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Innovation and Development

Institutional perspectives on technological change in agri-food chains

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Sietze Vellema and Myrtille Danse[1]

1. Introduction

In the current policy context for sustainable development, the concepts of value chain development and market access have come to the fore as ways to encourage entrepreneurship by linking smallholder producers in the South to agribusiness and food industry as well as to promising markets. An implicit assumption in these approaches seems to be that these types of linkages will also enhance the technological capacities of smallholder producers or manufacturers by way of cost-efficient technologies trickling down through the value chain or by quality requirements inducing best practices in performance. The argument put forward in this paper is that value chains are indeed instrumental in arranging market access and optimising transactions, but that realising sustainable economic development requires purposeful actions and institutional transitions, both in the public and private spheres, targeting improved innovative capacities. This paper aims to inform policy makers in governments, business and development organisations who support value chain development as a configuration for realising development goals, by exploring the institutional aspects related to technological innovation. Technological innovation is defined as the implementation and commercialization of a product with improved performance characteristics such as to deliver objectively new or improved services to the consumer[2].

Relevance

Although value chains are primarily installed to arrange an optimised and efficient flow of physical products, which includes trading and processing, the question raises if a focus on the institutional roles in technological innovation provides new insights on the potential development impact of linking smallholder producers to value chains. Taking a value chain perspective, i.e. the activities bringing a product or service through the different phases of production, transformation, and delivery to the final customer[3], entails a strong focus on complex divisions of labour and forms of coordination. This involves an institutional perspective when addressing the question, posed by Humphrey (2004)[4]: how do changing value chain relationships affect the processes of learning and innovation as well as the acquisition of technological capabilities? This paper complements Humphrey's question by asking: how do changing relationships between a value chain configuration and its enabling environment, i.e. the combination of government policies, laws and regulations setting the rules of the game, providing incentives, and influencing performance[5] affect the processes of learning and innovation as well as the acquisition of technological capabilities[6].

This shift in focus is motivated by the concern that the current concentration on compliance with technical standards and safety requirements in food chains leaves aside the debate on how to stimulate innovative capacity among local enterprises and smallholder producers linked to value chains[7]). Assuring food safety and quality is an essential aspect in the commercial transactions in agri-based value chains, which is related to the decision on where to locate risks and liabilities in the chain, frequently arranged by formal contracts and inspection procedures. Standards and voluntary regulatory systems, complementary to public food safety regulation, accompany these assurance schemes.

In this context, an implicit assumption seems to be that prescribing Good Agricultural Practices or demanding technical compliance with safety and quality requirements automatically induces technological change. This causes the risk of overruling the diversity of agricultural production, processing and trade[8], which is embedded in local social and economic systems. Also, it makes innovative capacity in agri-food chains strongly dependent on exogenously determined technological

knowledge and skills, namely by leading players directly linked to the market. Consequently, the pattern in agri-food chains may reinforce a unidirectional technology transfer model that has been questioned and altered in the practice of public research. Hence, the question posed in this paper is whether effective technological change for sustainable development will be the automatic result of stimulating market-led led development schemes. This paper argues the contrary by elaborating on two modes of thought that consider technological innovation as an outcome of locally embedded relationships and development processes.

Discussion: Push and Pull in technological innovation

The policy debate on technical change has been characterised by an oppositional discussion between two broad categories, namely "demand pull" and "technology push" theories. The distinction relates to the degree of autonomy the innovative activity has in relation to short run changes in the business environment, and the role attributed to market signals in directing innovative activity and technical change. Demand-pull views point to the market forces as the main determinants of technical change, recognising (immediate) technological needs of productive units in markets. While technology-push perspectives define technology as the autonomous factor, originating in an institutionalised process of scientific discovery and technology development. This viewpoint implies that technological choice is limited and solutions are primarily technically defined, ignoring the economic factors shaping the direction of innovative processes. A strong version of demand pull has difficulties to take into account the complexity, the relative autonomy and the uncertainty associated with technological change and innovation. While a strong technology push approach does not take into account economic growth and economic change, variations in distributive shares and in relative prices factors and commercial considerations, affecting the course of technical change and speeds of innovative activity. This paper grounds technological innovation in agri-food chains in the complex structures of feedbacks between the social and economic environments and the directions of technological changes[9]. This explains the focus on the nature of the inter-active mechanisms between markets, governments, buyers and users of technology for understanding the processes of learning and innovation.

Approach: Two frameworks on technological innovation

The approach taken in this paper is to concentrate on two related institutional aspects of technological change, namely the balance between push and pull and the division of responsibilities between public and private actors. To further unravel these institutional features of technological innovation, the paper first elaborates on two established modes of thought inspiring innovation and development strategies as well as R&D in both public and private spheres. The first approach, the National System of Innovation (NSI)[10] addresses the institutional features of primarily public research organisations and emphasises the importance of continuous interactions between users and providers of knowledge and technology (Section 2). The second approach, Bottom of the Pyramid (BoP)[11], gives the private sector a leading role in technological innovation and introduces markets of low-income customers as a prime focus for directing innovation and product development towards poverty alleviation (Section 3). The BoP approach prefers business models leveraging the strengths of market environments and social infrastructures rather than those focusing on overcoming or correcting weaknesses[12]. The paper examines these two complementary frameworks in more detail.

