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Five inter-linked transformations in the Asian agrifood economy: Food security implications

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ABSTRACT

“Five interlinked transformations” of the agrifood system are occurring rapidly in Asia and are well along in Latin America and emerging in Africa: (1) urbanization; (2) diet change; (3) agrifood system transformation; (4) rural factor market transformation; (5) intensification of farm technology (the agricultural transformation). These transformations are linked in mutually causal ways in all directions—the transformation is of an integrated system rather than piecemeal, independent changes. This means the overall transformation has the potential to be very rapid and complicated. The new situation is not linear and easily predictable, but there remains the need to act – by both the private and public sectors – in this rapidly changing environment. Having an informed vision of these dynamic interrelationships can sharply improve the potential to act appropriately.

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1. Introduction

“Five interlinked transformations” of the agrifood system are occurring rapidly in Asia and are well along in Latin America and emerging in Africa: (1) urbanization; (2) diet change; (3) agrifood system transformation; (4) rural factor market transformation; (5) intensification of farm technology (the agricultural transformation). These five transformations are the fundamental drivers of the overall structural transformation of an economy as it modernizes, becomes more productive, and “escapes from hunger” (see Fig. 1 and Timmer, 2009).

The five transformations are occurring in waves over developing regions, with the waves roughly correlated with initial level of income and development and degree of “openness” and market liberalization. Moreover, the diffusion of the five-transformations is highly correlated with connection to urban growth nodes, or zones: (1) “dynamic, commercial zones” in the 8–10 h market catchment areas of large and medium cities; (2) “intermediate zones” that are in the pathway, over time, of urban centers’ economic “pull” of supply from rural areas, and that have medium to high potential in agro-climatic terms, but are in a situation of

under-realization of potential in terms of current performance; and (3) “hinterland, traditional, semi-subsistence zones” further from cities and in more remote and agro-climatically challenged areas.

As illustrated in Fig. 1, the five transformations are linked in mutually causal ways in all directions—the transformation is of an integrated system rather than piecemeal, independent changes. This means the transformation has the potential to be very rapid and extremely complicated. Consider first that the five transformations can be grouped in three sets: downstream/demanding (urbanization and diet change), intermediating (food system transformation in particular as rural-urban linkages) and upstream/supplying (transformation of rural factor markets and farm technology and product composition).

These three sets form a triangle, with the points mutually linked—but also a circuit along which demand flows downstream to upstream and food products and labor flow upstream to downstream. The “circuit” is driven along by three forces: (1) urban food demand pulls, and the intermediation-supply chain communicates that demand to rural areas and delivers the flow in the circuit of food products; (2) profits from farming and income from nonfarm employment of rural households (mainly local but also from migration) fund the investments by farmers in technology change and by the rural supply chain off-farm components (distribution and processing); (3) the above demand and

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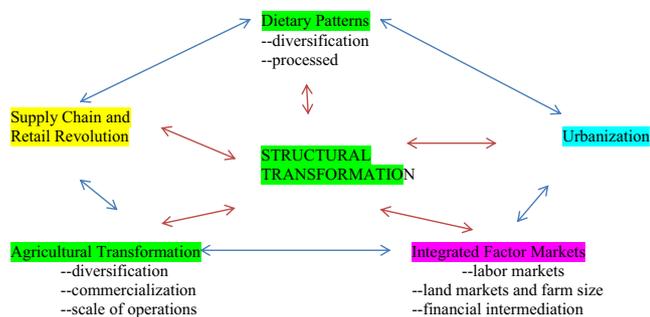


Fig. 1. Integrating the transformations of five key components of the agri-food system.

investment funding would be both stillborn but for the supply response—supply of supply-chain and rural services (like credit and water) in the factor markets, and of farm output.

The food security debate often starts and ends with the latter, farm output, but all the circuit is needed for food security as an outcome. Thus the food security debate today is “out of sync” with broader developments in the food system. In the 1960s/1970s, the debate focused on the supply side push from the Green Revolution (in the face of rapidly growing population). But the supply chain and urban demand were relatively unnoticed in that early debate; the focus was on own-demand for food among the rural millions. A half century later, when (as we show below) the urban food economy is the majority of the national food economies of Asia, the focus has shifted: in the 2000s/2010s there is growing realization that the impetus comes from the downstream pull of urbanization and diet change, and more broadly from the great turning of the “wheels of commerce” which drive modernization of rural-urban supply chains and distribution more generally.

However, the lurch of the debate from a focus upstream to focus downstream does not serve well the pursuit of food security. The latter depends on connecting urban and rural, demand and supply of products, inputs, and funding; that interdependence has grown sharply in the past decades as Asia has shifted from a predominantly rural to a predominantly urban economy, and subsistence farming has become a minor niche of the hinterlands. The national food economies depend overwhelmingly on domestic food supply (for 95% of their food, while imports are a mere 5%); they are dominated – two-thirds to three-quarters – by urban demand; the prices to consumers are highly influenced by conditions in the supply chains beyond the farm gate (for some 50–70% of the cost of food), and they are highly diversified beyond rice. A single figure suffices to sum up these points: the rice farming segment, on which Asian food security debates focus, constitutes 10% of the total value of food in the Asian economy.

The contribution of this paper is to lay out for the first time in a single framework the relations among these five transformations. To that end we briefly review the evidence related to each of them and explain their links, illustrating the latter where evidence exists. We then draw implications for the food security debate in Asia, with lessons for other regions, of the need for this integrated perspective.

2. First transformation: Urbanization

Rapid urbanization is occurring in Asia. United Nations (2011) (cited in Hazell, 2013) shows Asia was at an urban share of 45% by 2011, and estimates the share will rise to 56% by 2030 and 64% by 2050; they also estimate that the Asian rural population rose from 1.63 billion in 1970 to 2.31 in 2011, but then will decline absolutely to 2.17 in 2030 and 1.83 billion in 2050.

Population shares underestimate the importance of urban populations in the overall food economy. Urban residents typically have lower shares of food expenditure in total household expenditure compared with rural residents—but have sufficiently higher incomes that urban consumers spend more on food per person than do rural consumers. India exemplifies this: Ablett et al. (2007) note that by 2006, while 29% of population was in cities, they accounted for 43% of overall expenditures on food consumption (given higher average incomes than in rural areas).

