweight in recent years. The prevalence has also increased in the Philippines and Viet Nam. Strikingly, Japan is an interesting case that shows the lowest prevalence of child overweight (which is consistent with the pattern of processed foods consumption). The gap between stunting and overweight is particularly large in Thailand and the Republic of Korea; the prevalence of overweight is much higher than that of stunting.

NCD Risk Factor Collaboration (2016) used 1,698 population-based data sources, with more than 19.2 million adult participants (9.9 million men and 9.3 million women) in 186 out of 200 countries for which estimates were made, to see changes in age-standardized mean body mass index (BMI). They found that global age-standardized mean BMI (in kilograms per square meter) increased from 21.7 (with the 95 percent credible interval being 21.3–22.1) in 1975 to 24.2 (24.0–24.4) in 2014 in men, and it increased from 22.1 (21.7–22.5) in 1975 to 24.4 (24.2–24.6) in 2014 in women. In the dynamics of adult BMI, East Asia (including Southeast Asia) is very interesting. Strikingly, China's obese populations in both men and women increased dramatically in

FIGURE 3.11 Prevalence of stunting among children under age 5 (%) in East Asia, 1972 to 2016

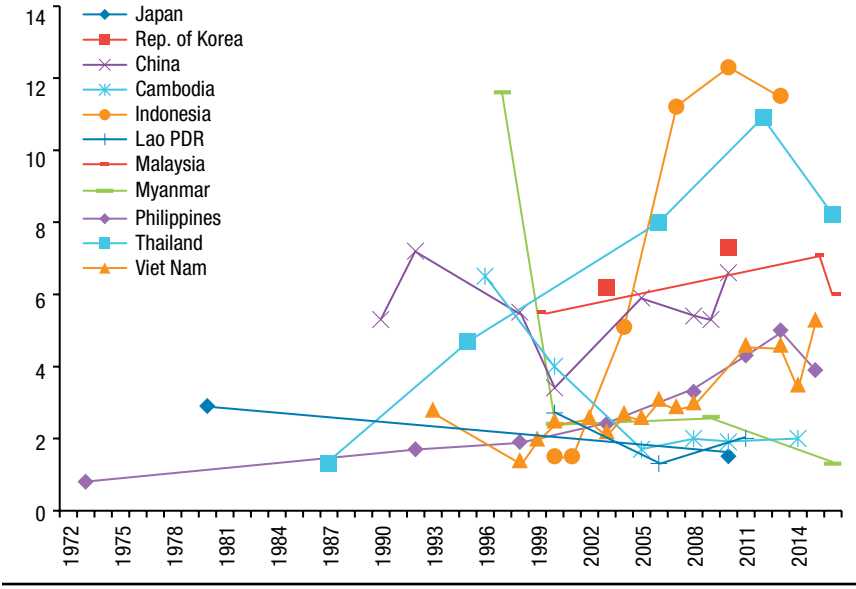


Source: Data from World Bank (2019).

the same period, from 0.7 to 43.2 million in men and 1.7 to 46.4 million in women, elevating China to the top of the obese population ranking in 2014 (NCD Risk Factor Collaboration 2016, Figure 7). In severe obesity, change in the global ranking of China is even more dramatic: from number 60 to number 2 in men and from 41 to 2 in women. Interestingly, some countries from this region, such as China, Indonesia, Viet Nam, the Philippines, Thailand, and Japan, remained among the top in the ranking of underweight population in 1975 and 2014.

There are only two countries in the world that have no hunger and no problem of rising overweight; they are Japan and the Republic of Korea (Laborde, Mamun, and Vos 2019). A variety of reasons unique to these countries explain this phenomenon. Further research on the agrifood system is needed to factor out the causes for achieving no hunger and no overweight.

FIGURE 3.12 Prevalence of overweight among children under age 5 (%) in East Asia, 1972 to 2016



Source: Data from World Bank (2019).
Note: In China, 1995 and 2002 were omitted because they showed too high prevalence, outlying from the trend.

