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An institutional approach to manure recycling: Conduit brokerage in Sichuan Province, China

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ABSTRACT

With increases in living standards and dietary changes, the livestock sector has grown rapidly worldwide, which has led to considerable environmental pollution through livestock manure. Particularly in East Asia, meat production has increased fast. While part of the problem can be resolved by further processing manure into commercial organic fertilizer, technological solutions do face their limits in dealing with high pollution loads at farms. There is hence urgent need for policy instruments that could help mitigate environmental pollution. However, not much is known about related policy initiatives. This paper introduces a cooperative in Sichuan Province, China, which connects livestock farms to crop farms that are willing to use livestock breeders' manure on their land. As no frameworks exist which could aid the analysis of such a cooperative, we develop a framework based on the concept of "brokerage". Our analysis shows that for the case of Qionglai, structural conditions are favourable to the cooperative closing the nutrient cycle by means of brokerage. However, as our analysis shows, constraints to the cooperative's effectiveness foremost come from its daily operations. Within the given institutional structure, further qualitative improvements should be undertaken in terms of manure processing and manure management. The application of the framework to manure recycling shows that the framework and brokerage in general are useful analytical concepts for the circular economy. We conclude that the framework could also be applied to other fields of the circular economy, like food waste or bioenergy.

1. Introduction

For the sustainability of the global food system, improving the environmental performance of the livestock sector is essential (Herrero et al., 2013). Nitrogen losses from manure have increased over the last decades as livestock production has grown considerably, responding to a change in living standards and dietary changes together with global population increase (Lassaletta et al., 2016). In the European Union, the livestock sector significantly contributes to environmental pollution by the whole agricultural sector, e.g. it makes 73% of the agricultural sector's water pollution, both in terms of nitrogen and phosphorus (Leip et al., 2015). But also in emerging economies like China, livestock production has major impacts on the environment. In 2017, more than 150 million tons of meat and eggs were produced in China, resulting in about 3.8 billion tons of animal manure. 40% of this manure is not effectively treated and utilized, adversely affecting the environment and people's livelihoods (Ministry of Agriculture, 2017).

In the European Union, despite early policy initiatives (e.g. the 1991 Nitrate Directive), high nitrogen emissions can still be observed, particularly in areas with high livestock breeding density (Bouaroui et al., 2014). Against this background, the question arises how environmental pollution by nitrogen and phosphorous can be managed in developing countries or transition economies. Particularly in East Asia, meat production has increased rapidly (Thornton, 2010; Liu et al., 2017). For example, in the last thirty years, China's meat production increased twice as fast than the world average (Zheng et al., 2015). While a number of publications document environmental pollution from livestock production in China, less is known about initiatives that aid to overcome this problem. For example, Zheng et al. (2015) provide scenarios of different policy instruments' effectiveness in motivating farmers to deal with manure in an environmental friendly way. Ma et al. (2017) use scenarios to assess the impact of a broader range of measures, from changes in human diets to balanced fertilization of cropland. In their review of manure management practices in China, Chadwick et al. (2015) find that the transportation of manure is one of the bottlenecks for a more environmentally friendly manure management in China. The manure cooperative presented in this paper is a relevant measure in this regard.

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Environmental pollution from manure to a large extent occurs due to a disconnect between crop and livestock production (Lassaletta et al., 2016). The nitrogen cycle is not closed as manure (i.e. nitrogen surpluses) is not applied on crop land but emits into the soil and water bodies eventually. In China, particularly in the pig-farming sector, livestock production traditionally took place in smallholder structures (Zheng et al., 2014) where manure was recycled as organic fertilizer on farmers' land. The increase in demand for livestock products led to these smallholders often extending their farms in their backyard, without proper waste management facilities. As a result, manure drained into water bodies and soil (Zheng et al., 2013). Without fermentation in a biogas digester, manure contains pathogens which can lead to the spreading of pests. Furthermore, excessive disposal of manure can lead to soil pollution by heavy metals, and to nitrogen overload and eutrophication accordingly. The government responded to the uncoordinated expansion of smallholder farming with a policy of professionalization and standardization, i.e. by supporting the development of large–scale farms. Farms were required to install proper manure collection tanks, often combined with a biogas digester. However, they often do not have enough land where to eventually dispose of their manure (Bluemling, 2017).