Moreover, urbanization rates *per se* abstract from the “type of city”—that is whether its growth is linked or not to the surrounding rural area. This point applies the well-known concept of production and consumption linkages to consideration of the nature of town and city development (see Renkow, 2007). On the one hand, the urban area may have developed either as an emanation from those linkages, such as in the case of the growth of towns and cities in the Peanut Basin of Senegal, where the urban areas at least initially are built on clusters of services, upstream and downstream, to the agricultural areas. On the other hand, the urban area may develop as a relative enclave with respect to the surrounding rural area (like “entrepot” cities such as Singapore) or mining towns in hinterland agricultural areas. In the latter case, urbanization *per se* may have little effect for the local agricultural area.

However, regardless of the “type of city”, Asian urban food markets (and thus the standard of living during urbanization) depend on the midstream (rural urban supply chain) and upstream (factor markets/rural services and farming). At first this point seems counter-intuitive because it is often assumed that the cities can and often do live substantially from international food trade—from imports. But imports only constitute 5% of food in Asia, while the cities’ food share is some 65% or more.

3. Second transformation: Diet change in Asia

Income increases, via Bennett’s Law—the desire for a diverse diet (Bennett, 1954), and lifestyle changes accompanying urbanization that increase the opportunity cost of women’s time, lead to changes in product composition of demand. These include an increase in the level and shares of: (1) non-grains (meat, fish, dairy, edible oils, fruit, vegetables), plus derived demand for feed-grain for animals; (2) processed products to cook at home; and (3) prepared foods bought away from home. There is abundant evidence that these shifts are occurring in Asia (Pingali, 2007; Timmer, 2013).

The corollary is that the share and in some cases the level of cereals for direct consumption is declining (with the correlate that the share and level of meat, fish, edible oils, dairy, and fruits and vegetables are increasing). The Government of India (2010) shows that the share of cereal consumption in the urban food basket has declined from 36% in 1972 to 23% in 2006. In the same period, the share of cereals in rural areas declined from 56 to 32%. For urban and rural populations together, Reardon and Minten (2012) find that roughly 29% of India’s food economy was in cereals in 2006, versus 52% in 1972.

Diet diversification is linked with “downstream” transformation as it is spurred by urbanization. Consumption of non-grains is growing faster and/or further in urban areas than in rural areas. In India, for instance, Dev et al. (2004) show, in constant 1999/2000 rupees (per capita per month), that: (1) cereals in rural areas dropped from 137 to 109 from 1983 to 1999, while in urban areas they dropped from 120 to 107; by contrast, (2) fruit and vegetable expenditures jumped from 18 to 38 in rural, and from 55 to 74 in urban areas; (3) dairy jumped from 31 to 43 in rural, and 55 to 74 in urban areas; (4) meats, eggs, and fish actually stayed steady

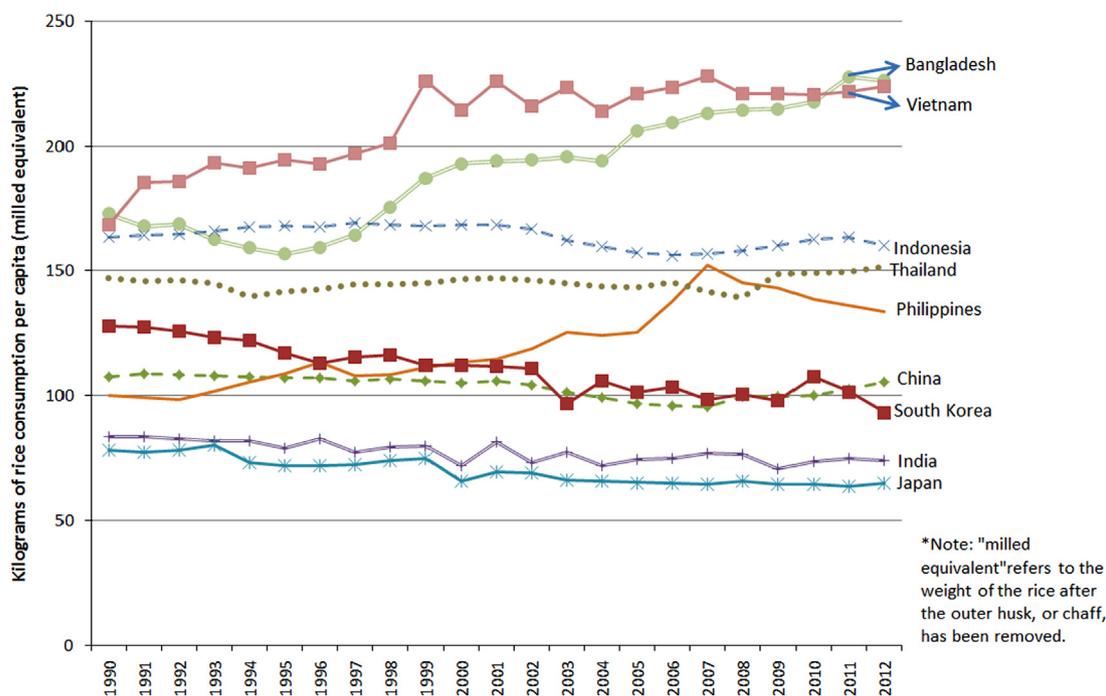


Fig. 2. Rice consumption per capita in major Asian countries, 1990–2012, using USDA data (production, supply, and distribution (PSD) database of USDA.

during that period, at about 17 in rural areas and 28 in urban areas; and (5) overall food expenditure nudged up in rural areas from 278 to 289, and in urban areas, from 357 to 410.

Of course, rice is still important in Asia. Rice is currently and traditionally the most important item in the food consumption basket of Asian countries. For example, most of the food grain consumed in Bangladesh is rice, and rice comprised about half the food grain consumed in China and India. However, there are differences between rural and urban areas. For example, in China, in 2004, urban residents consumed 51 kilograms (kg) of rice per capita, while rural residents consumed 93 kg.

