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Moving Toward Sustainable Agri-Food Value Chains: Challenges and a Proposed Way Forward

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Abstract

Chain failure is widespread in agri-food value chains, due often to the presence of externalities within and beyond the chain. Since many of these externalities have intergenerational aspects, this situation results in poor sustainability outcomes. Chain failure can be overcome by the provision of chain goods that internalise the externality. Joint action by value chain partners is required to develop and implement chain goods, and this action is made more effective if the appropriate chain governance model is applied. Such action will influence the sustainability of agri-food value chains and hence the welfare of farmers supplying the agri-food sector. In this paper we outline a process toward making an optimal decision to correct for chain failure that is based on actions by a value chain governor rather than the typical application of taxes and subsidies. Investment within the chain and exploitation of consumers' beliefs in a sustainable future can also help to internalise externalities. The more tightly circumscribed are such externalities, the more likely it is that a solution can be found within the chain through appropriately-governed joint action by chain members, obviating the need for government intervention or at least facilitating chain-government collaboration. These solutions are likely to be more feasible within agri-food value chains than in society at large because of the shared interest of members in making the chain work better and making chain activities more sustainable.

Background

There is a burgeoning literature on sustainability in agri-food value chains (Baldwin, 2009). Of hundreds of definitions of sustainable development,¹ the most commonly used one is by the Brundtland Commission (1987): 'meeting the needs of the present without compromising the ability of future generations to meet their needs'. In the context of the food industry, a narrower interpretation is that actions by participants in the agri-food sector to meet the demands of the current generation of food

¹ For the purposes of this paper, we shall refer mostly to the concept of sustainable development but regard the use of the term sustainability as interchangeable with sustainable development.

consumers should not compromise the ability of future generations to meet their food and nutrition needs.

Interest in sustainable agri-food value chains stems from strong preferences by consumers for credence attributes relating to sustainable farming practices accompanied by a corresponding willingness to pay for such attributes. Global certification schemes and brands with overtones of sustainability have emerged, such as GlobalGap (Moeller, 2019), Marine Stewardship Council (Cummins, 2004) and FAIRTRADE (Fairtrade Australia New Zealand, 2017). Local certification schemes relate to organic production, animal welfare and the environment.

Recently, this interest has extended to 'whole-of-chain sustainability' (FAO, 2014). Luo et al. (2018) provided an up-to-date and thorough review of the literature on agri-food value chains. They selected 1770 articles from Scopus to conduct a bibliometric analyses, and also conducted a content analysis on 188 articles in six areas of research focus selected from their co-citation analysis. They found that the theme of sustainability pervades five of the six themes. Two main themes of food safety and traceability in a food supply chain are directly related to sustainability. Most research on the global food supply chain theme focuses on development issues. Research in food supply chain modelling concentrates on reducing food waste and improving environmental sustainability (Luo et al., 2018, p. 2).

Barriers to Economic Analysis of the Sustainable Development of Agri-Food Value Chains

Efforts to apply whole-of-chain sustainability concepts and conduct economic analyses of sustainable development using definitions of the type proffered by the Brundtland Commission (1987) and others (Luo et al., 2018) face six main barriers:

1. Assessing empirical evidence to support a statement based on positive analysis
2. Specifying the appropriate theory underpinning the definition
3. Developing an analytical framework transcending economic, social and environmental systems
4. Dealing with equity issues between and within generations
5. Taking account of the time value of money
6. Quantifying the sustainable development concept.

First, as worthy as they sound, there is an unresolvable problem with the definitions of sustainable development such as that by the Brundtland Commission (1987). A compromise that inevitably has to be made when evaluating sustainability, is that the 'needs' of future generations cannot be defined. Mean non-negative change in the value of an agri-food value chain in the long run is a good place to start when making any compromise to evaluate sustainable development, but it is not sufficient if market prices are used. Beckerman (2007) remains the gold standard in assessing the validity of using the concept of sustainable development in an analytically useful way to bridge the generational chasm in resource allocation in the whole economy or its parts. Of all the numerous studies attempting to define and employ this concept, the Brundtland Report provides a useful base on which to conduct a critique and determine whether the concept has any analytical value. Beckerman's critique of the Report provides us with a rationale for using the concept of sustainable development in a meaningful way, avoiding the approach that he definitively criticises as an impossible endeavour, by conducting normative economic analysis in contrast to the approach adopted by the Brundtland Report (1987).