Both approaches, NSI and BoP, emphasise that technological innovation evolves from institutional interactions within a network of public and private actors as well as with customers in locally embedded markets. They relate technological innovation to either institutionalised relationships in innovation networks (NSI) or socially embedded interactions in local markets (BoP). NSI takes a more open-ended perspective, emphasising the importance of interactions and intermediary organisations connecting different capacities. While BoP pays more attention to the selection of technological alternatives and relates this to the articulation of users' demands in specific markets. The discussion in this paper focuses on the complementarities of both approaches and relates the conceptual views to the processes of learning and innovation in agri-food chains (Section 4). The discussion in section 4 invites us to consider institutional modalities for technological change in agri-food chains, which build on socially embedded capacities *and* local market demands, rather than on an approach based on

uniformity of technological practice and liability-driven contracts that is also evident in agri-food chains[13].

2. National Systems of Innovation

In the history of working on development in Southern agriculture, public research institutes have featured prominently as leading agencies in introducing technological change. In particular, their role in introducing new crop varieties in the context of the Green Revolution strategy has been an important element of development practice and debate. However, their role has become increasingly subject of debate, due to different reasons. First, the unilateral model these institutes have used to develop and transfer technology, has led to growing criticism about the social and institutional aspects of such technology transfer, raising the question whether this model will indeed lead to the desired development goals. Second, notions like participatory design and intermediate, tailor-made technologies have been added to this overall idea since practice has shown that generic technological solutions do not necessarily work under the different socio-economic and agro-ecological conditions in the South[14]. Thirdly, the tandem of deregulation policies, altering or weakening the position of marketing boards or public research, and globalisation of economic activities drastically changed the roles of public research institutes in development[15], which led to strategies placing private sector development in the centre. The National System of Innovation framework incorporates these different aspects by looking into the institutional dynamics between users and providers of knowledge and by considering the individual capacities of public and private actors as elements composing the larger whole: a system of innovation.

The NSI framework considers technological innovation as an outcome of an evolutionary process and gives optimality a minor role in innovation. Consequently, the innovation system approach criticises the model solely dependent on a one-way transfer of technology by emphasising the processes of interaction. It takes an interest in existing market structures and social institutions bringing about endogenously determined technological opportunities. The patterns of behaviour and partnerships, and the rules and regulations governing them, are located usually in the setting of a NSI [16]. An innovation system can be seen as a web of actors active in a specific technological system, which is accompanied by a certain infrastructure and forms of knowledge exchange[17]. In this sense, an innovation system connects distributed technical knowledge, which broadens the scope from individual technologies and organisations to systems and networks[18]. This makes management of the interactions between distributed competencies and forms of innovation in various sub-units an important task in the innovation[19]. Particularly the absence of an organisation managing the interactions between actors with different technological capacities can lead to fragmented and non-responsive technological infrastructures in developing countries[20] (Box 2).

In the debate on agricultural development, Hall and colleagues[21] used the National System of Innovation framework to shift the focus of development policies from fixed technological packages to the processes of research and development. The innovation system framework considers innovation as a dynamic and interactive process rather than a linear process. It takes an interest in institutional mechanisms and arrangements patterning behaviour and interactions[22]. Basically, the framework entails a critique on technological expertise and knowledge 'locked up' in research institutes. It states that R&D organisations need interactions with users, e.g. farmers, and commercial settings, e.g. value chains, which are hampered by a rigid institutional distinction between research and use or diffusion. The NSI perspective proposes a policy shift to constructing a viable and flexible institutional environment, in which technological opportunities will evolve, rather than supporting a predefined search for suitable technological recipes by R&D organisations largely disconnected from their environment and the actual users. In this perspective, local institutions and innovation networks receive roles as translators of external technologies, in order to provide technical solutions tailored to specific circumstances. Simultaneously, these actors are seen as providers of feed back to national and international R&D systems, with the idea to set research agenda flexible enough to incorporate local needs and demands[23].

In accordance with the idea of the NSI perspective, it is relevant to manage and promote interactions between various actors that can produce technological innovations and services contributing to economic and environmental sustainability of a specific sector. This entails installing interactions and feed back between flower producers and knowledge generation in public research institutes as well as in private research laboratories. In the case of rose production in Vietnam (Box 1) flower producers make incremental improvements, mainly by learning from the practices of other producers. Consequently, technological innovation comes down to adequate selection and adaptation of existing technological packages. Hence, despite the prominence of environmentally unfriendly pest control methods, the weak vertical linkages of flower producers with public and private research and development organizations can be considered a hindrance in tailoring environmentally friendly production methods to the specific conditions in flower producing regions. In the Vietnamese rose sector, distribution, certification and registration of pesticides importantly constitute vertical interactions between flower producers and other actors.

Box 1: *Technological learning and innovation for environmentally friendly flower production in Vietnam*
This box describes the institutionalization of technological learning for innovation, specifically with respect to the control of pest and diseases in the Vietnamese floriculture sector. The Vietnamese floriculture sector is growing fast and is expected to be able to make a substantial contribution to an increase of income for the rural population in specific regions, including farmers in cooler higher altitude areas such as the Central Highlands and Northern Mountains. So far the flower sector development has been almost exclusively developed throughout private sector involvement, mostly innovative small farmers. Almost all flower production is destined for the domestic market.[24]

Roses, planted for a period of approximately 7 years, are considered a "preferred crop" because they need less handling work than vegetables, and bring up 5-7 times as much as rice and 3-4 times as much as vegetables. However, roses require more pesticide input (about 3-5 times more pesticides than vegetables), and consequently the amount of work and the costs related to spraying are relatively high. Hence, the level of pesticides use appears to be very high in the sector, causing a negative effect on the environment, the health of the growers and the surrounding community, and also the economic performance of the rose farms. A risk of the intensive use of pesticides is the accumulation of pesticides in surface and groundwater, which in many areas is the main drinking water source. Also, farmers seem to have a lack of knowledge on safe application methods, which might result in health problems. Finally, inefficient pesticides use might result more elevated production costs than necessary and a possible negative impact on the quality of the final produce offered to the market.