Fig. 2 shows the most recent data on consumption of rice per capita, using USDA estimates of production, trade, stock changes and domestic disappearance. Rice consumption per capita is still rising in Bangladesh, has stabilized in most Asian countries, and is clearly declining in the more advanced countries. The apparent rise in Thailand is almost certainly not due to higher rice consumption by households, but to unreported stock increases.

The basic stability of rice consumption per capita shown in Fig. 2 confirms that the importance of rice as a *share* in the diet of most Asian consumers has been declining during the past several decades (Timmer et al., 2010). The decline in *relative* importance is expected to continue for some time because (1) the income elasticity of rice demand is falling over time as incomes rise in Asia, and is now significantly negative for Asia as a whole; (2) as rural-to-urban migration occurs, rice consumption shifts downward; and (3) rice demand seems to be lower among younger age groups.

Whether the absolute level of rice consumption is declining in Asia is controversial. As Fig. 2 shows, time series data from food balance sheets, which are based on rice production data, show a decline from the mid-1990s to the mid-2000, with an increase to about 2007/2008, and a modest decline since then. Household survey data continue to show declining rice consumption among all urban groups and among most rural households. The household data also reveal substantial heterogeneity among age groups, regions within countries, and across the economies themselves, but the overall trend is clear (Timmer et al., 2010, and Timmer, 2013).

Table 1

Food balance sheet data from FAO.

Year	Japan	Malaysia	South Korea	Indonesia	Indonesia (SUSENAS)
1990	65.2	83.1	97.2	127.2	115.4
2009	54.0	74.0	81.3	127.4	91.6

The following data compare some representative rice consumption data from Food Balance Sheet sources (using reported rice production as the foundation) with data from the one large country where the FBS data can be compared directly with household expenditure data that report rice consumption directly. All the data are in kg per capita per year, milled rice equivalent. Quite clearly, the Indonesian rice consumption from the Food Balance Sheet data, based on reported rice production, overstate the level of rice consumption as reported at the household level. More troublesome, the bias has increased dramatically in the two decades between 1990 and 2009. The advantage of looking at rice consumption levels in the more advanced countries – Japan, Malaysia, South Korea – is that they offer a perspective on the future for the lagging countries – Indonesia, China and India. The future of rice consumption in Asia will be largely determined by these three countries Table 1.

Even with Food Balance Sheet data, the upshot is dramatic. By 2009, only 28% of calories in Asian consumers' diets came from rice (comprising 5% of their food budget in money terms), down from 38% in 1975. The calories from rice changed in the PRC (from a low of 444 in 1961 to a high of 872 in 1990, then dropped to 794 by 2009) and India (from a low in the 600 s in the 1960–1970s to a high of 781 in 1990, then dropped to 676 in 2009). The calories from rice rose slightly in Bangladesh in absolute terms (from a high in the 1500 s in the 1960–1970s, down to 1311 in 1980 and 1473 in 1990, and up to 1727 in 2009), as Bangladesh rode through the Green Revolution, a prolonged crisis, and a long recovery.

Offsetting the fall in rice consumption in Asia, there has been a rise in wheat consumption—and wheat imports (see Fig. 3 for Southeast Asia). Wheat is still minor in most Asian countries compared with rice (except in India and China). But the rise of

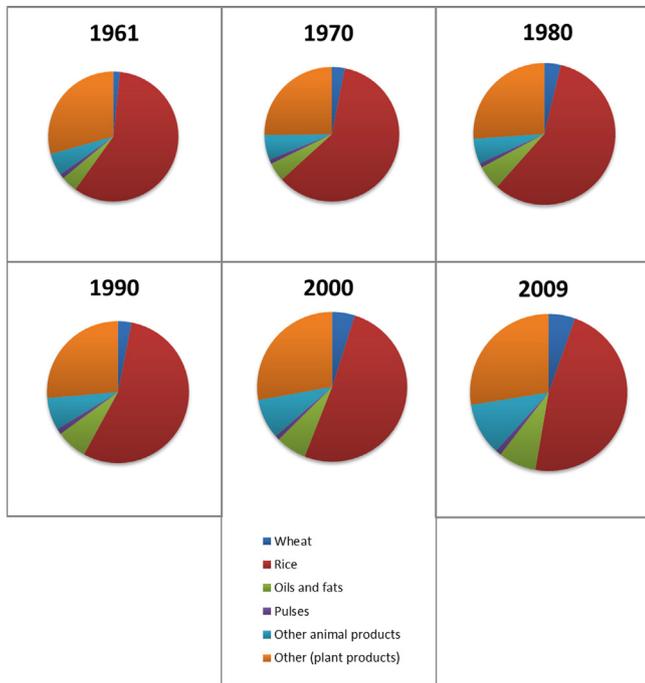


Fig. 3. The dietary transformation in Southeast Asia.

wheat from a low base to a significant presence in consumption is especially marked in Southeast Asia (Timmer, 2013): from 1 million metric tons of imports of wheat in 1961 to 13 million tons by 2010; wheat was 2.8% of the level of rice consumption in 1961, and by 2009 was up to 11.5%. Senauer et al. (1986) documented the early stages of this rise of wheat in Sri Lanka in the 1980s. In both cases, the rise of wheat brought increases in imports as Sri Lanka and Southeast Asian countries do not produce wheat. A similar process in Africa sees the rise of rice imports, also fulfilling convenience needs in urban areas (Reardon, 1993).

Diet patterns are malleable in Asia, with “traditional food culture” appearing to be only moderately constraining these shifts. Many non-traditional food products have quickly become “traditional” and widely diffused in Asia. For example, Central/South America’s products (potatoes, tomatoes, chili peppers, corn, pineapple, papaya) have become leading food items in Asia.

Diet transformation is also linked to and dependent on mid-stream (supply chain) and upstream (factor market and farm technology and product composition) transformations. A shift toward more consumption of non-grain foods and more processed foods is conditioned by supply side factors that vary over time, over countries, and over product types. Several factors in Asia have been amenable to the shift over the past 20 years.

First, except in the case of rice and wheat penetrating diets in Africa (and wheat in Southeast Asia), imports are not driving diet change—although “Westernization” of diets is clearly a factor. Imports as a source of food are minor as a share of total food consumed. Rather, domestic farm supply of non-grains is rapidly increasing: farmers are undertaking agricultural diversification toward fruits, vegetables, fish, meat, and dairy has been proceeding apace in Asian countries (Pingali, 2007). Rao et al. (2006) note for India that there is a strong correlation between agricultural diversification on the one hand, and the urban share and road and population density of the district in India; urbanization and infrastructure development have thus encouraged that diversification over the past several decades.