A positive approach to economic analysis explains 'what is', and its theoretical basis is validated by empirical evidence. The definition of sustainable development proffered by the Brundtland Report is a

positive statement. As Beckerman points out, this definition cannot be validated by empirical evidence, as demanded of a positive approach; nor is it embedded in economic theory. A normative approach, on the other hand, focuses on 'what ought to be' or what is best, and 'is often supplemented by value judgments' (Pindyck and Rubinfeld, 2001, p. 7). According to Pindyck and Rubinfeld, normative analysis 'is not only concerned with alternative policy options; it also involves the design of particular policy choices'. It is noteworthy that, in his seminal book, *The Age of Sustainable Development*, Jeffrey Sachs stresses that 'Sustainable development is an analytical and normative concept' (Sachs, 2015, p. 1). Second, sustainable development definitions of the Brundtland Commission (1987) mode are not based on a well-established economic theory that is suitable for analysing the concept. Beckerman (2001, p. 85) opined that:

It constitutes an attempt to replace the time-honoured economist's concept of welfare maximization, from which precise theoretical criteria for policy action can be derived and which reflects widely acceptable ethical judgments, with a confused and morally highly contentious principle.

The third issue is related to the second, and concerns a lack of application of suitable analytical tools to study market failure and the emergence over time of externalities and public goods and bads, concepts that we believe are basic to analysing the sustainable development of agri-food value chains. The welfare economics theory underlying these tools typically encompasses sustainable development across all economic dimensions. Benefit-cost analysis done properly (that is, by including all benefits and costs) encompasses outcomes of a social and environmental nature. For example, prevention of poor environmental and public health outcomes in the agri-food sector is an oft-defined aim. These outcomes are social externalities. As discussed below, there are also the possibilities of chain externalities, where there are spillovers within the chain that are not appropriately priced that lead to chain failure. Whole-of-chain performance warrants measuring in terms of chain values and, where spillovers occur to parts of society beyond the chain, social values. Measures in the literature cover examples of chain externalities without providing a consistent valuation procedure of chain parts.

The fourth and fifth obstacles to defining sustainable development stem from the potential for intergenerational trade-offs amid striving for intergenerational justice². Beckerman (2001, p. 91) argued that 'it is difficult to see why one should attach crucial normative significance to the current level of welfare' and that 'there is no case for intergenerational egalitarianism anyway'. While acknowledging that equality is not the same as equity, he claims that 'most – if not all – theories of equity or distributional justice contain, as a crucial ingredient, some appeal to the desirability of equality ...'. This leads him to reject intergenerational egalitarianism as an objective. An approach to defining sustainable development in a way that assumes the current level of welfare is optimal ignores the prospect that actions taken today may mostly benefit the better-off in the future but the less well-off may bear most of the current cost.

Any attempt to apply the principles of benefit-cost analysis to determining the desirability of an intervention to sustain the development of an agri-food value chain by a chain governor or policy maker requires the specification of a discount rate. Beckerman and Hepburn (2007) considered the ethics of applying a discount rate in the context of climate change, which was the theme of the Stern Review of the Economics of Climate Change (Stern et al., 2006). As arguably the major issue facing those responsible for designing policies and programs for sustainable development, attempts to measure the

² In many respects these points are similar to the barriers to joint decision making in cooperative theory (Fama and Jensen, 1983; Borgen, 2004).

benefits and costs of interventions to mitigate climate change provide a useful basis on which to consider the role of the discount rate in the sustainable development of agri-food value chains. Beckerman and Hepburn (2007) provide an excellent review of the difficulties in developing a sound measure of the discount rate. In particular, they assess the pros and cons of methods to quantify the 'utility discount rate' and the 'elasticity of marginal utility', and point to the dangers of a normative approach to using the market interest rate as a guide for the social discount rate.