A case study of rose production areas near Hanoi and in Sapa, close to the Chinese border shows that flower producers experiment with different flower varieties and chemical input applications, and these experiments are mostly based on trial and error.[25] Producers obtain information about new technological and cultivation practices from a variety of actors. The most important sources are neighbouring farmers or rose farmers in other regions, and shopkeepers selling pesticides. In some cases, also information is obtained from local officials at the plant protection department. Farmers told that they received trainings on pest and disease diagnosis from public authorities, but that these general courses on vegetables production did not specifically address pest and diseases in rose cultivation. The Plant Protection Department also issues certificates to the pesticide shop owners, and control regularly their performance by surprise inspections. The Vietnamese government is responsible for tasks such as regulation on the use of pesticides, regulation on the production of pesticides, labelling of products (pesticides), and registration of pesticides. Major agro-input suppliers focus their Vietnamese operations on repacking of (imported) products into small packages; product development tailored to specific conditions or crops is hardly present. In the field of pest management, technology programs tend to focus on safe and effective product use and personal protection and safety equipment for the growers.

The research revealed that the solutions applied by these small rose producers to solve pest and disease problems were mostly aggregated solutions from earlier experiences with food crop production. Parts of these practices are not considered to be accurate for flower cultivation. The research team observed that the identification of insects (trips, red spider mite) is rather accurate. This is not the case for the identification of fungal and bacterial diseases. For instance, farmers confused the symptoms caused by certain fungal diseases with an insect damage, and nutrient deficiencies as well as pesticide damage were confused with fungal diseases. They do not have the possibility to send samples to a laboratory for determination of the pathogen. Moreover, the knowledge about plant deviations (abnormal colour or spots not caused by pathogens but by nutrient deficiencies or even by

pesticide damage) is very limited. The capacity to diagnose pest and diseases is important for shifting from a regular preventive spraying programme, which seemed to be common practice in Vietnamese floriculture, to reactive spraying after the identification of specific symptoms. The case study indicates that working towards environmentally friendly production requires knowledge and skills not always present among farmers. Hence, technological innovation produced through vertical and horizontal linkages in an innovation system may alter this situation.

As a result, the policy debate tends to become linkage oriented and seems to be less occupied with the actual outcomes of technology transfer and innovation. The idea of quick technological fixes to complex development problems is radically abandoned. This also implies a different role for public research institutes. They become participants in an open-ended process involving various actors. Moreover, the approach claims to create space for dovetailing innovation with the stages of development in specific nations or regions, in order to make capacity building activities more effective[26]. The precise organisational types or models for achieving this will vary: institutional arrangements respond to new technological needs or opportunities as well as to changing political and economic circumstances. This also suggests an open view on variant solutions to similar problems, depending on the institutional context.

Experience with weak and fragmented NSI in developing countries indicates that a tandem with institutional experiment in the commercial domain may improve the pace of technological learning in a sector or chain. The combined approach to regionalised Innovation Systems and specialised Economic Clusters in Thailand (Box 2) puts forward the challenge of leveraging micro innovative strengths through systemic change at meso level[27]. In general terms, the combination of cluster and innovation system development in Thailand aims to intensify the interaction among firms and between firms and non-firm organisations. This resulted in innovative and competitive strengths at micro level. However, these experiences still remain isolated and encapsulated, which hampers leveraging innovative and technological capacities at the level of a regional or national innovation system. Public research organisation tend to concentrate on generic R&D and to put less effort in building lower level capability such as technology assimilation and adaptation, designing and engineering[28].

In Thailand, linkages of innovative firms with universities and public research organisations are still quite limited. A possible consequence of this weak link between micro and meso levels may be that actual upgrading, such as building capacity in design, R&D and engineering[29] is difficult to achieve. This suggests that effective technology and innovation policies explicitly addresses building socio-institutional framework embedded in local and regional economies. This requires installing intermediary functions, such as trust building or creating feed back mechanisms, which can be performed by various organisational set-ups. London and Hart (2004)[30] argue that alliances and trusted connections with governments and civil society organizations will make the boundaries of a firm or value chain more permeable and strengthen local legitimacy. Such a perspective also widens the focus from reorganising the public research infrastructure to finding the right institutional modalities for building on innovative strengths already present in the relationship between various actors in value chains or markets.

Box 2: *Cluster development and Innovation Systems in Thailand*

In Thailand, the Innovation System has been related to the development of (agro) industrial clusters. Intarakumnerd (2005; 2006) observes that the innovation system in Thailand is weak and fragmented, resulting in slow technological learning[31]. This provides a new challenge for the Innovation System approach, namely to make it feasible in the context of economies in transition or in developing countries. Accordingly, the Thai government adopted an interventionist approach based on the idea of cluster development. This entails working towards specialized associations of economic actors, which are embedded in specific regional economies and build on available skills and capacities. This shift to the development of indigenous technological capability as an integral factor in the process of industrialisation proposes an alternative to Science & Technology policy considering firms primarily as users of knowledge produced by government agencies or universities. This

strategy shifts the focus of innovation to existing networks of small and medium enterprises and their linkages with non-firm actors[32].