Second, domestic supply chain development after the farm-gate is facilitating the supply of non-grain products to Asian cities. Supply chain actors (off-farm) have invested enormous sums in

rural-urban supply chains for non-grain products: storage, packing, logistics/shipping, and commercial services. These services are developing rapidly in Asia, both in the modern large-scale sector and in the informal, small-scale sector. A clear example is the very rapid emergence in the 2000s of potato cold storage facilities in western Uttar Pradesh (to serve the Delhi market, where fully two-thirds of potato consumption is now from cold storages in nearby production areas) (Reardon et al., 2012a) and even in poor areas of Bihar (Minten et al., 2011).

Third, farmers have made enormous investments in livestock husbandry, fruit and vegetable farms and associated irrigation, and aquaculture in the past decade. This is dealt with further in the last transformation.

4. Third transformation: Food system transformation in Asia

The food system (a general term for food supply chains and markets) transformation is taking place along several lines in Asia.¹ Most important is the transformation of the “post farm-gate” segments of the supply chain: wholesale/brokerage/logistics/cold chain, processing, and retail. About 50–70% of the total costs of food (depending on the product and the situation) to the urban consumer are incurred in these segments.

The transformation of the post farm-gate segments is intimately connected with urbanization, because the majority of food supply chains in Asia already are from rural to urban, and many of the post farm-gate activities are in towns, secondary and primary cities.

Here we briefly review key evidence on the food system transformation in Asia (mainly) and some initial evidence for Africa, drawing from Reardon and Timmer (2012) and Reardon et al. (2012b); most of the evidence comes from the 2000s as the food system transformation has been relatively recent.

There has been a dual revolution in food, comprising:

- A “Modern Revolution”—large scale, largely retail and second-stage processing sector focused transformation, with an important component of FDI (Reardon and Timmer, 2007);
- A “Quiet Revolution”—mainly small and medium scale, largely first-stage processing and wholesale as well as upstream agricultural services—mostly based on domestic capital (Reardon et al., 2012a).

Reardon and Timmer (2007) emphasize that there have been two “broad phases” of agrifood industry transformation over the past 50 years (in both Asia and Africa): “pre-liberalization/pre-globalization” (mainly 1960s–mid 1980s) and “liberalization/globalization” (mainly mid-1980s to now). Contained within those two stages are the successive transformations of the three segments of the agrifood industry. The timing of the transformation of each segment is approximate, as it differs by region and country: (1) transformation of wholesaling, in two waves, with a public-sector driven stage mainly in the 1960–1990s, and a private-sector driven stage mainly in the 2000s; (2) transformation of processing, with a public sector phase mainly up through the 1970s, and then a private sector stage mainly in the 1980s to now; (3) and then the transformation of retailing, with a small public sector stage in the 1960–1980s (or later in some cases such as India), then a private sector stage mainly in the 1990–2000s.

Overlaying the above two broad phases are a series of waves of transformation of food systems. The first wave tended to be the

¹ In Latin America there are parallel stages – more advanced – and in Africa these stages are less advanced and in some cases just emergent.

Asian developing countries that started their post – WWII growth spurt earlier, urbanized and started industrializing somewhat earlier – in particular, East Asia outside China. The start of wholesale sector transformation (with major investment in wholesale markets) started in the 1960–1980s, processing transformation occurred with FDI liberalization and the start of privatization in the mid- 1980s to early 1990s, and retail transformation “took off” from the early 1990s.

The second wave tended to be the countries that had their growth and urbanization spurts later and/or had strong internal pressure to limit FDI; these limits were often more for retail FDI than processing FDI. Hence one found that in much of Southeast Asia (outside Vietnam, Cambodia, Laos and Myanmar), wholesale sector transformation started in the 1970s, processing transformation took off in the 1980s but retail transformation did not start until the mid to late 1990s.

The third wave tended to be countries that had their growth and urbanization spurts mainly in the 1990s/2000s, and/or had lagged liberalization into the 1990s. This was the case of China, India, and Vietnam, among others. Wholesale sector transformation mainly occurred (in its wholesale market investment phase) variously over the 1970s to the 1990s; processing transformation then occurred somewhat before retail, with the latter mainly in the late 1990s and into the 2000s, with China starting well before India and Vietnam.

A fourth wave includes other South Asian and Southeast Asian countries, like Bangladesh and Cambodia, that are in the initial phases of processing and retail transformation. Moreover, diffusion of the transformation (in all three segments) tended to occur earliest in more urban and later in more rural areas, and earliest and fastest in processed, then semi- processed, then fresh products.

There has been rapid transformation of the wholesale/logistics segment. This started with rapid growth, then transformation, and then in some cases decline, of the public wholesale market sector. State wholesale markets were substantial investments by cities or provinces, and were put in place in waves mainly from the 1960s on, starting with main cities, then secondary cities, and so on. A typical pattern was a hub-and-spokes model, with a set of primary wholesale markets in big cities and then “feeder” or secondary wholesale markets in smaller cities and rural areas, such as one finds in China, Indonesia, and India.

The large investments in public wholesale markets partially transformed this segment—substantially “de-fragmenting” and integrating markets, by providing “economies of agglomeration” and channeling wholesale from field brokers into a network of covered markets with *in situ* wholesalers, and thus also altering its technology and organization. By imposing regulations, it changed its institutions, at least for the portion that passed via the regulated markets.

The massive proliferation (even into towns) of wholesale markets, the extension and improvement of rural roads, and the regulatory liberalization of their operations in most countries opened the door to progressive “dis-intermediation” in the rural areas and in supply chains. Two important trends are involved. First, the regulatory changes (such as in some states in India) that have liberalized the wholesale sector have also favored direct private sector relations with farmers—such as (incipient) development of contract farming by processors and collection centers by supermarket chains.

