

A System Dynamics Approach to Chain/Network Analysis in the Primary Industry Sector: Case Studies of Beef, Dairy, and Amaranth in the Developing World

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Extended abstract

The research problem and gap this paper examines is that although received value chain analysis (VCA) is well designed for establishing a narrative, describing the chain, and identifying influencing factors, it is less good at measurement and objective analysis. Similarly, analytical attempts to quantify value chains to date have mostly targeted micro – firm level – economic analysis and, hence, have been weak in analyzing and evaluating overall chain performance under a variety of policy and commercial interventions. A major gap in VCA is thus in understanding the *impact* of VC investments such as the general *performance* of a chain and the ability to evaluate *ex-ante* different options. The gaps in the widely used approaches to VCA include the lack of an approach to reconcile the various systems and constraints at different nodes or stages of the value chain.

This paper aims to address this gap by designing a conceptual framework to demonstrate the suitability of the system dynamics (SD) modelling approach to address the complexity of the agricultural value chains in a quantitative whole chain context. This paper uses a SD modelling approach to build on value chain and partial equilibrium analysis to construct a

conceptual framework to address the research gap identified in this paper. The author then provides applications of the conceptual framework and SD models to three agricultural value chain case studies to provide a proof-of-concept and to direct future applications. The case studies represent different commodities (cattle, beef, milk, and crops) and regions (Botswana, Tanzania’s Kilosa district, and East Africa) across multiple chain stages, and in the contexts of market power, international trade, transboundary disease control, communal resources, food security, technology uptake, market reorganization, and development in an agricultural value chain context.

The first case study on the beef value chain in Botswana reported an *ex-ante* impact assessment of policy changes associated with trade liberalization and disease management in a value chain context. It provided performance measures to evaluate the gains and losses of value chain actors (and of the whole chain) under various policy interventions. Model results suggested that although disease control policies benefit all value chain actors, gains from market liberalization come at the expense of substantial losses to Botswana

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Meat Commission (BMC) and its contracted feedlots. They also suggest that combining market liberalization policy reforms with better animal disease controls greatly improved the financial performance of all value chain actors.

The second case study on the dairy value chain in Tanzania's Kilosa district reported results of an *ex-ante* impact assessment to address issues of low productivity of local breed cows and limited market access. Interventions included provision of artificial insemination (AI) as a technological change to increase dairy productivity; and organizational change entailing a dairy market hub to enhance producer access to distant markets. The dairy case study evaluates the economic feasibility of switching from extensive pre-commercial production systems to more intensive more commercial production systems as means of upgrading the dairy value chain in Tanzania's Kilosa district. The results demonstrated through multiple performance indicators – producer profits, milk production, proportion of cross-breed cattle in the total cattle population, and the volume of milk traded to market hubs and processors – shows the potential for upgrading the smallholder dairy value chain in Kilosa, but this requires that third parties support producers in the initial stages (first five years) of investment to subsidize the high costs of AI.

The last case study on the amaranth value chain in East Africa examines the food security and commercialization potential of amaranth from a whole of chain perspective. It reported results of *ex-ante* impact assessment of the impact of producer adoption of improved production technologies (improved seed varieties) and changes in demand for amaranth products,

on producer profits and planting behavior. It provided performance measures based on producer profits and endogenous land allocation to amaranth. This case study results showed that profitably upgrading and commercializing amaranth value chains requires multi-faceted and chain level interventions that improve supply and demand side conditions. Interventions that only target the supply side serve to increase amaranth production but have minor economic gains for producers.

These case studies, through addressing different research questions and providing different value chain performance measures, served to show proof-of-concept and versatility of the conceptual framework. This demonstration emphasis has constrained the extent to which a comparison between SD and alternative modelling approaches is made. Such a comparison in the context of agricultural economics is deferred to other research. The modelling of case studies has similarly focused on demonstration of elements of the conceptual framework, at the expense of detailed coverage of industrial and sector characteristics.

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