Rapid transformation of food systems in developing regions: Highlighting the role of agricultural research & innovations

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A B S T R A C T

Developing regions’ food system has transformed rapidly in the past several decades. The food system is the dendritic cluster of R&D value chains, and the value chains linking input suppliers to farmers, and farmers upstream to wholesalers and processors midstream, to retailers then consumers downstream. We analyze the transformation in terms of these value chains’ structure and conduct, and the effects of changes in those on its performance in terms of impacts on consumers and farmers, as well as the efficiency of and waste in the overall chain. We highlight the role of, and implications for agricultural research, viewed broadly as farm technology as well as research pertaining to all aspects of input and output value chains.

Methodology

Scientific method of “causes (conditions and shocks), behavior/mechanisms, effects”; evidence base is review of survey and case study evidence.

1. Introduction

The “food system” (the dendritic cluster of R&D value chains and the value chains linking input suppliers to farmers, and farmers upstream to wholesalers and processors midstream, to retailers then consumers downstream) has transformed enormously over the past 50 years. The most rapid change occurred only in the past 25 years. It shifted from being a traditional system to a mix of transitional and modern. From a historical perspective, the transformation was abrupt, not gradual. Reardon and Timmer (2014), illustrating with Asian evidence, explain the drivers as a confluence of “five interlinked transformations:” (1) Downstream demand side change “pulling” system transformation: (a) urbanization; (b) diet change; (2) Midstream/downstream change, “intermediating” system transformation: (c) change in retail, wholesale, logistics, and processing; (3) Upstream change, “feeding” system transformation: (d) intensification of farming; (f) farm input supply chain change.

Our paper extends the above work by comparing transformations, extending analysis to Africa and Latin America and updating analysis of Asia. We also extend the analysis to the role of agricultural research as a determinant of food system transformation. Here “agricultural research” includes both research on the inputs and farm segment (breeding, input design, agronomic practices, and so on) and research on the off-farm post-farm segments (on technologies and organization of processing, packaging, logistics, wholesale, retail).

We address four questions:

(1) How are food systems transforming?
(2) How have research and non-research factors (urbanization, income growth, diet change, policies) influenced food system transformation?
(3) What have been the effects of transformation on consumers and on small and medium farmers, as well as on system performance measures such as supply of affordable and safe and quality food, and efficiency and waste in the system? By chain-rule logical extension, we thus examine how research affects consumers and farmers via the “pathways” of food system transformation.
(4) What are the implications of the transformation for agricultural research strategies?

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Our findings lead to the two main messages of the paper.

First, the research community, hitherto mainly focused on the farm segment of the system, needs to take into account the entire food system and its transformation in their research strategies. This will determine whether innovations in farm technology and products lead to profitable marketed output by farmers. Increasingly, the urban market, the food industry firms that mediate access to the urban market, input supply chains, and agribusiness firms that determine the development of input supply chains, set the market incentives and conditions for the affordability and profitability of new farm technologies, and thus their adoption.

Second, the research community needs to understand and act on the importance of processing and logistics and wholesale (of outputs and inputs) in the food system, and research on these off-farm components of the food system. Research on and productivity of technologies for input manufacture and output processing, packaging, logistics, and commerce have equal weight in the performance of the food system relative to the farm sector. Investment in research and development (R&D) for these off-farm segments needs a much higher profile in the context of the transformed food system where off-farm segments occupy 40–70% of value added and costs of food.

To address the research questions we face two challenges. First, unlike other pathways of the impacts of research on farmers and consumers, such as breeding research on farm yields, it is particularly complex to examine research impacts on food systems and thence on farmers and consumers. Research is just one of the conditioners of the transformation and its impacts. The emphasis must be put on discussing the transformation itself and positing impacts of research in combination with other factors (such as urbanization). Second, as food system transformation in these regions is relatively recent, and the great majority of studies have been on the farm sector, empirical evidence on the transformation of the off-farm segments of the food system is only emerging and incomplete. We do our best to survey what is available.