Second, the diffusion of wholesale markets in towns near or in rural areas, and the improvement of road systems leading from rural areas to urban wholesale markets, has spurred “disintermediation,” the decline of village traders in diverse settings, and development of direct purchase from farmers by wholesale market traders who often formerly had to procure via village trader

networks (see Reardon et al., 2012a for cases of rice and potatoes in India, China, and Bangladesh).

Now, wholesale market traders based in towns and cities dominate, buying directly from farmers and “dis-intermediating” the supply chain by displacing the traditional village trader. For rice, village mills have declined rapidly in the past decade—if persisting, they are relegated to custom milling for local farmers for home consumption. Instead, small but especially medium and larger scale mills have risen to dominance and are located in the towns. By contrast, less-dynamic areas are starting to follow the above trends, but they are doing it with a strong lag and much more slowly than the dynamic areas (Reardon et al., 2014).

There has even been an incipient emergence of various “off-market” actors specialized in meeting the sourcing requirements of modern processors and supermarkets. The first of the modern wholesale actors are the “dedicated wholesalers” (such as Bimandiri in Indonesia). These wholesalers are dedicated to either one company or a segment (such as modern retail, processing, or HORECA (hotels, restaurants, catering) or exports), tend to be specialized in a category, and handle procurement relations suppliers.

The second of the modern wholesale actors are modern logistics companies. Commonly they undertake a variety of logistics tasks—wholesaling (intermediation), warehouse management, ICT system integration into retail and distribution systems of companies, cold chain development, and packaging. FDI has been an important driver of the rise of this second type of firm; this was spurred with the liberalization of FDI in “distribution” (logistics and wholesale) as part of general liberalization in the 1990s and 2000s.

There has also been rapid transformation of the agrifood processing sector in Asia. The general debate about food systems fails to realize how large a share of food in developing Asia undergoes some processing. Morisset and Kumar (2008) show for Indian urban areas that only 16.8% of food undergoes no processing (like fresh whole fruit); that share is 15.3% in rural areas. In India that means about 85% of all food undergoes some processing: grain milled, made into bread or polished rice; milk churned, fermented; and so on. Of course, a high share can be classed as “first processing” with low value added (up to 5%), with 35% of urban food, and 44% of rural food, in this category; first processing high value added (5–15%, is some 38 and 35% respectively. Second-processing food reaches only 10 and 6% of food in urban and rural areas.

The processed food sector has grown quickly in the past several decades; this growth is mainly in the first-stage high value added and the second stage processed food subsectors, such as milled and second-stage processed cereals, dairy, processed meat and fish, and condiments. These trends are driven by increases in income, urbanization, women increasing their participation in labor markets outside the home and wanting to save time cooking, improvements in packaging and processing technologies, and eventually by diversification of the variety of processed foods, abetted by modern retail (Gehlhar and Regmi, 2005).

The public-sector role in food processing has always been limited (more so than it seems when viewing the large role it had in public policy debate), and today is very small. Although the parastatal grain processing sector has been important in urban food security debates for decades, the government’s direct role in inducing food processing transformation has been limited in most countries, even in its heyday in the 1960s/1970s. It was mainly confined to grain sold to urban markets. In that period, the urban population share and the marketed share of grain were lower than today. The local small-scale (and thus not parastatal) share of grain processing was higher. And the parallel market (not via parastatals) was often larger than the government channels. There was

then rapid privatization of grain parastatals in most countries in the late 1980s or 1990s.

Only a few countries' governments still had substantial food processing operations into the 2000s. For example, in Asia it is only India that maintains a substantial presence via its grain parastatal; even that only procures 20% of India's grain output (and 40% of the market, which is even higher than in the 1970s). The numbers are far lower in other Asian countries (Rashid et al., 2007), and far lower yet in other regions.

Since the late 1980s (earlier than the supermarket revolution in most cases), there has been rapid growth in the private-sector food processing sector in developing Asia—combined with rapid consolidation, multi-nationalization, and technological, institutional, and organizational change. In many countries, with structural adjustment in the 1980s and 1990s, state grain mills and slaughterhouses were privatized or eliminated, and import licenses disbanded. The private sector has made significant investment in processing. This led to two competing lines of consequences.

On the one hand, there was a proliferation of small and medium scale enterprise (SME) grain mills and dairy, meat, fish, and produce processing, encouraged by market de-regulation, competing for the gap left by the demise of public sector operations and de-licensing of processing, and diversifying products for growing urban and rural markets. An example of such proliferation was observed for example in rice mills and potato cold stores in India, Bangladesh, and China (Reardon et al., 2012a).

On the other hand, privatization led not only to domestic private sector bids, but due to widespread liberalization of foreign direct investment (FDI) in processing, a wave of FDI, as well as domestic private and domestic state investments in large-scale plants. The FDI came first mainly from Western Europe and the US, with global firms like Nestle, Kraft, Danone, seeking less saturated markets with higher profit rates (Gehlhar and Regmi, 2005), then Japan, and eventually from regional multinationals such as Thailand's CP (Charoen Pokphand) or Singapore's Wilmar into China and other Southeast Asian countries and India. In 2012, CP created the largest shrimp processing firm in the world in Indonesia. The consequence was that foreign firms formed a major share of the large processing sector in a number of first and second wave countries by the 2000s, while that process appears to be just starting in third wave countries like China and India in the 2000s.

There has been rapid consolidation in developing Asia food processing, again, in the sequence roughly of the three waves. Regulations affecting the segment appeared to accelerate the pressures on SMEs. Examples include re-zoning of cities to reduce congestion, application of business registration laws to increase municipal revenues, and application of food safety and hygiene regulations to food. The new generation of food safety laws emerging in developing countries, such as the ones in China and India, may further accelerate consolidation in the processing sector. There is evidence that this occurred in the US with the impact of the food law of 1908 on food SMEs through the 1910s, such as with the exit of 90% of dairy SMEs in the main eastern cities (Levenstein, 1988). While the "pie" of the sector was increasing rapidly, the massive investments by domestic and foreign firms, creating or enlarging large-scale processors, has resulted in out-competing many small firms.

Finally, the retail segment has transformed very rapidly, especially in the past decade. As with processing, many governments had several types of public sector cum cooperative retail ventures, mainly in the 1970s/1980s and even into the 1990s/2000s in the cases of India, Vietnam and China. At the end of that period, with structural adjustment or liberalization, most were dismantled or privatized, although some continued into the 1990s/2000s and "morphed" into competitors with modern-private chains.