Making it work in rural economies, the Thai government had to make purposeful interventions and worked on selective policies, in terms of, for example, credit provision and other support services, exceeding the generic, functional interventions such as promoting infrastructure building or ensuring education. In the agri-food sector, the strategic label Kitchen of the World accompanied endeavours to upgrade existing food manufacturing capacities in rural economies, such as grilled fish chilli paste. However, the innovation strategy building on local networks may, eventually, contrast with the outcomes of pressures resulting from demands for safety, quality and traceability, which may lead to endeavours characterised by optimisation, standardisation and concentration[33].

The study by Intarakumnerd (2006)[34] shows the key role played by intermediary organisation in this process. Although the precise organisational forms may differ, e.g. a government research organisation, a sector agency or a housewife association, the functions they perform are to stimulate the sharing of information and knowledge and to build trust among individual actors. This research suggests that these intermediaries are the most effective target groups for innovation policy. Moreover, the approach embeds innovation in the vertical linkages existent in a supply chain, between suppliers and buyers and emphasises the need to involve non-agricultural actors in innovation policy targeting rural economies[35]. In the case of grilled fish chilli paste this was a firm introducing canning technologies, increasing the shelf life. The question remains however, whether chain actors are willing to share more than just product-related types of information.

3. Innovations for the Base of the pyramid

Stimulating innovation through technology transfer has been one of the strategies aiming to eradicate, or at least alleviate poverty. In the context of agricultural development in Southern countries, mainly public institutes have contributed to this endeavour for many decades: e.g. local governments, OECD governments through development cooperation, international research organizations, and non-governmental organizations. So far, the intellectual discourse has been largely in the fields of public policy and development economics. More recently, management experts and business schools have entered this arena. Prahalad is certainly the most visible and prolific writer in the field, addressing boards of multinational enterprises, academia and government officials. Prahalad and his colleagues have pioneered with new approaches linking the private sector to poverty alleviation strategies[36]. They particularly seek ways to mobilise foreign direct investment (FDI) in addressing poverty, motivated by the observation that FDI has become the leading source of external finance for developing countries, surpassing Official Development Assistance and other international capital flows taken together[37].

Basically, the BoP argument is to stop thinking of the poor as victims or as a burden and start recognizing them as resilient and creative entrepreneurs and value-conscious consumers. This approach particularly challenges the current business models and technological strategies of firms[38]. The Bottom of the Pyramid (BoP) idea is that, from both a commercial and a developmental perspective, many firms mistakenly ignore the markets of lower income groups in developing countries. The BoP approach proposes to make the endeavour to compete against untapped consumption. The argument is that development will benefit from firms capable of tapping into these potential markets with less purchasing power: "selling to the aspiring poor". It advocates creating capacity to consume by balancing the three A's: affordability, access and availability. Together they must ensure that innovative products or services are scalable and can be tailored to a heterogeneous group of users. Important is that innovations should be "value oriented" from the customers or users perspective, taking into account both the objective and subjective performance of the product or service. The so-called disruptive innovations[39] take root in less demanding applications among non-traditional customers and are capable of achieving significant price reductions without compromising quality. They also provide an alternative choice to the products and services offered by, what London and Hart (2004)[40] call, 'low-quality vendors and predatory suppliers and intermediaries'. This approach entails new market-oriented alliances working on innovative products and processes tailored to unusual

markets. Leading firms try to include the approach, labelled 'Bottom of the Pyramid', into their market strategies (see Box 3).

Box 3 *Life science industry unlocking the bottom of the pyramid market*[41]
DSM, a leading Dutch multinational in chemicals and food ingredients, aims to unlock to the markets of food products for low income consumers. The company invests in product development that works towards fortified staple foods, such as flour, oil and sugar, with vitamins and minerals. In a media briefing on its sustainability performance the company acknowledges to narrow margins in these markets, but emphasised the high volumes generating profits. DSM related its market strategy to endeavours aiming to reduce micronutrient deficiencies. In its Nutrition Improvement Programme, the company collaborates with governments and NGOs.

So, the BoP approach locates innovation in a process of re-evaluating the price-performance relationships for products and services[42]. The approach does not require major technological advances, for example through major investments in generic technologies such as genetics or nanotechnology, but relies on tailoring quality products and processes to the demand of customers with lower levels of incomes. Innovation is about creating something new in different contexts of competition. This requires firms to be able to manage a variety of business models and market strategies, which ensure the needed flexibility in approaching non-traditional markets[43]. The BoP framework assumes to be capable of creating jobs, capturing value and encouraging local industriousness.

BoP authors consider adaptation and translation of available products and services to untapped markets as a key element of innovation, which entails incrementally modifying current business models on innovation and internationalization strategies[44]. This implies that the conventional international business strategies applied by multinational enterprises require adjustment. Reliance on capabilities on national responsiveness, global efficiency and worldwide learning are not sufficient to serve the BoP market[45]. Creating centrally developed global solutions or adapting solutions created elsewhere to local conditions is not considered effective. BoP markets require firms to build, consolidate and leverage learning from the bottom up. This involves the development of new products or services capable to adapt to fixed or less malleable constraints. This contrasts with a business model that only succeeds under 'ideal' conditions, more often found in top-segment markets, where development costs are recuperated by high introduction prices. Likewise, the approach contrasts with endeavours to make technologies and services available through, for example, public sector subsidies; it rather calls for innovative efforts and experimentation to make products and services attractive for low-income buyers[46].