Finally, efforts to quantify sustainable development have proven disappointing despite some heroic efforts to design indices that incorporate environmental, social and economic measures (some of which are mentioned below).

Clearly, these three elements of sustainability introduce many potential complications to the original simple definition [by the Brundtland Commission (1987)]. The goals expressed or implied are multidimensional, raising the issue of how to balance objectives and how to judge success or failure.

(Harris, 2001, p. 6).

We argue below that a process for making decisions to correct for chain failure can, at least in part, avoid the six analytical barriers mentioned above. Following a normative approach based on established principles of welfare economics provides an analytical framework that accounts for market failure in all economic, social and environmental systems, and the extent of this market failure can be quantified at least in terms of the current and next generation. In respect of the core issue with which we are concerned, a normative approach encompasses an optimal distribution of intergenerational resources within an agri-food value chain.

We examine whether actions by a value chain governor can bring about a more sustainable level of throughput in an agri-food value chain in the presence of externalities, and whether such joint action by chain members can obviate the need for government intervention or at least facilitate chain-government collaboration. Key concepts are introduced to explain how identifying and treating the causes of failure in agri-food value chains can promote their sustainable development, followed by a summary of ways to measure such parts in value chains. A process is outlined for making decisions to correct for chain failure to help sustain value in an agri-food value chain. Opportunities vary for making value chains more sustainable, and depend largely on an ability to counter the criticisms of the concept of sustainable development, outlined above. Finally, some conclusions are drawn.

Key Concepts

Chain failure, chain externalities and chain goods

Griffith et al. (2017) introduced three key concepts that are useful in understanding how a value chain can be operated in a sustained manner: chain failure, chain externalities and chain goods. Chain failure occurs when value creation is constrained by misalignment between the financial incentives for individual firms and their collective incentives when they are part of a value chain. Chopra and Meindl (2013) identified a particular challenge to sustaining a value chain when it requires efforts that do not provide obvious returns on investments. Such a situation is consistent with the definition of chain failure and of market failure beyond the value chain when spillovers occur.

The concept of externalities at the national and global levels can be modified in the context of value chains. A negative chain externality is a cost incurred by a participant in the value chain that is imposed

on a third party who is not directly engaged in producing, trading in or consuming the good causing the cost, and this participant does not compensate the third party. It may be a negative production externality such as pollution in an agri-food value chain or a negative consumption externality such as any adverse effects of fast food consumption. A positive chain externality is a benefit received by a third party who is not directly engaged in producing, trading in or consuming the good providing the benefit, and this third party does not compensate the participant in the value chain who provides the benefit. Production of healthier foods is an important positive production externality while improved dietary habits from consumption of better-quality and healthier foods are an example of a positive consumption externality.

Similarly, the concepts of public good and club good (a sub-type of public good) can be modified to refer to a chain good that is derived from these broader concepts without the condition of non-excludability (Mounter et al., 2016; Fleming et al., 2018). Chain goods such as the products of research, development and extension (RD&E) are those types of goods and services that allow effective coordination across value chain members but it does not pay individual members to provide them. Absent or poorly functioned chain goods caused by friction in the chain result in chain failure.

Governance

The construct and nature of its governance is central to the sustainable development of a value chain. The foremost publication in this sphere is by Gereffi, Humphrey and Sturgeon (2005) who acknowledged that 'although the search for paths of sustainable development in the global economy is an inherently difficult and elusive objective, our task is greatly facilitated by having a clearer sense of the various ways in which global value chains are governed' (Gereffi et al., 2005, p. 100).

There is a need to govern the interdependent activities of otherwise legally independent actors within the chain in pursuit of sustainable development. According to Marketlinks (n.d.):

Value chain governance refers to the relationships among the buyers, sellers, service providers and regulatory institutions that operate within or influence the range of activities required to bring a product or service from inception to its end use. Governance is about power and the ability to exert control along the chain – at any point in the chain, some firm (or organization or institution) sets and/or enforces parameters under which others in the chain operate.