In the 1990s and 2000s the "take-off" of private-sector modern retail occurred—what has become known as the "supermarket revolution" (Reardon et al., 2003). In broad strokes, the diffusion of modern food retail has rolled out in three waves over Asian countries (Reardon et al., 2012b). A similar set of waves rolled out over Latin America and Africa. In all these cases, there was a slow initial spread and then "suddenly" a takeoff.

Inside a country, typically the diffusion has spread in the following two sets of paths: (1) from large cities to small cities and finally into rural towns in adapted formats, and from upper to middle to poorer classes; (2) from processed foods to semi-processed foods to fresh produce. These paths are essentially the same as occurred "historically" (in the 20th century) in developed countries; for example, it took almost 40 years for US supermarkets to start selling vegetables, as consumers had been used to buying them only in wetmarkets, from hawkers, and from tiny shops.

The descriptive work on these trends has also found the gradual diffusion of modernization in retail and processing company procurement systems, mainly in semi-processed and processed foods (that form 85% of supermarkets' sales, reflecting, as noted above, the consumption basket), and recently and incipiently, in fresh produce procurement. The modernization provides a cost advantage to the large and an acceleration of consolidation inside the modern retail segment, even at early stages. This allowed the driving down of prices (such as has been observed in Delhi, see Minten et al., 2011). The foremost impact of the transformation of retail has been on the processing sector, as some 85% of the food sold is processed to some degree. There is emerging evidence that supermarket chains' buying direct from processors is excluding small processors.

Direct purchase of fresh produce by supermarkets from farmers is still rare in most Asian countries, except where there are larger agribusiness producers on the supply side (such as supermarket chains in Indonesia buying directly from large potato production companies). Rather, supermarket chains tend either to still buy from wholesale markets, or to buy fresh produce from specialized/dedicated wholesalers (as in the Bimandiri case in Indonesia) who in turn tend to buy from sets of preferred suppliers.

Above we note that each segment of the food supply chains of Asia is transforming; but it is important to note that overall the supply chain itself is restructuring. It is at once "lengthening geographically" and "shortening inter-mediationally." The former implies that food markets are integrating over districts in a zone and zones in a state and states in a country; it also implies "de-seasonalization" of the market, such as Reardon et al. (2012a) show for the potato market in India, Bangladesh, and China. This lengthening represents the increase in the "merchant catchment area" of the cities as each grows in population and thus food market reach; this was demonstrated for Europe and China in the middle ages and renaissance period by Braudel (1982) and one sees it in Asia today. Intermediational shortening by contrast implies dis-intermediations ("fewer hands in the chain"): this is not just the cutting out of village traders noted above, but retailers starting to buy direct from large processors, processors from farmers in emerging contract farming, and large retailers and large processors procuring ingredients via specialized wholesalers.

Beside the food supply chain transformation being influenced by urbanization and diet change as we discuss above, the chain's transformation itself influences both downstream transformation (in urban food markets and diet composition) and upstream (in factor markets and in farming). First, supply chain transformation affects urban food markets and diet transformation. On the one hand, supply chain changes of the types noted above can reduce urban food costs (via dis-intermediation and investments in large scale operations with economies of scale and larger procurement

zones due to longer supply chains). Modern procurement systems can reduce food prices relative to traditional systems, such as Minten et al. (2010) show for Delhi's supermarket chains. Long supply chains, especially if they draw from a variety of regions that have little co-variation in climate risk and shocks, can also decrease instability of supply.

On the other hand, (geographically) longer supply chains feeding cities carry risk for cities. A long supply chain may decrease seasonality of the food supply, but can expose the city's food supply to climate shocks (such as floods along the route) and energy cost shocks (that weigh more heavily on supply chains with higher transport costs to begin with). These shocks can be mitigated by investments such as: (a) more energy efficient equipment, (b) greater scale economies to outweigh energy costs; (c) greater storage capacity such as larger distribution centers with greater cold storage area; d) redundancies in supply chain facilities to handle outages, such as CP's building redundant port facilities inland to handle primary port outage in Thailand.

Food safety (and bio-terrorism) vulnerability also increases with longer supply chains and more massive scale of operation, especially obviously for perishable products. The rapid climb in the urban consumption of the latter, combined with change in supply chains, exacerbates that vulnerability. It is unlikely that Asian cities will opt out of supply chain investments toward the kind of transformation we note above, to go "backward" to short local supply chains that are sharply seasonal and more expensive (and possibly more energy using) per ton/mile of food supply. Rather, what seems to be a probable continuation of supply chain transformation, combined with these frightening and costly vulnerabilities, imply large investments in cold chain, diversity of routes, scale, and so on—all of which will magnify and further hasten the structural transformation toward larger scale enterprises.

Second, supply chain transformation is closely linked (in both directions) with the development of upstream factor markets (that in turn condition farm development) in several ways: (a) supply chain finance, both traditional and nontraditional, is a direct rural credit supply (often in credit-output "tied" markets; however, with supply chain transformation there is evidence for example in India and Bangladesh of the demise of trader credit to farmers, even while it persists at other levels of the supply chain); (b) off-farm employment demand, as rural processing and distribution services are an important part of rural nonfarm employment (and thus a major source of investable cash to farmers); (c) a direct source of inputs like farm machinery, manufactured in cities (and sometimes featuring traders "backhauling" food products).

Third, supply chain transformation directly conditions farm segment transformation in several ways: (a) most importantly, the degree of development of the supply chains conditions farm profitability in general and the potential for commercialization; this is why we find the latter highly developed in the rice value chains feeding large cities in India, Bangladesh, Vietnam, and China (Reardon et al., 2014); (b) the "depth" of the market, a function of the development of the supply chain, conditions market risk faced by farmers. Of course it is possible that supply chains also bring from the city processed foods or competitive fresh foods from other regions and form a source of competition risk for local farmers. That can induce competitive investment (just as it can induce the exit of asset-poor farmers or those with poor access to rural services markets).

