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Value chain innovations for technology transfer in developing and emerging economies: Conceptual issues, typology, and policy implications☆

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ABSTRACT

The adoption of modern technologies in agriculture is crucial for improving productivity of poor farmers and poverty reduction. However, the adoption of modern technology has been disappointing. The role of value chains in technology adoption has been largely ignored so far, despite the dramatic transformation and spread of modern agri-food value chains. We argue that value chain organization and innovations can have an important impact on modern technology adoption, not just by downstream companies, but also by farmers. We discuss conceptual issues and provide an empirical typology of institutional innovations through which value chains can contribute to technology transfer to agriculture in developing and emerging countries.

1. Introduction

The adoption of modern technologies in agriculture is widely believed to be important for improving the productivity and welfare of poor farmers in developing countries and a key ingredient for achieving poverty reduction, food security, rural development and structural transformation. However, the adoption of modern technology, including improved seeds and chemical fertilizer, has been disappointing, particularly in Africa (Evenson and Gollin, 2003; Sheahan and Barrett, 2014). The existing literature has tried to find explanations for this phenomenon by looking at various factors, including credit market imperfections (Feder et al., 1985), learning processes (e.g. Lambrecht et al., 2014), the quality of technological inputs (e.g. Bold et al., 2015), and profitability (e.g. Suri, 2011).

The role of value chains in technology adoption has been largely ignored so far. This is an important gap in the literature, as agri-food value chains have transformed dramatically in the past decades (Reardon and Timmer, 2007). Privatization and liberalization in the 1980s and 1990s induced important transitions in the institutional organization of value chains (Swinnen and Maertens, 2007). This has coincided with a major influx of domestic and foreign direct investment in wholesaling, processing, and retailing and an increase in trade of high value agricultural products (Reardon et al., 2009). Urbanization and a global increase in consumer purchasing power resulted in an increased demand for high value and differentiated food products. Food safety and other quality aspects, such as convenience, diversity, branding, and the sustainability of the production process have become increasingly important.

While the extensive literature on technology adoption in agriculture is largely ignoring the role of value chains, the emerging value chain literature has paid relatively little attention to the role of technology transfer – with some exceptions (Kuijpers and Swinnen, 2016). Most value chain studies focus on the determinants of farmer participation in modern value chains and the welfare implications for small farmers (e.g. Andersson et al., 2015; Maertens and Swinnen, 2009; Michelson, 2013; Reardon et al., 2009). We connect these two bodies of work and argue that (1) understanding the value chain in which a farmer is operating is key for understanding farmer technology adoption; and (2) understanding the role of technology is key in understanding the welfare effects of modern value chains.

Value chain organization and innovations can impact modern technology adoption, not just by downstream companies, but also by farmers. There is widespread evidence that food processors, marketing and retail companies in developing and emerging countries have upgraded their production processes using new technology in the past decades, often as a result of FDI and its horizontal spillover effects (Gow and Swinnen, 1998; Reardon and Timmer, 2014). This technological upgrading typically included a modernization of procurement systems for sourcing high quality raw material necessary to meet new consumer demands. One important aspect of this modernization process was the

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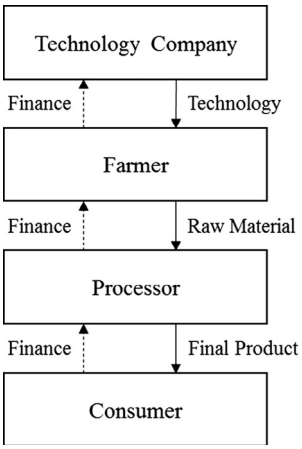

Fig. 1. Value chain and technology transfer with perfect markets.

introduction of private standards (with corresponding traceability, auditing, and certification systems) to overcome information asymmetry, reduce transaction costs, and as a marketing tool (Swinnen, 2007).

More stringent product or process standards often require investments in new technologies by farmers.[1] Many studies have pointed at the challenges for small and poor farmers to satisfy these new requirements and at the risk of further marginalization. In this paper we argue that these standards and required investments may also stimulate innovation, technology transfer, and thus inclusion for these farmers. With imperfect (or non-existing) technology markets, various forms of value chain innovations have been introduced by up- and downstream companies to overcome the technology constraints experienced by farmers. Value chain innovations include various forms of vertical coordination, one of them being smallholder contracting with interlinked technology transfer.