Innovations and Agricultural Transformation

Given rising real wages in rural areas, the conventional view that small farms are more productive is currently challenged. Labor-intensive production methods are not an optimal choice anymore in Northeast Asia. However, transition to more capital-intensive methods using machines requires a realization of scale economies, and a critical constraint is the relatively small farm size in the region (Figure 3.1). We discuss technological and institutional innovations under such circumstances in this region. They include activation of land rental markets, land consolidation, and mechanization in different forms (including the emergence of machine service providers), which together introduce more labor-saving production methods. The emergence of the advantage of large-scale farming is discussed here.

Technological and Institutional Innovations

Although small farms in Asia achieved higher land productivity than their larger counterparts in the past, they are facing more and more challenges as

structural transformation has been occurring in most developing countries in Asia. In these countries, the rapid growth of the nonfarm sector has created more lucrative employment opportunities, which has resulted in a higher real wage in both farm and nonfarm sectors. Coupled with technological advances in manufacturing industries, the price ratio of labor to machine use is increasing, which renders the substitution of labor by machine profitable. The rapidly growing machine rental markets in China and Viet Nam represent a response to such trends in recent decades (see, for example, Liu et al. 2020; Zhang et al. 2011). As farming systems gradually change from labor-intensive to capital-intensive systems, the advantage of small farms relying on family labor is declining, while large farms' advantages are enhanced by the use of farm machinery.

Recently, we also observed an evolution of machine service providers as an institutional response to reduce the user cost of machine use. For example, in China (Yang et al. 2013), small farms can contract with the provider to use machine services, rather than renting or purchasing machines, in order to save on labor costs. By contracting with a large number of small farms, the provider can enjoy scale economies, provided that the transaction cost of machine service provision is sufficiently low. If it is high, small farms cannot save labor as much as large farms.

It is still also possible that farmland consolidation can be facilitated by market transactions as well as institutional arrangements. Historically, consolidation was largely achieved through market transactions in many of the Organisation for Economic Co-operation and Development (OECD) countries. Previously in China land transactions were seriously constrained by the insecurity in farmers' individual land rights, but recently farmland rental arrangements have been facilitated through both more secure land contract rights and online services provided by county and township governments in every province in China. In some areas, land banks are also established to facilitate borrowing and lending (renting in and renting out) of farmland. In this way, farm size expansion is taking place in China (Huang and Ding 2016).

In sum, when the real wage rate is low, the optimum farm size is small and the inverse correlation between farm size and productivity tends to emerge. When the wage rate increases, mechanization will take place to save labor. Since machines and land are complementary and machines are indivisible to some extent, the optimum farm size tends to increase. If farm size adjustments take place smoothly through market transactions and institutional arrangements, efficient large farms emerge. In practice, however, land markets may not function smoothly, so a positive relationship can arise between farm size and productivity in high-wage economies.

We examine the validity of our arguments by drawing on recent empirical evidence available from East Asian countries (Otsuka, Liu, Yamauchi 2016). They include case studies in Indonesia (Yamauchi 2016), Viet Nam (Liu et al. 2020), and China (Wang, Yamauchi, Huang 2016; Wang et al. 2016, 2018). These recent studies explicitly look at the impact of rising real wages on land and machine service transactions and the dynamically changing disadvantage of small farms (or the emerging advantage of large farms). This is a major departure from the earlier literature that assessed factors that were considered to explain the inverse relationship between farm size and productivity observed in cross-sectional data.[2]

Indonesia is an interesting case for the purpose of our study due to the coexistence of small farms in Java and relatively large farms in the outer islands. Yamauchi (2016) examines the dynamically changing patterns of land use, capital investments, and real wages by using farm household panel data from seven provinces collected in 2007 and 2010. His regression analyses show that an increase in real agricultural wages induced the substitution of labor by machines, either through machine rentals or machine service providers, notably among relatively large farmers. The total amount of payments for hired-in machines or services or both has increased significantly in response to rising real agricultural wages, especially among relatively large farms. They tend to increase the scale of operation by renting in more land when real agricultural wages increase. Furthermore, the effect of an increase in farm size on crop productivity per hectare becomes positive among relatively large farms. Thus, the Indonesian case study clearly supports our hypothesis that the efficiency of large farms increases with rising real agricultural wage rates.