5. Fourth transformation: Development of rural factor markets, especially the rise of the rural nonfarm labor market

Rural factor markets include: (1) labor markets in the farm sector and the nonfarm sector; the latter also includes activities in

the off-farm components of the agrifood system like processing, wholesale, and transport; (2) credit markets; (3) other farm input markets including fertilizer, other farm chemicals, water, and farm machinery; (4) land rental and purchase/sale markets. There is strong evidence of the very rapid development of all of these markets in Asia in the past 10 years.

All these are important to farmers (and rural actors in the rest of the food supply chain) to respond to market growth and change induced by urbanization and diet change. The rural services of these markets are crucial to enabling farmer supply response to the developing urban markets. Rural processing and logistics services, and credit, water, land, information, and wholesale and cold store/warehousing are key to farmers' capacity to undertake intensification, commercialization, and product and quality/safety upgrading. These needs of farmers are often cited in the literature, but the economics of the rural supply of these services (apart from credit) is seldom discussed or analyzed but are crucial.

Here we focus for illustration on the importance of these factor markets in enabling upstream supply. Rural nonfarm employment (RNFE) has grown over the three decades to be an important share of rural employment and incomes in Asia. RNFE income is important to rural Asians. Haggblade, Hazell, and Reardon, henceforth HHR (2007, 2010) note that, based on review of a number of surveys in various Asian countries, that the average share of rural nonfarm employment, RNFE (employment in manufactures and services, in rural areas) is 40% of total rural incomes; migration income is an additional 11% of total rural incomes; these two (local plus migratory nonfarm income) sum to 51% of rural incomes. RNFE employment in general is much more important to rural Asians than migration employment and farm wage labor.

RNFE activities tend to be mainly services (commerce/transport including of food products and inputs, personal services like repairs or tailoring, and construction) and about a quarter to a third, manufactures (HHR, 2010). The activities are a mix of: (1) casual wage employment (for relatively low wage, sometimes often below or at the agricultural wage (as in Bangladesh) or modestly above the farm wage (as in India); (2) salaried "regular" employment (like a government employee, e.g. a rural teacher); (3) self-employment (such as owning/managing a micro/small enterprise making cheese).

The casual wage jobs, and the self-employment jobs (although these vary markedly in returns) are typically relatively low return, while the salaried employment (and some self-employment) are high return. It is important to note that the returns can vary widely across these activities; for example, for Bangladesh, Hossain (2004) showed a long list of RNFE activities ranging from earnings of 4 taka/day to 27.5 taka/day.

Zones with low aggregate demand can manifest low-return RNFE diffusion. That low aggregate demand can be from poor agriculture without other sources of income (HHR), or growing agriculture in a zone with poor links to cities (such as shown for Bangladesh by Deichmann et al., 2009), or to export markets so that the farmers cannot "realize" sufficient profit from agricultural development; the most extreme case is where production causes a glut and a price decline. One can find then a paradox of a combination of growing or high level of RNFE (of the low return variety) and stagnant agricultural zones.

RNFE develops especially in proximity to cities and towns. This is a key point that links discussion of urbanization and of RNFE in Asia. Renkow (2007) analyzed conceptually the links between RNFE development clustering around cities and towns, and the presence of agglomeration economies from urban and rural areas as a centripetal force of RNFE toward proximity to urban areas, and congestion diseconomies in urban areas as centrifugal forces to push NFE from cities into surrounding rural areas.

Several empirical studies have tested and confirmed this hypothesis, showing RNFE clusters near cities/towns; this suggests that RNFE may grow with towns and thus urbanization in general. For example, for Bangladesh, [Deichmann et al. \(2009\)](#) found that in the areas near cities and towns, the RNFE share of rural incomes was 56%, versus only 41% in the hinterlands. The hinterland features RNFE of the low-return type, while RNFE near towns is higher-return wage and self-employment. Moreover, crossing the analysis of effects of urban proximity and agricultural potential shows that high potential farm areas that are near to cities have a lot of high-return wage and self-employment RNFE—but that if the high potential farm area is far from the city (and thus aggregate demand sources and agglomeration economies), the share of high return RNFE is low and low return RNFE by far predominates, often just focused on local services; they note that 28% of the latter is at a return below even the low farm labor wage ([Deichmann et al., 2009](#)).

RNFE and rural-urban (and international) migration remittances in turn appear to facilitate purchase of farm machines (such as [Estudillo and Otsuka, 1998](#) and [Takahashi and Otsuka, 2009](#) show for Luzon, Philippines in a panel study) and other lumpy investments that permit diversification. Also, RNFE and migration remittances are one way (beside labor- and capital-led intensification, discussed below) for farm households to continue to farm very small farms as part time farmers ([HHR, 2007](#)).

However, urbanization in/near rural areas can be a two-edged sword for RNFE: urban manufactures, produced for mass markets using large scale plants enjoying economies of scale, may compete with RNFE-supplied manufactures. The cities and towns in rural areas, and the rural roads and inter-city highways are conduits from urban industry to rural areas of these products. This can challenge small scale rural manufacturing with both cost and quality and variety competition.

Rural nonfarm employment is, surprisingly (given it is nearly half of rural household incomes in Asia) usually “relegated” to only its role in livelihoods and risk and poverty reduction for rural households (of course an important subject)—but its role in financing investments in rural services more generally, in supply chain services in particular, and being a major funder of farm investments in particular, is neglected in the debate.

6. Fifth transformation: Capital-led farm technology intensification in Asia

Over the past three decades in Asia (with significant variation over locations), there has been “intensification-cum-commercialization/diversification”: (1) farms have commercialized; (2) the agricultural sector has diversified (into non-grains, mirroring the diet diversification) while individual farms have specialized (into cropping, or livestock, poultry, aquaculture); (3) farms have shifted from non-purchased to purchased input use (from human to animal to machine power, from manure, byproducts, and residues to chemical fertilizer, and to use of more pesticides and herbicides) ([Pingali and Rosegrant, 1995](#); [Cassman and Pingali, 1995](#); [Estudillo and Otsuka, 1998](#)). These changes occurred earliest and fastest in the “classical Green Revolution” zones, particularly lowland rice systems and irrigated wheat areas. It should be noted however that in these areas as early as the mid-1990s/early 2000s there were warnings that yield growth had begun to plateau despite this intensification (see [Cassman and Pingali, 1995](#)).