Consequently, the BoP view aims to focus the innovation process on identified constraints in markets of the poor, such as the informal nature of transactions or low capital intensity rather than relying on, for example, formalised contracts or legal institutes. Also, corporate strategies aiming BoP markets in emerging economies have to recognize weaknesses in the business environment use the locally embedded organizations and innovation patterns as a basis for creating competitive advantage[47]. This may require supportive policies creating the right conditions for such an approach, although Prahalad[48] emphasizes the importance of allowing private sector actors to act as much as possible based on market principles. Accordingly, developing innovations for BoP markets partly implies the transition of governance capacity towards creating the capacity of self governance. This helps to decrease the negative effects of overregulation caused by public institutions or the use of public sector corporations as a way to creating a culture of subsidies disguised as commercial operations.

A number of successful examples cited in the literature on the BoP approach focus on consumer products, such as small shampoo sachets finding their way among consumers with small and unreliable daily incomes. Yet, the overall message of the BoP approach for development and innovation strategies also applies to agri-food chains: work with the fixed constraints of producers and

adapt your business models and technological packages accordingly. There are examples available that focus on agricultural producers as customers facing constraints regarding production and income, such as reengineering telecommunication and information services using mobile telephony and internet (Box 4). This and other examples indicate that poor people are prepared to purchase novel products and services when meeting the right balance between quality and price in lower end markets. The technological change introduced in sugar and soy chains was accompanied by new business models, for example, relying on information services run by franchising companies in rural villages.

Box 4: *Information technology and agri-food chains in rural India*

The BoP approach is collecting a series of case studies as catalysts of the discussion. A number of case studies are on consumer goods. This box presents two case studies about making information accessible to farmers and, consequently, changing the functioning of the supply chains of sugar and soy in India[49]. In the sugar chain, a corporation running a sugar factory decided to set up internet kiosks. The corporation already maintained close linkages with the farming communities, as buyers of produce and as a provider of farm inputs. The internet kiosks used a franchise-based business model. The access to internet was leveraging ICT in three areas in the supply chain: distribution of inputs, trade of farm product, and communication and information. The case studies describes how the internet kiosks enabled the dissemination of knowledge on agricultural technologies, supported the articulation of demand for knowledge, provided information on the markets for selling goods, and generated information supporting transparency in prices. The information was distributed through a portal in which universities, firms and research stations participated. Farmers in the communities were willing to pay for these services. Depending on the franchise taker the internet kiosk could combine this ICT service with printing and copying services. The leveraging of ICT altered the situation of intermediaries blocking and controlling the flows of information and using ambiguous price setting procedures.

A similar case study in the Indian soy chain shows how a trading house firm used information technology to reengineer procurement practices[50]. A local farmer operated an information centre, linked to the internet, in his village. This centre was linked to numerous transactions in the chain, such as weighing, grading, or pricing. The access to information on technology and markets supported the integration of farmers in the supply chain, and resulted in sustainable commercial engagement by providing a viable procurement practice. The viability was related to the opportunities the information centre offered for obtaining knowledge about weather conditions, for articulating crop specific interventions the trade house can provide, and for communicating information making the price-quality relationship transport. The trade house used the philosophy of modular increments acknowledging the specific conditions in the villages and the trading systems. In this sense, it was reengineering rather than reconstructing procurement practices, and, consequently, opening the opportunity of dovetailing technological interventions with the needs of farmers. This approach built new networks and created trust among the actors in the commodity chain.

In the context of value chains, it is relevant to consider the institutional implications of seeing producers as buyers of these products, technologies and services. Still following the line of argument of the BoP-approach, this implies that producers become decision makers in a competitive market for new production processes and services rather than receivers of technologies developed in public or private R&D departments. The challenge the BoP approach poses to providers of inputs and services is to adjust their business models to the constraints encountered by their non-traditional customers, who, presumable, do not yet 'consume' affordable and innovative technological products.

That this approach indeed leads to major shifts in business models and management styles inside business is shown by the account presented in box 5, where the institutional obstructions linked to rearranging the provision of pest control methods by a leading life science firms is discussed. In this sense, the BoP approach can be complemented by the focus on institutional interactions and transitions put forward by the National System of Innovation perspective.

Box 5: *Considering small farmers in developing countries as customer of life science companies*
Vorley's[51] inside account of the introduction of a farmer support strategy in a major life science company, Ciba-Geigy (now Syngenta), reveals the complex alterations and reactions in the institutional corporate setting following from the argument put forward by the Bottom of the Pyramid approach. This is especially so because entering new and low-income markets requires drastic changes in the common business model. In the 1980s, the company adopted a visionary approach to combining sustainability and business. In this period the chemical industry was facing unprecedented hostility related to the negative environmental effects their business caused and, in the case of agriculture, the growing critique on intensive use of agro-chemicals. The vision was the company's response to growing public awareness, revealing increased engagement with the sustainability debate.

The experience of the company in developing countries was largely based on working with large contracts and big projects with government projects and parastatal marketing boards. However, towards the end of the 1980s these organizations gradually broke down due to the Structural Adjustment Programmes. Consequently, the company was confronted with an emerging market of millions of farmers making independent pest-control decisions, with limited access to information and making purchases in distribution systems involving large numbers of salesmen.

The public awareness and policy discussions in, for example, FAO raised expectations of the industry's commitment to reducing pesticide related risks in agriculture, which resulted in a strong attention to proper use of existing products, and not, as would be argued by the BoP approach, in technological innovation tailored to specific conditions of these large numbers of small farmers in developing countries. Although research staff seriously considered Integrated Pest Management (IPM), with reduced application of pesticides, as an alternative, the marketing of existing products proceeded as usual.