The case of Viet Nam is similar to that of Indonesia. Liu et al. (2020) use data from 1992 and 1998 Vietnam Living Standards Surveys (VLSS) and from four rounds of Vietnam Household Living Standards Survey (VHLSS) data between 2002 and 2008. This makes it possible to investigate machine use and the farm size–productivity relationship from the 1990s to the 2000s. Descriptive analysis suggests that tractor rental has become more common: in 2008 more than 60 percent of farms rented in machines, whereas less than 20 percent did so in 1992. Rapid increase in tractor use would be associated

2 The existing empirical tests on the inverse relationship are grouped into several types. The first type investigates whether the advantage of small farms can be attributed to imperfect factor markets, particularly the labor market. The emerging reality that real wages are rising rapidly in East Asia is related to this. The second type inquires whether unobserved factors such as soil quality can explain the inverse relationship if such factors are unevenly distributed between small and large farms (Benjamin 1995). The third is concerned with the effect of measurement errors of farm size on the inverse correlation between farm size and productivity (Lamb 2003).

with an increase in the relative advantage of large farms. Consistent with such an expectation, large farmers are more likely to use agricultural machines, pointing to the scale economies arising from machine use. Interestingly, machine use was not responsive to the real agricultural wage in 1992 or 1998 but became significantly responsive in 2006 through 2008, suggesting the emergence of a clear substitution relationship between machine and labor in recent years when the wage rate has become high. Such differences may be attributed to the development of machine rental markets over time. The estimation results of the paddy yield regression demonstrate that the inverse relationship between farm size and land productivity has significantly lessened: when farm size doubled, the expected paddy yield is estimated to have decreased by 15.6 percent in the 1990s but only by 6.1 percent in the late 2000s. Thus, the inverse relationship is lessened but not reversed. Yet, another interesting finding is that the inverse relationship may be reversed in areas where farm size is larger and the wage rate is higher. This indicates that a positive relationship has emerged between farm size and productivity in advanced areas where the wage rate is higher. This result is also consistent with the observation of Estudillo and Otsuka (2016) that the average farm size among their sample households increased from 1.0 hectare in 1996 to 1.4 hectares in 2009 in the Mekong Delta region.

In China, the economy has been rapidly growing over the last three and one-half decades, and the wage rate has been rising sharply, particularly since 2003 (Zhang, Yang, and Wang 2011). Correspondingly, the use of riding tractors and combine harvesters is increasing (Yang et al. 2013). Yet the average farm size remained at 0.6 hectare in 2010, increasing only by 0.05 hectares per year since 2000, even though land rental markets have become increasingly active (Kimura et al. 2011; Huang, Wang, and Qui 2012). More recently, Huang and Ding (2016) pointed out that farm size in China is somewhat underestimated.

Using farm household panel data from China, collected in six provinces in 2000 and 2008, Wang et al. (2016) analyze the dynamic changes in land rental transactions, machine investments, and the use of machine services. Their study looks at the effects of nonagricultural and agricultural wage growth, changes in the migration rate, and the proportion of nonagricultural income, all of which are estimated at the village level, on changes in self-cultivated farm size, rented-in land areas, machine services used, and machine investments. The regression results show that increases in nonagricultural wages, the proportion of nonagricultural income, and the migration rate lead to the expansion of the operational farm size. Consistently, the demand for

machine services also increased along with increases in agricultural wages and migration rates. This effect is larger for relatively large farms.

As in the case of the Indonesia study, the regression results of crop income equations support the hypothesis of complementarities between rented-in land and machine services demanded, especially among relatively large landholders in China. In other words, the possibility of renting in land and the availability of machine service providers led to expansion of farm size to take advantage of scale economies.