A second wave of this intensification-cum-commercialization occurred, also mainly still in rice and wheat and horticulture areas, in zones that in the 2000s were “catching up” with the initial Green Revolution zones; e.g. in western and central Uttar Pradesh in India, northern Bangladesh, and northeast China in rice and

potato (see [Reardon et al., 2012a](#)). There was another source of intensification with the development of horticulture in the 1990–2000s (see for India, [Joshi et al., 2004](#), and [Birthal et al., 2012](#)).

The increase over several decades of the farm wage drove a continuous rise in the use of farm machinery—first for “power” replacement of human and animal power, for example in land preparation, and then “control” replacement for harvesting and weeding (with the latter also and especially addressed by the rise of the use of herbicide) ([Pingali and Rosegrant, 1995](#)).

Machine-using intensification is linked with rural factor market development. RNFE (and thus urbanization, by extension, given the discussion above) appears to have two way effects on the increase in farm machines. On the one hand, RNFE and migration remittances are associated with ownership of machines, as RNFE provides cash to buy the machines (as credit for machine purchase is usually limited); [Takahashi and Otsuka \(2009\)](#) illustrate this in the case of Central Luzon in the Philippines over 1979 to 2003. On the other hand, using farm machines also frees labor for both migration to cities and local RNFE; a similar effect comes from using RNFE cash to replace home labor on farms with hired farm labor, as shown in [Takahashi and Otsuka](#).

Empirical studies find that RNFE is poorly correlated with use (rather than ownership) of farm machinery—mainly because of the existence of active rental markets for farm machines, that appear to have grown quickly over time. Rental of farm machines has further developed recently with the spread of outsource- services of teams of labor with large harvesting machines in China that go from province to province harvesting rice ([Yang et al., 2013](#)). This allows economies of scale on the machine side to small farmers which are analogous to small farmers on the output market side dealing with post-harvest services that are increasing in scale. Thus small farms are wedged between consolidating and scale-increasing services on each side of them in the supply chain.

Areas well served by rural roads, and those closer to urban areas, have lower transaction costs of getting inputs, and higher use rates. Striking findings of differences in external input use between hinterland and non-hinterland areas are found in the [Fafchamps and Shilpi \(2003, 2005\)](#) study on Nepal, for three states in India, comparing dynamic/connected and hinterland areas. There is however the methodological issue of controlling for agro-ecology when examining the impact of urban distance and rural road density; hinterland areas can often be mountainous or arid areas. That is why the study by [Deichmann et al. \(2009\)](#) in Bangladesh is particularly interesting for its crossing of distance to city with agro-ecological indices.

Areas that are generating RNFE and migration remittances can also exhibit capital-led intensification. This is a complex and sometimes ambiguous relation. On the one hand, nonfarm income can generate cash to invest in farm machines and inputs, and even hired labor, as [Takahashi and Otsuka \(2009\)](#) illustrate; this may be even more marked in areas with credit constraints. On the other hand, in some areas nonfarm activity can be a substitute for intensification, relieving the need for it (including where agro-ecological conditions make it impractical) by diversifying income.

7. Conclusions and policy implications

It is often hard to see the role of public sector policies and investments in such a complex and rapidly changing system. Our story has focused on describing the rapid changes and identifying the key drivers that link them together. Policy has been in the background, although public investments in infrastructure, especially rural roads, communications systems, power grids and

irrigation were seen as essential ingredients to virtually all of the five transformations underway. Still, the impact of policy has also been pervasive, if somewhat unnoticed.

First, despite the role of local *supplies* filling local demand, the openness of economies to international trade, investment, and global price *signals* has been essential to productivity growth on the farm and along the entire supply chain. Both Indonesia and India clearly suffer from an over-emphasis on self-sufficiency in basic foods and an under-emphasis on being competitive on their farms and in their markets. Providing stability to domestic food systems is a worthy goal, but local self-sufficiency campaigns have a poor track record even on this score.

Second, the public sector budget allocated to agriculture and the food system is not a reliable guide to effective public support. In particular, subsidies for “private” goods such as fertilizer and power contribute little to productivity growth in the longer run. For this, public goods such as agricultural research and development, high-quality public education reaching to the PhD level to train local researchers and analysts, and transparent regulation of financial and commodity markets to provide equal access and greater stability are far more important.

Finding the appropriate balance between an effective public role and an efficient private role in the modernization of agriculture narrowly and the entire food system more broadly has always been a difficult challenge. It requires careful analysis and a technocratic capacity, even within the most vigorous of democratic governments, to do the “right” things and not do the “wrong” things. The political economy of this is, of course, tricky (Timmer, 2012). But finding this balance has always been the essential ingredient in starting this dynamic set of transformations rolling and keeping them on a path of inclusive economic growth that is the only way to provide food security in a sustainable fashion.

Several key *analytical* lessons also emerge for food security strategy formulation from the above analysis.

First, significant inter-dependence now exists among the downstream (urbanization and diet change as sources of food demand change), midstream/intermediation (the supply chain), and upstream (the combination of rural factor/service markets and the farm segment). Any food security strategy that focuses on one of these points of the triangle and neglects the others will fail in this new era of large urban markets, rural-urban linkages, and the need for the enabling of farm intensification and commercialization. Neither urbanization *per se* nor farm technology upgrading *per se* will be sufficient.

Second, the corollary of the first point is that *productivity growth* in all five components is important for overall food security. As emphasized above, the immediate source of productivity growth is nearly always via private sector investments, but these are significantly, often critically, conditioned by the nature of public policies and investments.

Third, because of their interrelation and mutual facilitation, the overall transformation of the agrifood sector can be very rapid and complex. The new situation is not linear and easily predictable, but there remains the need to act – by both the private and public sectors – in this rapidly changing environment. Having an informed vision of these dynamic interrelationships can sharply improve the potential to act appropriately. This points to the strong need for detailed surveys of all the segments of the agrifood value chains in the region to track the transformations discussed in this paper, and redress data gaps.

Finally, it is important to move the food security debate out of its silos—rural development and food security, food supply chains/agri-business and food security, urbanization and rural development. In the modern world these are bundled and interconnected. The food security debate should be too.

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