At the beginning of the 1990s, the Plant Protection Division approved a new strategy, labelled the Farmers Support Team (FST), which aimed to build on farmer skills for working towards safe and environmentally benign methods of pest control. This strategy fitted in the overall sustainability vision of the company. However, the approach was strongly down to earth, essentially claiming to develop the markets of small farmers in developing countries. "The objective of the FST was to approach these small farmer markets as opportunities to build farmers' skills in maximizing the benefits and minimizing the risks from pest and pesticide management and thereby to gain advantages in the market place and acceptance in society at large"[52]. This marketing strategy also implied a break with the safe-use projects, and could lead to reduced market volumes in areas of overuse of agro-chemicals. The FST aimed to provide small farmer markets with new pest control methods, and thus, phrased in BoP terminology, offering a higher quality product, i.e. IPM^{+}, for lower costs, e.g. resulting from lower volumes or dosages. The approach was also accompanied by a decentralisation of marketing and training activities, bringing the commercial operations closer to the diverse market places, creating an organizational culture of learning and innovation around sustainable development.

Managerial changes in the company, creating financial transparency between divisions, put pressure on the FST initiative. In the eyes of managers the markets in developing countries proved to be rather trivial as a proportion of their sales, and mainly targeted larger plantations and not difficult to reach farmers. Managers and shareholders began to demand short term results, which hindered to longer-term marketing perspective adopted by the Farmer Support Team. Clearly, the FST marketing strategy would affect the common business model, and was not an easily shared idea within the company. The challenges the new business model posed to existing minds-sets, functions and structures inside the company made it difficult to achieve some institutional stability for this novel way of doing business. Eventually, the Plant Protection Division decided to stay close to its original business model and technology trajectory, by focusing the company's sustainability vision on soft, selective pesticides, essentially maintaining the same ways of operations and R&D and searching for the familiar[53]. Similarly, sustainability efforts are now channelled through philanthropic endeavours and not, as would be the BoP argument, through innovative market strategies. Despite the encouragement the Farmers Support Team initiative received, the strategy aiming for turning sustainability into an opportunity in markets of small farmers in developing countries did not succeed to transform the mode of business in the life science industry.

4. Discussion: innovation and development in agri-food chains

The previous paragraphs introduced two distinct but complementary perspectives on the institutional aspects attached to technological innovation in the agricultural and food sector of developing countries. This section aims to relate these perspectives to the concept of agri-food chains, in particular those involving sourcing from smallholder producers. The following discusses what we can learn on the institutional processes defining the distribution of responsibilities between public and private actors in the enabling environment of an agri-food chain. Next, within the boundaries of the agri-food chain, the discussion centres on the balance between push and pull factors, important for understanding the selection of technological innovation in the realm of commerce.

Public and private roles in the enabling environment

The NSI appreciates technological innovation arising from multiple interactions in a national or regional system linking public and private actors. The framework focuses less on the actual results of a technical intervention, e.g. addressing real problems in the field of safety or quality in food provision, and perceives innovation as an integral part of evolving NSI. The latter form the enabling environment for agri-food chains. A consequence of this view is that value chains may enhance their performance by creating viable linkages with the innovation system before introducing fixed technological packages.

A functioning NSI is supposed to connect distributed competencies in such a way that the whole is more than the sum of the elements. In the sphere of commerce and trade, typified by incremental technological change and negotiations among competitors, this is not the most obvious way to move forward. The process orientation and the bias to the public sector in the NSI perspective tend to set aside the negotiations in the economic realm, which importantly determine the stabilisation of technological innovation towards final products and technological processes[54]. Hence, policy efforts may be required to improve the institutional capacities for managing the interdependencies and patterns of specialisation underlying the evolving innovative performance, which also involves negotiated coordination and strategic alliances in supply chain. In the case of agri-food sector, the small scale of many firms and the tight alignments between suppliers and buyers suggests a careful approach embedded in local and regional social structures[55].

The strong bias towards open-ended processes in the public domain is, however, also a major pitfall of the NSI approach. The NSI framework seems to bypass the strategic patterns of behaviour apparent in the economic and social transactions in a value chain[56]. Critical reviews of the NSI literature observe a bias towards the structure and reform of the brick-and-mortar public sector organisations, rather than on the 'rules of the game' underlying priority selection and agenda setting[57]. Taking an NSI perspective invites new lines of thought, but in the actual functioning of networks and coalitions in agri-food chains it remains to be seen how such ideas relate to concrete behaviour of actors with opposed interest or diverging perspectives. Consequently, the unintended outcome of the discussion may be limited to changes in physical organisations, i.e. replacing one organogram of R&D by another, rather than involving changes in the behaviours and interactions between organisations and actors involved in technological innovation in a value chain. The analysis of cluster development in Thailand suggests that investments may better be directed towards intermediary organisations performing specific function enabling innovation, such as trust-building or exchanging information[58].

The case on cluster development in Thailand (Box 2) suggests a leading role for intermediary organisation in processes of technological change embedded in innovation networks. Taking the BoP perspective, this may be a financially sustainable service provider, for example, a diagnose service in the production can help the producers in the determination of new, unknown or less commonly occurring diseases and to choose the right fighting method: physical control (plant removal), chemical control, instead of recurring to the trial and error method (cf. Box 1: Floriculture in Vietnam). Then, technological innovation will be accompanied by adjustments in the institutional framework. These adjustments may enable agricultural producers to establish (stronger) linkages with external experts

and to obtain new knowledge that will not be found using the current learning practices. Weak vertical linkages of producers with public and private research and development organizations can be considered a hindrance in tailoring more disruptive innovation of cultivation practices and the technology solutions used to reach environmentally friendly production methods that apply to the specific conditions in flower producing regions.