Global value chain governance featured as one of four sub-themes in the fourth research area of the global food supply chain theme (e.g., Alvarez, Pilbeam and Wilding, 2010; Gibbon, 2003; Vermeulen, 2010). Gereffi et al. (2005) contended that 'the structure of global value chains depends critically upon three variables: the complexity of transactions, the ability to codify transactions, and the capabilities in the supply-base' (Gereffi et al., 2005, p. 98).

Gereffi et al. (2005) defined five types of chain governance – market, modular, relational, captive and hierarchy – 'which range from high to low levels of explicit coordination and power asymmetry' (Gereffi et al., 2005, p. 78). In a similar manner, Marketlinks (n.d.) described these governance types as being along a continuum from 'the market, characterized by "arm's-length" relationships, to hierarchical value chains illustrated through direct ownership of production processes'.

The type best suited to engaging a chain governor tasked with the responsibility of developing a sustainable agri-food value chain is relational (literally, regarding the way in which entities connect to each other). Relational governance types comprise separable independent stages rather than those chains driven by either a large retailer, a global processing company or a cooperative as outlined by Carbone (2017). Gereffi et al. (2005, p. 99) described the relationship as 'complex interactions between buyers and sellers, which often creates mutual dependence and high levels of asset specificity'. Codification of production and transaction details is difficult in relational governance models, and may be particularly so between generations.

Trust and reputation are features of such inter-firm relationships within value chains. These chains 'are populated by reciprocal and pooled relationships and ruled by a more relational kind of governance, potentially bringing advantages in terms of decision power and economic benefits' (Carbone, 2017, p. 1). Again, this may be more difficult in intergenerational situations.

This governance class can be usefully modified to distinguish between two types of relational governance: independent inter-firm relationships, as implied by the typology of Gereffi et al. (2005); and a 'club' relationship between these independent firms. We consider 'club' relational governance as having greater potential for improving chain surplus by reinforcing the trust and reputation of individual firms in the chain and by enhancing trust within, and reputation of, the chain as a whole. Carbone (2017, p. 1) pointed out that the independent relational governance model raises 'difficulties and drawbacks due to complexity of functioning, heterogeneity of stakeholders, and ambiguity of the nature of relations among them'. We believe that the application of club theory to relational governance as defined by Gereffi et al. (2005) provides an organising framework to overcome these drawbacks. Such a framework can be used to improve the alignment of incentives among chain participants and reduce any information asymmetries, thereby reinforcing existing levels of trust and reputation in the chain and maximising opportunities to sustain practices well into the future.

For the purpose of analysis, the 'club' relational governance type is considered typical of agri-food value chains. We use the term, chain governor, to represent the firm, organisation or institution referred to by Gereffi et al. (2006) as having the responsibility for managing a relational form of chain governance. Chain governors raise funds to implement and evaluate activities that correct for chain failure. They may be aided in these endeavours by government agencies, especially where government legislation is needed to enable a governor to levy chain members.

Australian examples emphasising sustainable development of agri-food value chains are numerous but two examples, Horticulture Coalition of SA and Meat and Livestock Australia (MLA), give a flavour of their aims and structure. Horticulture Coalition of SA is a good example of the dynamics of 'clubs' in agri-food value chains in that it was formed only recently (it represents the interests of 14 organisations from various parts of value chains in horticultural industries in South Australia), is 'evolving all the time', and is strongly aware of the importance of sustainable development of businesses in horticultural industries in South Australia for their future success (<http://ppsa.org.au/members/commodity-associations/horticulture-coalition-of-south-australia/>). Like many 'clubs' in agri-food chains, its primary membership is growers but a growing recognition of the importance of value chains means that membership and stakeholders are not confined to growers.

MLA is a statutory authority offering a chain goods solution through its functions of providing marketing and RD&E services for Australia's cattle, sheep and goat producers. Most of its funding is derived from compulsory transaction levies placed on the sale of livestock (MLA, 2013). MLA prides itself in 'delivering

research and development that contributes to producer profitability, *sustainability* [emphasis added] and global competitiveness (<https://www.mla.com.au/about-mla/>).

