Links among innovation, food system transformation, and technology adoption, with implications for food policy: Overview of a special issue

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ABSTRACT

This overview paper introduces the special issue focused on links among innovation, food system transformation, and technology adoption in all segments of agrifood value chains from inputs to farming to post-harvest segments including logistics, wholesale, processing, and retail. We identify the issues and the gaps in the literature, and then note key points and contributions of the papers in the special issue. We then highlight food policy implications.

1. Introduction

Practitioners and scholars have recognized the importance of technology adoption in development, and the challenges to understand adoption behavior in the context of markets and institutions, and to design policies to enable the conditions (incentives and capacity) for innovation and adoption. One line of work, initiated by the Technological Treadmill of Cochrane, emphasized the challenge for farmers to adopt a new technology and sustain and adapt its use while other farmers swarm to its use and eventually compete down the profit rate, forcing the need for a new round of innovation, adoption, and diffusion. These rounds of repeated innovation and diffusion ratchet up the technology level of farming and lead to more, cheaper and better food, yet may harm farm income and thus justify safety net interventions (Cochrane, 1979).

Another rich and established line of research on technology adoption and diffusion by farm households (reviewed/analyzed in Feder et al., 1985; Feder and Umali, 1993; Foster and Rosenzweig, 2010), models adoption of technology as a function of incentives and capacity. The incentives such as input and output prices and risk are functions of natural conditions and the economic context, as well as public policy. Much of the literature on the latter has attributed a lack of technology adoption or partial technology adoption behavior of farmers to either credit constraints or risk (Just and Zilberman, 1988). This micro-level line of work has been generalized to form the generalized threshold model of diffusion, recognizing heterogeneity between individuals and processes of learning by doing, learning by using, and network externalities, resulting in an S-shape diffusion curve (Sunding and Zilberman, 2001).

However, with few examples, this literature typically abstracts from the role of input and output market structure and conduct in conditioning both information flows and other variables in the enabling environment for technology innovation and diffusion. Some exceptions to this abstracting from the role of input markets include Stoneman and Diederen (1994), who analyze links between imperfection in output and input markets and imperfection in the market for information about new technologies, and argue for public policy to address the information market imperfection in this situation. Another line of work is on interlinked markets, such as Eswaran and Kotwal (1985), where idiosyncratic market failures facing farmers that limit technology adoption are resolved by provision of services (such as management and inputs and credit) by landlords. This idea was extended in work covering situations where agribusiness companies resolve market failures by providing inputs and credit and knowledge to contracted farmers (e.g., Swinnen and Gow, 1999, and Key and Runsten, 1999). Within the generalized threshold model, Zilberman et al. (2012) extended this line of work by emphasizing (i) activities of input providers to help farmers in the absence of appropriate insurance markets, and (ii) provision of demonstrations, money-back guarantees, as well as credit.
The above literature then introduces the idea of food industry and agribusiness firms’ use of strategies to encourage and enable their supplying farmers to adopt technologies that meet the firms’ needs (product attributes, transaction specifications, and so on), and their use of contracts to both enforce the requirements and include provisions for inputs and services for farmers to adopt the needed technologies (and commercial practices). However, the existing literature stops short of a systematic analysis exploring how downstream and midstream firms design supply chain coordination strategies to induce farmers to adopt the needed technologies to implement the innovation that the lead firm introduces – and in turn how value chain institutions and organizations affect farmers’ uptake of new technologies. Moreover, the existing literature does not adequately address how downstream firms, which introduce new innovations to the market, may develop supply chains to secure the new inputs they need.

Hence, the goal of this special issue is to undertake that systematic analysis and to draw implications for agriculture and food policy to influence and complement those strategies so as to maximize efficiency and equity in food supply chains. The papers in the special issue explore linkages among lead firms’ (food industry and agribusiness) design of coordination strategies (among which, contracts) in their product or input supply chains in order to condition the incentives and capacity of farmers to technological innovation.

We expect the manifestation of these linkages to differ by region and product, but also by stage of transformation of food systems. In this introduction we use the concept of the transformation of food systems or value chains and use terms for the stages of that transformation (Reardon et al. 2012):

1. The least advanced stage is the “traditional” system. This tends to be spatially short (“local”) and fragmented in structure, using technologies with little capital and much labor, with no contracts or formal standards, and spot markets linking all segments.

2. The next stage is the “transitional.” It is spatially long (as cities grow and their catchment area is larger and larger) but still fragmented. Chain actors use a mix of labor-intensive and capital-intensive technologies. There are emerging public standards of quality. But still spot market relations dominate.