Historically, technological change in agriculture involved collective learning, sector-based innovation and public research, which alters the institutional conditions for innovation. Here, the BoP approach can benefit from the National System of Innovation perspective, which has a more precise understanding of the interactions between providers and users of technological innovations, embedded in the complex networks of public and private actors collaborating in research and development. However, the BoP arguments may add the idea that we need different innovation strategies, servicing the variety in technological needs and opportunities by designing products and processes adapted to different production systems or value chains. The BoP argument makes technological innovation largely dependent on interactions in local markets, while the innovation system view appreciates institutional arrangements supporting stakeholder participation in agenda setting and providing access to public and private R&D.

Push and Pull steering technological innovation in value chains

Within the last decade, the rapid rate of technological change, shortened product life cycles, and increasing global competition have made new product development a critical concern for the private sector. The discussion in the previous section indicates that the appreciation and acceptance of a specific technology in the market place is not thoroughly covered by the National System of Innovation perspective. When looking from a value chain perspective, presenting innovation as an open-ended search process, as the National System of Innovation perspective does, seems to disregard the fact that market players cannot buy what does not exist. A sole focus on institutional processes may not be able to come to grips with the selection processes operational in the economic realm. In the market place, where tangible solutions to problems in commerce or markets are required, actors tend to judge technological innovations on their tangible traits and functionalities in the sphere of competition. This requires decision making leading to a certain technological fix or closure. Closure refers to the end of the process of technical design and social construction by relevant actors, indicating that the specific technology –material, process or product- no longer goes through dramatic changes[59]. Closure also implies the end of interactions and negotiations in the innovation process[60], which are at the basis of the analytical framework used by the Innovation System perspective. Hence, in the commercial domain, a technological fix is necessary to make progress, which leaves little room for redesign or adaptation: the level of changeability by users is low. The process of technological closure is strongly dependent on the strategies, business models and internal decision processes of firms[61].

The Bottom of the Pyramid framework explicitly addresses business models and market strategies, and proposes a new orientation towards agricultural producers as customers of technological products and services. The BoP argument has a strong bias on individual entrepreneurs, favouring technology-based entrepreneurship and building on available tacit knowledge and skills. The approach is less explicit about the nature of the relationships between economic actors. The BoP idea seems to assume that the outcome of transactions in the market place leads to a maximised utility for poor buyers of technological innovations. Likewise, the interdependencies in value chains, for example leading to prescribed applications of technical inputs, are not taken into account. Additionally, the organisational obstacles inside firms, hindering the transformation of business strategies, are not explicitly addressed (Box 5).

Due to the strong focus on bringing new products and services to local markets, the BoP approach pays less attention to the processes through which local entrepreneurs gain entry into design, production or marketing networks elsewhere. Humphrey[62] connects the forms of entry to the process of up grading of local firms by incorporating and acquiring new skills, competencies and services. In this way, the approach relates innovation to a development trajectory for up grading developing

country actors in a chain from agricultural primary producers or industrial assemblers to actors capable of linking technological capacities to marketing strategies. Through acquisition of technological capacities or specialisation in certain tasks value chain actors may also strengthen their capacity to respond to new regulatory requirements and market opportunities. This also introduces the interesting field of mixing endogenous and exogenous knowledge and skills, which entails complex institutional arrangements between local actors and outside organisations.

Hence, technological innovation in agri-food chains is the outcome of the interaction between pushing and pulling factors rather than a direct result of market demand. However, most innovation systems lack an interface ensuring the translation of generic R&D into tangible technological uses for small and medium enterprises, including agricultural producers, through application research and product development. Hence, it seems to be worthwhile to find a way in which both approaches discussed in this paper can meet, with the National System of Innovation paying more attention to the construction of technological push and the Bottom of the Pyramid emphasising the pull perspective. Combining both views poses an alternative to the up stream transfer of knowledge and technology in agri-food chains, accompanying unidirectional requirements in the field of quality and safety. This needs an institutional modality capable of balancing push and pulls factors, incremental changes solving immediate problems and strategic innovations, as well as short-term and long-term processes. By its nature, a value chain is primarily concerned with immediate business demands and incremental technological changes. Embedding agri-food chains in an enabling environment, perceived as a system with different functions, appears to be an obvious suggestion, which, however, requires socially embedded institutional modalities that are not easy to install.

5. Conclusion: Policy insights

In their development approach, both frameworks discussed in this paper emphasize the importance of social embeddedness, leading to inclusive forms of technological innovation and (integrated) economic activities. An unintended outcome of efficiency strategies and standard setting may be the opposite, namely a form of technological change exclusive to preferred suppliers of top-segment markets. Although sourcing strategies and decentralized business practices closely interact with diverse conditions and a variety of producers and processors, appreciating the benefits of the existing social infrastructures is not strongly rooted in value chain strategies of firms participating in globally dispersed production systems[63]. In cross-border value chains, this leads to narrowly defined roles of developing country producers, with correspondingly limited technological capacities[64]. The approaches examined in this paper criticise the unidirectional technology transfer approach with a strong focus on optimisation, which is driven by quality and safety requirements in agri-food chains.