This paper is related to a large theoretical and empirical literature on industrial organization and technology adoption in various fields of economics and management science. This includes seminal contributions on how companies and supply chains are organized to overcome transactions costs and technology constraints (e.g. Economides, 1996; Gereffi et al., 2005; Klein et al., 1978; Milgrom and Roberts, 1990; Williamson, 1985) and to create a competitive advantage (e.g. Barney, 1991; Dyer and Singh, 1998; Hart et al., 1990); on contracting in developing countries (e.g. Bardhan, 1989; Bell and Srinivasan, 1989); on technology adoption in agriculture (e.g. Feder et al., 1985; Foster and Rosenzweig, 2010); on international technology diffusion and vertical productivity spillovers from foreign direct investment and trade (e.g. Havranek and Irsova, 2011; Keller, 2004; Martins and Yang, 2009); on modern food value chains, standards and sourcing (e.g. Reardon et al., 2003; Swinnen and Maertens, 2007); and on the optimality of farm structures (e.g. Allen and Lueck, 1998; Pollak, 1985).

The contribution of our paper is in the first place empirical by documenting various types of technology transfer through value chain innovations in developing and emerging countries and relating them to conceptual models. To our knowledge this is the first article to systematically document these forms of technology transfer to agriculture and to provide a typology of the different value chain innovations.[2] In addition, in the second part of the paper we relate these different types of institutional innovations to several factors, such as tightening safety and quality standards, market imperfections, the value in the chain, and the nature of the technology investment (i.e. long versus short term and contract specificity). Finally, in the concluding section we draw on the combined empirical and conceptual insights to draw implications for policy.

The remainder of this paper is organized as follows. The next section introduces a conceptual framework that explains under which conditions private-initiated value chain technology transfer is expected to arise. In Section 3 a variety of different value chain innovations for technology transfer are discussed and illustrated by empirical examples. Section 4 draws lessons from the empirical review and identifies key factors that played a role in value chain innovation for technology transfer. Section 5 concludes and draws some policy implications based on the theoretical and empirical insights. In particular, it discusses the role of governments in financing technology transfer programs.

2. Some conceptual issues

2.1. Technology adoption with imperfect markets

Consider a simple value chain (Fig. 1). With perfect markets, decisions to invest in technology are made independently at each stage of the chain.[3] Demand and supply for a product with certain qualities determines the price level and thereby the incentive to invest in necessary technology. For example, a change in consumer demand for higher quality food will translate into a demand for high quality farm output and an incentive to upgrade technology by the farmer—and thus technology investments if profitable.

Notice that parallel to the flow of goods and technology in the value chain there is a flow of finance (in the opposite direction). Access to finance (in the form of own liquidity or loans) at each stage of this chain is crucial as production costs and technology investments are carried in full by the individual actors. Moreover, costs of technology investment are incurred at the start of the production cycle, while payment occurs at the end, making access to capital essential to bridge this gap. This is especially the case in the agricultural sector where the duration of the production process is relatively long.

Note that next to the flow of finance there exists a flow of information (not depicted by the figure). Information is important as farmers may need to adjust their production practices and technology when demand, government regulations, or consumer preferences change.

It is not difficult to see why technology adoption in a value chain organized by spot-markets might not be working in the context of imperfect markets. Information transmission may be incomplete, such that farmers are unaware of the requirements for their products or the precise management practices that are required. It is also well known that financial markets are often not working well in developing and

[1] Most standards, codified or not, either directly or indirectly prohibit the use of less costly technology (Swinnen et al., 2015). In fact many of the most visible standards for consumers directly prohibit or require the use of certain inputs. Examples of commonly prohibited inputs are child labor, chemical inputs (in accordance with organic farming standards), or battery cages in the production of poultry. Examples of commonly required inputs are milk cooling equipment for dairy farmers and traceability systems for farmers supplying supermarket channels. Additionally, standards often require certain practices. For example, GlobalGap certification requires Lychee farmers in Madagascar to use clean water for pre-harvest hand washing and to implement good picking and packaging practices for the transportation from the farm to the processing unit (Subervie and Vagneron, 2013).

[2] Throughout the paper we use the concept of "value chain innovations" as institutional designs and models that deviate from the standard value chain structure (as illustrated in Fig. 1) that have been introduced to address specific objectives.

[3] Foster and Rosenzweig (2010) define technology as "the relationship between inputs and outputs" and the adoption of technology as "the use of new mappings between inputs and outputs, and the corresponding allocations of inputs that exploit the new mappings". In practical terms, technology adoption therefore refers to a transformation of the production process, which might result in enhanced efficiency (requiring less inputs to produce a given output) or in different product attributes (i.e. enhanced quality). This means, in practice, a firm can change its production technology by either combining its current inputs in a different way, or by applying new intermediate inputs (e.g. machinery) in the production process, with a certain technology embedded in it. A farmer for example, may change its production technology by combining his inputs (e.g. labor, land, seeds and water) in a different way, or by using a new intermediate input (e.g. high yielding seeds, chemical fertilizer, or pesticide) produced by an input supplier.

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