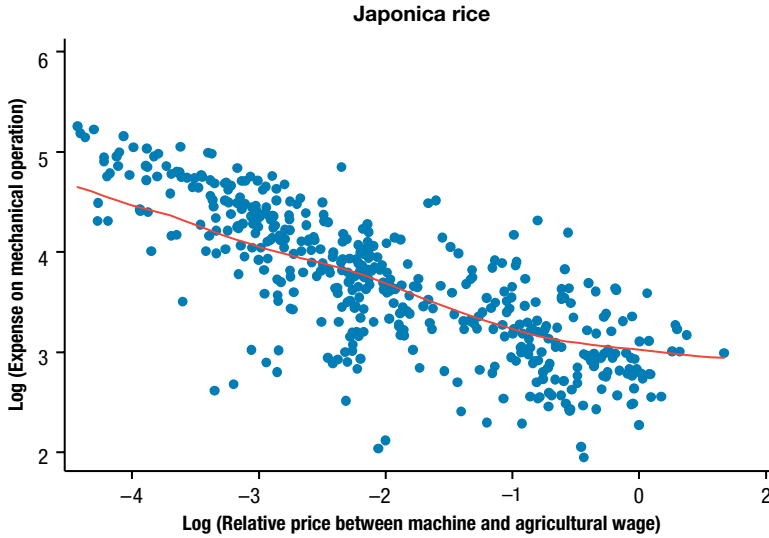
Wang, Yamauchi, and Huang (2016) used province-level crop-wise panel data in China to investigate the substitutability between agricultural labor and machine service. They support the conjecture that machines are increasingly used to substitute for labor under the circumstances where the real wage has been rapidly increasing. Figure 3.13 shows the relationship between machine use per hectare (expenses) and the relative wage of labor to machine cost in wheat and (japonica) rice production. In the production of both crops, an increase in agricultural wage relative to machine cost led to intensive machine use (measured by expenses on mechanical operations).

Wang et al. (2020) used the same household panel used in Wang et al. (2016) to investigate the role of land fragmentation in mechanization. It is clearly shown that fragmented farmlands discourage mechanization. All conditions being equal, the consolidation of fragmented lands could improve production efficiency by lowering transaction costs in mechanization.

Two recent movements in China deserve special attention. First, in northeast China, machine service providers directly attempt to consolidate farmland by renting in land from smallholders to realize scale economies. However, such land rental contracts with small farmers are mainly short-term and often subject to annual renewals, because small farmers feel insecure about renting out their land under long-term contracts, due to the lack of private land ownership. They also expect the land rent to increase over time, and thus they hesitate to sign long-term contracts. Second, recently, farmland rental arrangements have been facilitated through the Internet by local governments in nearly every province. In all likelihood, these new institutional arrangements are induced by the increasing optimum size of farm operation in China (Huang 2017).

In contrast to the conventional view of the small-farm advantage, the evidence shown above supports the dynamic shift of the relative advantage from small to large farms in Asia. That is, the inefficiency of small farms increases with rising real wages, whereas large farms increase their productivity by utilizing large-scale machines efficiently, saving increasingly costly labor, and

FIGURE 3.13 Expenses for mechanical operations in China, 1984 to 2014



Source: Wang, Yamauchi, and Huang (2016).

thereby realizing scale economies. How far and how rapidly this trend continues will significantly affect the efficiency of farming in East Asia in coming decades. Smooth transfer of farmland from those who exit from farming to those who expand farming is critically important, and this would be a solution for the labor shortage problem, including the intergenerational transfer of farming, discussed in the previous section.

These analyses suggest that the relationship between the land-labor ratio and the use of machinery is not simple, because the development of land and land rental markets and that of machinery rental and service markets affect such a relationship. This is likely to explain why the relationship between land-labor ratio and machinery use per unit of land portrayed in Figure 3.3 varies from country to country even in East Asia.

Market Innovations—Diversification and Modernization of Food Value Chains

Successful economic growth and rapid urbanization have also changed the nature of food demands, which is intimately related to the nutrition transition. Consumers, especially in urban areas, demand high-value and high-quality foods (Reardon, Timmer, and Berdegue 2008; see Chapter 12 for further discussions on value chains). The rising demand for safe, high-value, and differentiated agricultural products has created large opportunities for farmers to participate in value chains to potentially improve productivity (for example, by contract farming, which improves access to technology, information, and capital) and increase incomes.

