Land Use Policy 73 (2018) 184–194

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Critical factors for crop-livestock integration beyond the farm level: A cross-analysis of worldwide case studies

Masayasu Asai[a,*], Marc Moraine[b], Julie Ryschawy[c], Jan de Wit[d], Aaron K. Hoshide[e], Guillaume Martin[c]

[a] Policy Research Institute MAFF (PRIMAFF), 3-1-1 Kasumigaseki, Chiyoda-ku, Tokyo 100-0013, Japan
[b] UMR Innovation, INRA, CIRAD, Montpellier SupAgro, Univ Montpellier, 34060 Montpellier cedex 02, France
[c] AGIR, Université de Toulouse, INPT, INP-Purpan, INRA, Université Toulouse, ENFA, 31320 Auzeville, France
[d] Louis Bolk Institute, Hoofdstraat 24, 3972LA Driebergen, The Netherlands
[e] School of Economics, 206 Winslow Hall, The University of Maine, Orono, ME, 04401, USA

A R T I C L E I N F O

Keywords:
Crop-livestock systems
Mixed systems
Collaborative farming
Collective farming
Transaction costs
Innovation

A B S T R A C T

Despite their recognized agricultural sustainability benefits, mixed crop-livestock farms have declined in the Northern hemisphere. As such, crop-livestock integration beyond the farm level is a promising alternative to this trend, but the knowledge of critical factors and strategies towards its successful implementation is still lacking. We developed an analytical framework to assess the critical determinants of the emergence and outcomes of integration, which helped us understand farmers' collective strategies for reducing integration transaction costs. The resulting framework distinguishes between three types of transaction costs: information gathering, collective decision-making, and operational and monitoring costs. These costs are influenced by several factors: external environment attributes, resources engaged in crop-livestock integration, and participating actors and their arrangements. Application of the framework onto six case studies all across the world (Asia, Europe and America) demonstrated it can be utilized for various projects implemented at multiple organizational levels (farm-to-farm, local groups, and regional levels) over distinct farming systems (conventional and organic). Specific policies should be developed to strengthen social networks through the mutual understanding of such integration benefits, since they play a key role in lowering the costs of information gathering and collective decision-making. A legal framework to establishing a formal contract should contribute to lower long-term monitoring costs, especially when trust among actors developing. Operational costs largely depend on the spatial proximity of farms, but this can be overcome by extending the scale of integration in terms of covered area and number of participants. Here, appropriate coordination by third-party entities is essential, and should be targeted by financial and technical support.

1. Introduction

During the mid-twentieth century, in numerous countries of the Northern hemisphere, agriculture has evolved towards mono-cultural production systems, aimed to maximize yield to satisfy both local and export food demands (Matson et al., 1997). This evolution occurred through accelerated mechanization; increased use of fossil fuels, fertilizers, and pesticides; and globalization of agricultural markets. These changes in farm technology and market conditions allowed for the specialization and enlargement of production (e.g., Björklund et al., 1999; Kristensen, 1999; Aguilar et al., 2015). Since then, stringent environmental regulations, detailed animal welfare demands, and higher product quality standards strengthened this trend by requiring increased expertise from farmers, while the environmental impacts (soil, water and food pollution, etc.) of specialized agricultural systems (Oomen et al., 1998; Horrigan et al., 2002) are no longer accepted by some society members.

Diversified systems, such as integrated crop-livestock systems, promote ecological interactions over space and time between system components (e.g., crops, grasslands, and animals) and allow farmers to limit the use of inputs through development of 1) organic fertilization from livestock waste and 2) diversified crop-grassland rotations to feed animals (Hendrickson et al., 2008; Ryschawy et al., 2017). When well suited to local conditions, such integration improves nutrient cycling by re-coupling nitrogen and carbon cycles (Martin et al., 2016; Lemaire et al., 2014; Ryschawy et al., 2017). It can also generate higher

* Corresponding author.
E-mail address: asai.masayasu@gmail.com (M. Asai).

https://doi.org/10.1016/j.landusepol.2017.12.010
Received 31 March 2017; Received in revised form 24 November 2017; Accepted 3 December 2017

economic efficiency by reducing production costs and risks, with regard to market fluctuations (Russelle et al., 2007; Wilkins, 2008). However, the major constraints of on-farm integration are related to the limited farm workforce available, combined with a loss in the skills and knowledge required to optimize both crop and livestock sub-systems (Moraine et al., 2014; Martin et al., 2016).