Both views discussed in this paper, the national system of innovation (NSI) perspective and the bottom of the pyramid (BoP) framework, emphasise that technological innovation evolves from institutional interactions within a network of public and private actors as well as with customers in locally embedded markets (Table 1 typifies both modes of thought discussed in this paper). NSI takes a more open-ended perspective, emphasising the importance of interactions and intermediary organisations connecting different capacities. While BoP pays more attention to the selection of technological alternatives and relates this to the articulation of users' demands in specific markets. A combination of both approaches may lead to institutional modalities for technological change in agri-food chains, which build on socially embedded capacities *and* local market demands. This contrasts with an approach based on uniformity of technological practice and liability-driven contracts that is also evident in agri-food chains. It also poses an alternative to development strategies investing in innovation networks *per se*, while bypassing the processes of selection and articulation of demand that tailor new products and services to low-income markets. Hence, some form of coordinated innovation, in which both market opportunities and institutional arrangements are integrated, may be needed to enhance the innovative capacities of chain actors and surrounding organisations for leveraging sustainable development[65]. Also, strategic policy, both in the public and private spheres, is needed to relate more

radical technological innovation to the processes of incremental change and adaptation usually attached to tangible applications in business. This opens opportunities for relating commercially grounded arrangements in value chains and markets to the institutionalised arrangements in innovation networks. Installing feed back mechanisms and facilitating interactions appears to be more important than focusing on the organisational forms of technological innovation.

	National System of Innovation (NSI)	**Bottom of the Pyramid (BoP)**
Value Chain Configuration	o Focus on the interactions between users and producers of knowledge and technology	o Focus on the articulation of demand of customers in low-income markets.
Enabling Environment of a Value Chain	o Focus on systemic changes and invest in intermediary functions linking distributed capacities	o Focus on managing constraints and tailoring business models to socially embedded market opportunities
Technological Innovation: Balancing Push and Pull	o Produce options through experimentation and evaluation in an evolving network	o Start from demand pull for reengineering (existing) technological innovations

Table 1: Two frameworks to innovation and development

The discussion in this paper suggests that rooting technological change in value chains both in the interactions in national or regional innovation systems and in the low-income markets for products and services may result in institutional arrangements stimulating learning and acquisition of technological capacities. This also suggests that a transition to sustainable economic development will benefit from some form of coordinated innovation. Building such a collaborative model, instead of relying solely on economic efficiencies and standardized practices, requires purposive and strategic interventions and investments by chain actors in alliance with other players. Obviously, there is no blue print for this, and it seems appropriate to continuously diagnose value chain linkages in terms of the development of innovative and technological capacity[66].

The discussion identifies three topical terrains for arranging technological change in value chains differently: (1) a focus on interactions in a nation or region-based evolving innovation system clustering various functions and activities; (2) the conception of users of technology as buyers of technological innovations in local markets at the lower end of the economic pyramid; and (3) the value of embedding performance improvement in a process of reengineering existing institutional structures rather than constructing an agri-food chains based on ideal conditions.

From these insights, three lessons can be formulated for policy addressing both innovation and economic development in relation to value chains:

1. To make value chains instrumental in development strategies, it is important to provide resources and opportunities for interactions governing the innovation processes public and private actors are involved in. Eventually, this may lead to joint agenda setting and priority selection in technological innovation. This requires a combination of transparent vertical linkages in value chains and horizontal, web-based linkages between firm and non-firm actors in an innovation system. The institutionalisation of feed back mechanisms between micro and meso levels will improve the capacity of the public and private R&D infrastructure in supplying a choice of technological solutions, to be used and adapted by value chain actors This endeavour aims to build a constituency for science and technology in national or regional networks, linking short terms actions, offering real solutions to day-today challenges in market environments and value chains, with institutional settings involved in open-ended experimentation and long-term searches for technological innovation.

2. The impact of the enabling environment, e.g. public research institutes, on the performance and technological capacities of downstream actors in value chains, will improve by dovetailing

R&D activities with firms and innovators designing products and services tailored to low-income markets rather than supporting or subsidising the access of low-income producers and processors to 'standardised' technological recipes available in mainstream markets.

3. Leveraging the strengths of socially embedded capacities and market environments leads to a viable institutional approach, reengineering rather than reconstructing socio-technological practices, leaving space for a wider range of practices and organisational principles. This does not necessarily mean that big concessions should be made to common goals, such as food safety, health and the environmental sustainability. This observation raises the question whether public health and sustainability objectives in food production can only be achieved by one route, or whether more than one road leads to a similar outcome. Openness to a diversity of technological recipes would give small producers more chance of participating in regulated food provision and integrated value chains, demanding intensive interaction between members of the chain to select to practices producing the desired results, as opposed to a blanket imposition of agricultural standards.

6. NOTES

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[8] This observation corresponds with an advice in 2003 to the Dutch Minister of Agriculture, Nature Management and Food Quality by steering committee on Technology Assessment (discussed in Vellema, 2006). The steering committee observes that strict health and environmental requirements have largely been translated into rules and regulations appropriate for large companies. Companies and producers in exporting countries are stimulated by this to concentrate on the methods promoted in the regulations, e.g. the use of certain quality control systems such as HACCP, or the application of certain methods of pest control, as a condition for gaining access to the enticing consumer market. The committee points at the danger that mainly larger companies are in a position to fulfil the standards without getting a premium price to compensate for the costs of doing so. The imposition of rules therefore leaves little room for the diverse group of smaller companies. Source: Advice given in 2003 in response to the conference: Voedselveiligheid tot (w)elke prijs? (What price for food safety?). http://www9.minlnv.nl/pls/portal30/docs/FOLDER/MINLNV/LNV/STAF/STAF_DV/DOSSIERS/MLV_GOIK/INNOVATIE/ML_PUBLICATIES_KENNIS/BRIEFVEERMAN.PDF . (Accessed 12 December 2005)

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