Modern value chains typically coexist with traditional value chains. For example, supermarkets extend networks to directly procure from producers near urban areas, whereas most rural communities depend on traditional value chains (Reardon et al. 2003; Wang et al. 2009). In East Asia, the duality of modern and traditional value chains is clear partly because of the very fast structural transformation the region went through and the initial dominance of relatively small farmers who, for various reasons, including high transaction costs, might have failed to take advantage of the modern version of value chains. The speed with which modern value chains penetrate in rural communities in the region remains a key empirical question.

In the same line, the emergence of contract farming is significant in East Asia (see Chapter 11 for further discussions on contract farming). Its impact on farm income tends to be positive, according to the literature reviews by Bellemare and Bloem (2018) and Ton et al. (2018). While the participation in contract farming makes it harder to select qualified empirical studies, Cahyadi

and Waibel (2016) and Trifković (2014, 2016) show positive income effects from the participation in oil palm contract farming in Indonesia and in catfish contract farming in Viet Nam, respectively. Bellemare and Bloem, however, argue that there is considerable heterogeneity across contexts that limits external validity, and there is an identification issue of treatment effects due to the lack of appropriate instruments that limit internal validity. Furthermore, Ton et al. (2018) point out the survivor biases leading to the publication of mostly successful cases of contract farming. On the other hand, the impact of contract farming on productivity seems to be positive, especially if farmers are assisted to access better technologies and management practices (Otsuka, Nakano, and Takahashi 2016). Saenger et al. (2013) and Saenger, Torero, and Qaim (2014) point to the importance of actual contract designs in improving product quality from field experiments conducted in the dairy sector in Viet Nam.

There may be potential scale bias favoring large farmers in modern value chains as well as contract farming (Barrett et al. 2012). For example, the contractor may prefer to reduce the number of farmers in the contract to minimize transaction costs. To meet quality standards, farmers may be required to make investments prior to participation. If this is the case, large farmers have an advantage over smallholders. Given that East Asia holds a large number of small farmers whose financial and technical capacities are limited, such a setting may lead to low participation in modern value chains or contract farming (Simmons, Winters, and Patrick 2005; Stringer, Sang, and Croppenstedt 2009). This is a clear contrast to the dominance of supermarkets observed in Latin America (Reardon, Timmer, and Berdegue 2008). In the future, however, large farmers may dominate in the production of high-value products in East Asia. It must also be pointed out that Ton et al. (2018) found through their meta-analysis that smallholders can also benefit from contractual arrangement, even though the poorest farmers are rarely included.

Conclusions

This chapter has reviewed historical paths of agricultural development and described economywide changes that had undeniable impacts on agricultural transformation in East Asia. Though the region was heterogeneous in initial endowment, labor was relatively abundant (land is relatively scarce) and land productivity was augmented through intensifications such as labor-intensive production methods as well as applications of biochemical technologies. However, more recently, the region has encountered a dramatic change

in relative factor prices due to successful industrialization by which labor was absorbed in nonagricultural sectors. In many countries, labor is not abundant anymore, and thus labor-saving methods had to be introduced, for example, replacing increasingly expensive labor by machines. Under such circumstances, the inverse productivity-size relationship is becoming less likely to hold and is being replaced by the positive relationship. Some countries are showing a divergence from the Asian path to the European path, both initially described by Hayami and Ruttan (1985).

Consistently, a reversal of the declining trend of average farm size has also been confirmed in some countries. For example, active land rental markets enable some farmers to increase operational size, whereas other farmers exit from agriculture by renting out their lands. Emerging labor shortage in the region starts creating the advantage of large-scale farming, in contrast to the conventional small-farm advantage.

High income growth and fast urbanization introduced some other fundamental transformations, such as nutrition transitions on the demand side and modernization of value chains and emergence of contract farming on the supply side, that respond to diverse and new food demands especially driven by rapid urbanization and economic growth. However, East Asia remains characterized by the duality of modern and traditional systems due to the sustained dominance of a large number of smallholders who may not meet the conditions required to enter the modern value chains. In order to sustain agricultural production in this region, large-scale institutional and technological innovations beyond the purview of Hayami and Ruttan (1985) are called for.

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