The paper proceeds as follows. Section 2 lays out a conceptual framework. Section 3 explores “downstream” drivers of food system transformation – urbanization, income growth, diet change, infrastructure investments, and policies. Section 4 examines trends in the transformation of the structure, and Section 5, in its conduct (including technology change). Section 6 discusses emerging evidence of the system’s performance. Section 7 presents implications for agricultural R&D strategies.

2. The food system as dendritic

The food system can be thought of as “dendritic,” linking R&D, finance, input, and output supply chains, as follows.

The first and “core” supply chain is the output value chain. An example from the rice system is an output value chain composed of rice farmers producing paddy, which is collected by rural wholesalers or transporters and taken to mills where it is de-husked and polished. The rice is taken by wholesalers to urban wholesale markets and then to retailers.

The second and upstream “feeder” supply chains are the farm input supply chains, such as seed, fertilizer, farm equipment, labor, and arable land. These in turn are fed by input supply chains further upstream, such as the supply chain from phosphate mines to phosphoric acid plants to phosphate fertilizer factories.

The third and downstream “feeder” supply chains are those supplying inputs to the post-farmgate segments, in a sense “laterally.” An example is the truck and fuel supply chains to rice wholesalers.

The fourth “pan-system feeder” supply chain is that supplying finance into every segment of every chain in the dendritic system. This can be formal or informal credit supply chains, or the most common in developing countries, own finance from retained earnings.

The fifth ‘feeder’ supply chain is a broad set of public assets apart from agricultural research institutions such as infrastructure, police protection, and court systems for contract enforcement.

The sixth set of “feeders” is the R&D supply chains which supply technology and product innovations. For instance, companies and the National Agricultural Research System (NARS) or by private sector entities (startups, small companies, and major corporations). The innovations in agricultural technology, food processing, packaging, logistics, and so on that are supplied by R&D value chains are often powerful drivers of change in the other parts of the system.

The segments in each of the above value chains, and the six value chains themselves, are intertwined in “intersectoral (or intersegment)” linkages.” An increase in demand or supply from one segment “induces” investment in another segment or chain (Hirschman, 1958). The induced investment can be in physical capital or hiring labor, but it can also be in the formation of an R&D supply chain: innovators (public or private) cum entrepreneurs design and market new technologies or new products to meet demand in other value chains. For example, if supermarket chains demand shelf-stability in vegetable varieties they contract to procure, innovators can endogenously implement a vegetable breeding innovation to breed a shelf stable variety, as derived demand from farmers wishing to supply the supermarket chain.

But seen from the perspective of a given food system, there can be exogenous R&D “investment” that is not induced by factor scarcity or attribute demand in that food system. The R&D supply chain may endogenously arise in another context (another country, another product, etc.) and then present a technological innovation “exogenously” to the given food system. An example is the creation and manufacture of feeders for feed processing in the US. It might then be transferred to Bangladeshi feed mills using imported machines embodying this innovation. This would give the importer a competitive advantage and perhaps induce concentration in the feed supply chain in Bangladesh.

3. Transformation of food systems: downstream and context drivers

3.1. Meta conditioners: income growth, policy liberalization, and infrastructure investment

There are three “meta conditioners” that encouraged and facilitated nearly all the transformations we discuss.

First, growth in income and population in the three regions was crucial as a pull factor. Incomes rose, especially starting in the 1980s in Latin America and Asia outside the transition countries (China, Vietnam, and India) and 1990s in Africa and the Asian transition countries. Income growth, along with increasing opportunity cost of time as women worked outside the home in urban and rural areas, led to diet and shopping changes discussed below.

Second, policy liberalization and privatization occurred during the 1980s and 1990s (from the transitions in China and Vietnam, to the de-reservations in India, to structural adjustment programs in all three regions). This led to a minimization of governments’ direct role in food systems. It also increased private sector MSMEs (micro, small, and medium enterprises) that stepped into the void left by parastatals, with MSME proliferation encouraged by the expanding urban markets. The policy changes also led to entry of large-scale domestic and foreign firms such as processors and supermarket and fast food chains, as well as large input firms. The massive ingress of foreign companies was abetted by liberalization of the once-ubiquitous foreign direct investment (FDI) regulations in the 1980s–2000s.

Third, governments instituted large infrastructure programs in Asia
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