Measuring and evaluating sustainable development in agri-food value chains

According to Bell and Morse (2018), all major value chain firms report some social, environmental and sustainability metrics, but a large variation exists and few are assigned chain or broader social values. We are mindful of their counsel to appreciate the complexities of the task of developing a set of indicators of sustainable development and not to ask too much of any single indicator (Bell and Morse 2018, p. 13).

Food miles is a popular concept used to account for the divergence between market and social values but the concept has been widely criticised as inadequate and misleading in recent years (e.g. Agro-Ecological, 2009; Saunders, Barber and Sorenson, 2009). In particular, it is an incomplete measure of all divergences between market and social values. Recently, attention has shifted to carbon footprinting to take account of energy used throughout the product life cycle. Caputo, Nayga and Scarpa (2013) found that consumers now tend to prefer the CO₂ label.

Chopra and Meindl (2013) suggested that all firms in a value chain should measure and report the following four items: energy consumption; water consumption; greenhouse gas emissions; and waste generation. Two fundamental challenges in measuring and reporting these categories in an agri-food value chain according to Chopra and Meindl (2013) are the scope over which a category is measured and use of absolute or relative measures of performance.

Bonney et al. (2012) used a slightly different perspective from Chopra and Meindl (2013) in identifying two main ways to assess the environmental impact of a value chain. First, the relative impact of each activity in the material flow is concerned with whether the activity has a small or large environmental impact. Second, the comparative impact of each activity and product is compared with the impact of others in the same industry. It has proved difficult to make meaningful comparisons using the comparative approach, according to Bonney et al. (2012), who argued that relative assessment within the chain is more appropriate in terms of informing strategic decisions.

Bonney et al. (2012) discussed how to evaluate what they termed 'environmental sustainability' by focusing on the economic, social and environmental impact of a product over its life cycle. 'It involves systematic evaluation and management of resource use and environmental releases to air, water and soil from products, processes and services' (Bonney et al., 2012, p. 14). They observed that the activities to be included should reflect those particular to the case value chain, and the detail used for mapping the material flow. Ecological consequences to measure include: emissions affecting climate change; energy use; water use; biodiversity and land use; use/release of toxic chemical; water and air pollution; waste management; ozone layer depletion; depletion of oceans and fisheries; and deforestation.

Chopra and Meindl (2013) acknowledged the importance of expanding the goals of a value chain beyond the interests of its members to others who may be affected by their decisions. In some circumstances, spillovers from the chain to the broader national or global sphere may be sufficiently high to make the net benefits of action positive nationally or globally but negative to chain members. A good example of a comprehensive set of elements of sustainability in agri-food value chains is that developed by Heller and Keoleian (2000). They employed a set of sustainability indicators based on a food product's life cycle through the value chain. The indicators contain details on economic, social and environmental factors at

five life cycle stages: origin of resource; agricultural growing and production; food processing, packaging and distribution; preparation and consumption; and end of life. Heller and Keoleian (2000) used their set of sustainability indicators to analyse trends in a food value chain in the United States.

Van der Vorst, Peeters and Bloemhof (2013, p. 130) put forward a proposal for a 'sustainability research assessment framework' for Dutch 'food supply chain logistics'. Elements in this framework are 'drivers, strategies, performance indicators, metrics and improvement opportunities to measure and potentially enhance sustainability performances'. The authors asserted that a measure of 'triple bottom line performance' (economic, environmental and social) is needed, an assertion with which we disagree. A 'triple bottom line has no theoretically sound basis for determining the weighting between the three 'bottom lines'; nor does it provide a means to account for the inevitable trade-offs and complementarities between them.

Progress has been made in constructing hosts of indicators and indices to influence people with power (including the public) to do wiser things. There remains important second order work to engage with. This can be framed in terms of continuing reflection on the formulation of indicators by experts and communities, the strategic, tactical and operational value and targeting of indicators and the development of forms of assessment. But the absence of a consistent numéraire for valuing all the economic, social and environmental impacts of chain externalities and chain goods in and beyond the value chain detracts from all the above studies, not to mention the difficulties posed by the intergenerational issue. We address this shortcoming in the following section by modifying and adapting established evaluation processes used in microeconomic analysis.