As an alternative to on-farm integration, several authors (Entz et al., 2005; Russelle et al., 2007; Martin et al., 2016) suggest that integration can be structurally organized at larger scales than the farm, through cooperation among specialized livestock and arable farms. In such an organization, some of the synergies normally provided by on-farm integration can be obtained, but determine much smaller increases in farm workload, complexity of rotations, skills, and infrastructure for the individual farms involved (Regan et al., 2017). Since involved farms have opportunities to develop diversified crop rotations, integrate legumes or grasslands, and apply manure, they can also exploit a diversity of environmental benefits, such as biological regulation of pests and diseases, and improved soil quality (Duru et al., 2015; Martin et al., 2016; Moraine et al., 2016b, 2017). However, there may be several environmental limitations, depending on the level of spatial and temporal integration. These include green-house gas emissions associated with trucking around manure, and mismatches between nutrient supply and demand (Martin et al., 2016).

Crop-livestock integration beyond the farm level can take several forms. According to several authors (Entz et al., 2005; Martin et al., 2016), three main types of integration projects can emerge, depending on the level of spatial, temporal, and organizational coordination among farms. The first and simplest form is a partnership between specialized crop and livestock farms (farm-to-farm), where they exchange raw materials (manure, grain, fodder, and straw). A second type of direct exchange can be organized by local groups of crop and livestock farmers negotiating land-use allocation patterns. Furthermore, a third type involves upscaling to, for instance, a regional scale where spatially separated groups of specialized livestock and crop farmers integrate through coordination by a third party (e.g., agricultural cooperative or firm). Here, the farmers involved are not necessarily communicating directly.

Organizational challenges farmers face when they initiate, implement, and sustain projects of crop-livestock integration can be obstacles to the success of entire projects, regardless of their type. This is because integration beyond the farm level always requires coordination among multiple participants and the management of trade-offs between individual and collective objectives and performances (Ryschawy et al., 2017). The time and money spent for coordination and management may be additional costs in addition to the implementation costs of on-farm integration, needing to be minimized. Due to a lack of adequate measures and framework for the analysis of organizational coordination, the critical determinants of the emergence and outcomes of integration beyond the farm level are not analyzed. As such, research has been sparse on how farmers strategically and collectively overcome these challenges. This lack of knowledge limits crop-livestock integration beyond the farm level.

In this context, our study first proposes an analytical framework to address crop-livestock integration beyond the farm level, from the perspective of Williamson's transaction costs economics (Williamson, 1985) and Ostrom's institutional analysis and development (IAD) framework (Ostrom et al., 1994; Ostrom, 2005). We use this framework for cross analyzing six projects as case studies, in which we assess the determinants of the emergence and outcomes of integration. Here, the emergence and outcomes are evaluated qualitatively as transaction costs derived from the three phases of project development: information gathering, collective decision-making, and operation and monitoring. Based on our interpretation of these six projects, we identify attributes crucial for crop-livestock integration development and durability. By so doing, we try to understand farmers' collective strategies to reducing integration transaction costs. Finally, we conclude with policy implications and recommendations for the further development of crop-livestock integration beyond the farm level.

2. Materials and methods

2.1. Analytical framework

2.1.1. Transaction cost economics to analyze crop-livestock integration beyond the farm level

Applications of the theory of transaction cost economics (Williamson, 1985) allowed us to analyze crop-livestock integration projects, to explore organizational challenges of farmers in initiating, implementing, and sustaining integration beyond the farm level. Transaction costs can be defined as the costs arising not from the production of goods, but from their transfer from one agent to another (Niehans, 1971; Mettepenningen et al., 2011). They take numerous forms (e.g., Holloway et al., 2000), and Matthews (1986) distinguished ex-ante and ex-post transaction costs respectively corresponding to the processes of achieving an agreement and continuing to coordinate its implementation (Cacho et al., 2003).

As already discussed by Asai et al. (2014a), transaction costs have a major impact on the arrangement of integration beyond the farm level. Based on the literature (e.g., Hobbs, 1997; Abdullah et al., 1998; Widmark et al., 2013), we identified three main types of transaction

Table 1
Types of transaction costs for crop-livestock integration beyond the farm level.

Transaction cost category	Examples
1) Information gathering costs	– Acquiring new knowledge of, for example, machinery, crop/animal variety, animal feeding, organic manure use, employment systems – Gathering potential partner information, such as ● the quantity and quality of products that is ready to exchange ● the willingness of farmers to change their current practices for increased coordination (e.g., changing crop rotations) ● the equipment available (e.g., tractor and trailer) to harvest, transport, and store the products being exchanged – Collecting technical-economic data for the consultation
2) Collective decision-making costs	– Planning and coordinating land-use to accommodate the needs of partner farmers or group of farmers – Consultations and adjustment of management plans – Site visits, if necessary, in the course of adjusting management plans – Negotiating the terms of an exchange: sharing costs of transport, storage, or processing of exchanged products; investment to hire workers or buy equipment; and potential duration of contracts – Drawing up the formal contract, if necessary
3) Operational and monitoring costs	– Carrying out the resource distribution through, for example, transporting plant products and manure storage – Annual update of formal contract – Monitoring to ensure partners' satisfaction (e.g., qualities of feed and manure or payment arrangements) – Conflict resolution