3. The most advanced stage is “modern.” It also is usually spatially long. But it is consolidated in a number of segments (such as in retail, the rise of supermarkets). There is also some “dis-intermediation” such as supermarkets buying directly from processors, or urban wholesalers directly from farmers. Private standards are emerging, and some use of contracts. Capital intensification is common as the modern stage tends to coincide with higher wages in an economy and more quality and safety controls are demanded by the food industry.

To explore these linkages and agricultural and food policy implications of them, the Special Issue presents a set of nine papers. The first two are conceptual frameworks that explore the multidirectional links among innovating firms, value chain design and transformation, and farmer (and off-farm firms’) adoption of innovative technologies and products. The next six papers are mostly empirical, exploring those links with empirical studies of animal and animal product value chains. The following paper examines those links for the case of export coffee. The last section of the present paper concludes and suggests policy implications.

2. Overview conceptual papers to set the stage

We start the special issue with two conceptual papers containing illustrations that examine the relation between innovation and value chain transformation from two complementary, yet distinct, perspectives.

The first, by Zilberman, Lu, and Reardon, takes as the starting point an innovator – say a firm or inventor – creating an innovation, and then the firm that commercializes it has to design its “implementation” in the supply chain – with a variety of choices concerning the technologies, organization, and institutions of the supply chain, upstream and downstream from it. To “implement” the innovation in terms of procurement of feedstock (intermediate inputs), production and processing, and marketing, the innovating firm undertakes strategic design of its supply chain. It must decide how much to produce, what segments of the supply chain to undertake in-house versus sourcing externally, and what institutions, such as contracts and standards, it will use to coordinate the suppliers assuring its external sourcing. The firm does that to put in place the conditions to make and sell the innovation, such as a new seed or a new form or breed of chicken, or a new processed product, and to continue to protect its profitability and advantage in the market. The innovator’s actions are akin to those described in Cochrane’s Treadmill as a firm building a supply chain. The paper identifies factors that determine under what conditions various arrangements emerge, emphasizing the role of credit, risk and learning.

The second, by Swinnen and Kuijpers, takes as a starting point the shift from a status quo value chain to a transformed value chain, with the lead firm (Gereffi et al. 2005) or firms having decided on and put in place institutional choices (like private standards and contracts) and organizational choices (like vertical integration, or systems of resource provision contracts cum input or information provision systems to re-volve idiosyncratic market failures facing their suppliers). These institutional and organizational mechanisms and systems could be expected to affect farmers’ technology choices, leading to second-round innovations. Small farmers might at first find daunting the adoption of modern technology needed to meet standards required by a modern food industry company – but they show that the support systems, risk-reducing contracts and information flows from companies to farmers can make such adoption possible and even attractive to farmers.

3. Innovations in animal and animal product value chains: From early to late transitional and modern

The empirical and broadest ground of the special issue is focused on innovations in animal and animal product value chains. We chose this because in general the literature on food security in developing countries underemphasizes animals and animal products as well as their supply chains relative to their growing importance in food systems. For example, dairy has grown bigger than rice in India, where rice is the leading grain. In China, maize, used to feed pigs, chickens and fish, is a bigger sector than rice. Moreover, due to the extremely rapid increase in supply to match the skyrocketing demand, input and output supply chains feeding into animal-related supply chains are growing and transforming quickly. Innovations in technologies and products and the institutions and organization of these supply chains are central to their being able to grow and adapt.

The animal and animal product supply chains papers run from the early, post-traditional stage where supply chains are entering a transitional phase (aquaculture in Bangladesh and dairy in India), to middle-of-transitional stage (pork chains in China), to modern supply chains still evolving (hogs and cattle in the US, and chicken in Israel). We synthesize the papers below, linking the threads to the key issues of the special issue.

Hu, Zhang, Reardon, and Hernandez in “Value-chain clusters and aquaculture innovation in Bangladesh” examine a situation of an “early transitional” value chain transformation. The aquaculture sector in Bangladesh has grown extremely rapidly – expanding 25 times in a few decades. Fish farmers are innovating by moving beyond traditional slow-growing carps by adopting fast-growing non-traditional species (pangasius catfish and tilapia) introduced from Southeast Asia a decade ago and utilizing commercial feed. Actors in the farmed fish supply chain – fish traders, feed traders, feed mills, and hatcheries – are co-evolving and collaborating on innovations with fish farmers, by setting
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