Intervention to Correct for Chain Failure

We suggest the use of chain values and social values to assess the impacts of production and consumption externalities and chain goods in an agri-food value chain. The value of chain goods could be measured using procedures for measuring club goods (Sandler, 2013), which are in turn based on procedures for valuing public goods (Hubbard et al., 2012, pp. 454-456). The internalisation of these externalities can be measured following standard economic procedures but with a twist to separate the impacts within the chain from the impacts beyond it. Fleming et al. (2020) provide a variety of diagrams to present positive and negative production and consumption externalities

The economically efficient level of a negative externality in an agri-food value chain is not zero; neither is zero usually possible. The optimal decision is to continue an activity to the point where the marginal benefit from reducing the negative externality from that activity is equal to its cost. As the externality is further reduced, the additional benefits become smaller and the additional costs of reducing it become greater. This concept also applies to the provision of a positive externality, which entails setting the marginal cost of producing it equal to the marginal benefit from its creation.

Encouraging Joint Action in Agri-Food Value Chains

Thus far, it has been assumed that net benefits from actions to sustain value in an agri-food value chain would be sufficient to galvanise action, but friction in the chain frequently retards these actions. An agri-food value chain governor has a role to play in harnessing joint action, to use the terminology of Schmitz (1999), to overcome this friction and counteract the many different types of chain failure. Areas particularly prone to chain failure that can benefit from joint action by chain members include RD&E, market regulation within the chain, enhancing consumer and channel knowledge, education and

training, inventory aggregation, transportation policy, exploiting scale and scope economies, and risk sharing.

Ways to harness joint action can be adapted from the literature on ecosystem services. For example, Costanza (2008, p. 351) used a classification system of ecosystem services, some of which assume considerable importance in agri-food value chains.

Ostrom (1990), Ostrom et al. (1999) and Marshall (2001) are good sources of material on this form of collaboration. Marshall (2001, p. vi) proposed a theoretical framework synthesised from developments in the rational-choice theory of collective action that 'highlights the role that increasing-return, or positive-feedback, dynamics play in the emergence of spontaneous large-group cooperation, and thus the importance of the feedback upon which these dynamics depend'. He applied his proposed theoretical framework to collaborative agri-environmental governance in Australia and reported favourable results.

Griffith et al. (2015) provide three examples of internalising a chain externality through joint action in meat value chains in Australia that puts value chains on a more sustainable footing. First, export inspection services can be used to internalise a negative externality caused by an exporter selling low-quality meat products in the world market that damage the reputation of an Australian meat product. Second, disease problems can be managed at a stage in a meat value chain by introducing disease control regulations. Finally, investing in processes to internalise a positive externality that generate quality advances at one stage provide benefits to others in the chain. The more tightly circumscribed are such externalities, the more likely it is that a solution can be found through joint action without the need for government intervention.

Sometimes the chain governors can play a minor but effective role by 'nudging' some members in the value chain to solve a problem of chain failure privately. Private solutions obtained from applying the Coase theorem (Hubbard et al., 2012, p. 491) are likely to be more feasible within agri-food value chains than in society at large because of the shared interest of members in making the chain work better. There needs to be an economically efficient level of adjustment of an activity causing an externality that members of the value chain can agree to.

The governor can 'nudge' chain members by lessening three potential limitations of collaborative private action. First, limit the numbers of collaborators: a large number of chain members involved in bargaining makes the process unwieldy and consensus more difficult to achieve. Second, prevent unreasonable demands being made by chain members, especially those with market power. Finally, ensure all chain members have full information about the costs and benefits of taking action to internalise the externality – admittedly a difficult condition to create where much information is privately held by firms in the chain.

A Partial Approach to Countering Criticisms of Sustainable Development

As stated above, we recommend a normative approach to our use of the concept of sustainable development of agri-food value chains by adding to Beckerman's (2007) inclusion of global human rights as a necessary condition of any valid description of sustainable development. The value judgment underpinning our approach is that it should be reasonable for any future generation to expect past generations to have dealt with any chain failure that emerges and affects the welfare of future generations participating in these chains. Dealing with these forms of chain failure means internalising

any chain externalities, providing any chain goods and removing any chain bads – subject to the condition that these actions increase net chain benefits (and net social benefits where spillovers occur to society as a whole) net of transaction costs. Club theory, as outlined above, provides a sound theoretical framework for applying this analytical approach. It has the capacity to lead chain governors and policy makers to recommend joint actions that reduce chain failure.

A problem that we obviously encounter with this approach is that, in itself, it is not a globally optimal solution but a partial one, dealing only with those factors influencing the intergenerational transfer of resources that come under the auspices of chain failure in a particular market. Other issues dealing with intergenerational fairness in resource distribution are excluded but, as Beckerman (2007) points out, these fairness issues cannot be satisfactorily resolved. Therefore, the factors with which we are concerned provide at least the minimum set of policy changes that should be enacted in the pursuit of optimal intergenerational resource distribution in agri-food value chains. They should at least put the moves to correct for failure along the right path to satisfying the needs of future generations, even if we cannot know what the optimal situation is for each succeeding generation.

It is not possible to account for all inter-generational discrepancies caused by a lack of a satisfactory discount factor to account for the time value of money and equity trade-offs between generations. Nevertheless, reasonable judgments can be made as to the probability that there would be benefit-cost analysis and equity complementarities across generations from interventions to internalise externalities in the current generation. For example, Banerjee and Duflo (2019, p. 208) observed that ‘Climate change is massively inequitable’ and hence actions taken to prevent it now should have large equity complementarities for future generations. Soundly based value judgments, acceptable in normative analysis, can be used to exploit inter-generational complementarities where interventions to benefit the current generation also benefit future generations, resulting in a positive move in the direction of sustainable development, if not a precise estimate.

Satisfactory measures of the discount rate might be possible in certain circumstances, which avoid the need to adopt a normative approach to using the market interest rate as a guide for the social discount rate. Beckerman and Hepburn (2007, p. 206), point to some potentially useful approaches ‘including the use of stated preference surveys, behavioural experiments, and methods to reveal the social preferences inherent in our social institutions’.

We are less sanguine about the potential to provide quantitative measures of sustainable development in agri-food value chains. Current efforts to put a value on sustainable development in terms of an index lack a sound theoretical base and are fraught with inconsistencies. Beckerman (2007, p. 23) summed up efforts to develop a sustainability index as follows:

The impossibility of devising an intellectually coherent and operational definition of sustainable development is illustrated by the difficulties faced by bodies that have attempted to measure sustainability.

The best that can be achieved is to quantify current externalities and chain goods and bads, which in certain cases point in the direction a chain can move to both maximise welfare and satisfy sustainable development goals.

Conclusion

Making and implementing sustainable development policies have tended to be done predominantly in the public domain based on influencing the actions of private producers and consumers. We have made the case that there is a domain between private and public – the value chain – that can be exploited for purposes of sustainable development by effecting joint actions by agri-food value chain participants with common interests, even if they compete with each other in the market-place. Examples have been provided.

Standard analytical tools used in the public domain have been modified to suit the purposes of identifying and treating the causes of failure in agri-food value chains that act against their sustainable development. Methods to bring about the optimal intervention to correct for failure to sustain value in an agri-food value chain present challenges, especially valuation of non-market events and accounting for the welfare of future generations, and precise prescriptions are difficult to formulate. But they should highlight the most egregious forms of failure and make a substantial contribution to pointing agri-food value chains in the direction of welfare maximisation for current and future generations.

Establishing appropriate numéraires for chain and social values is not the end of the process of developing a strategy of sustainable development. These numéraires are highly desirable for establishing performance measures and trade-offs in the application of multi-attribute value and utility-based analyses to optimise a system in the presence of multiple objectives, as dictated by the concept of sustainable development. Ananda and Herath (2009) provide a comprehensive critical review of multi-criteria decision-making methods. They distinguish between continuous methods to identify an optimal quantity such as ‘linear programming, goal programming and aspiration-based models’ and discrete methods that they coin decision support techniques with ‘a finite number of alternatives, a set of objectives and criteria by which the alternatives are to be judged and a method of ranking alternatives, based on how well they satisfy the objectives and criteria’ (Ananda and Herath, 2009, p. 2536).

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