One solution to overcome environmental pollution from livestock manure can be to bring livestock farms into contact with crop farms that are willing to use manure on their land. While in traditional agriculture, manure was often recycled on the own farm land, nowadays, the use of organic fertilizer is limited. In the United States, the United Kingdom and other Western countries, organic fertilizer accounts for 50% of the total amount of fertilizer used. In China, the use of organic fertilizer accounts for less than 20% of the total amount of fertilizer used (Fu and Shan, 2017). In this article, we hence look at how a private sector party can help to close the nitrogen cycle. The Chinese government has for some years asked private actors to contribute to environmental policy implementation, with the result that new policy arrangements emerge, bringing together the government and different kinds of private actors, from primary producers to service providers. In such a situation where a former hierarchical political system becomes more dependent on horizontal structures of interconnected private actors, the question arises how the transformation towards more horizontal structures can be brought about, - how can actors get into contact so that they create these institutional arrangements that are needed to more sustainably govern the environment?

This article introduces an institutional arrangement in which horizontal structures were created that link livestock farms and crop farms to facilitate manure recycling on agricultural land. The idea seems simple and pertinent, however, as we will show, some conditions apply under which a cooperative's involvement can be effective. Accordingly, the overall objective of this article is to find out under which conditions the nutrient cycle can be closed by means of horizontal institutional arrangements that come about within a process of "brokerage". On the one hand, the paper wants to assess how effective an institutional arrangement can be in reducing pollution loads from intensified livestock breeding. On the other hand, it wants to test a framework that is based on "brokerage". No conceptual framework exists so far by means of which we can analyze new horizontal structures for manure recycling, which is why a second aim of the paper is to devise and test a framework based on "brokerage".

The paper starts out with introducing the framework, and then applies it to a case of a cooperative of former livestock farmers in Qionglai District, Sichuan Province, China, which, responding to increased demand for manure collection services, acts as a broker for manure collection and distribution.

2. Material and methods

This section is divided into two parts. First, an introduction will be given to the analytical framework that was devised for the analysis of brokerage (Section 2.1). Second, methods and data are described that were used for the application of the framework to the case of a cooperative in Qionglai District, China (Section 2.2).

2.1. Analytical framework: brokerage

Simply speaking, brokerage can be defined as "behavior by which an actor influences, manages, or facilitates interactions between other actors" (as in Obstfeld et al., 2014, 141, who base their definition on Marsden et al., 1982). According to Fernandez and Gould (1994, 1457), brokerage is a "relation in which one actor mediates the flow of resources or information between two other actors who are not directly linked".

This article employs the conceptualization of brokerage as defined by Obstfeld et al. (2014) who understand brokerage as a *process* "that alters interaction between two or more parties in a wide variety of triadic structures" (Obstfeld et al., 2014, 136). Obstfeld et al. (2014) distinguish different kinds of brokerage, i.e. *conduit brokerage*, *tertius iungens* and *tertius gaudens*, and this paper focuses on *conduit brokerage* as brokers are relatively free whom to connect, and do not intend to induce collaboration between the two parties. Obstfeld et al. (2014) describe several conditions for conduit brokerage. For the framework at hand, we organize these conditions into three steps. The first step looks at conditions for brokerage on a structural level, which are important for the initialization phase: What conditions need to be given so that a cooperative can act as a broker for manure recycling? The second step looks at conditions for the institutionalization of the cooperative: Under which conditions can brokerage be maintained? And the third step looks at the conditions for the cooperative to be effective in the distribution of manure: Under which conditions will a cooperative distribute manure effectively, i.e. in how far does it help in redistributing manure so as to balance pollution loads? Fig. 1 provides an overview of these steps and their variables. In the following, the analytical steps will be further outlined.

2.1.1. Structural conditions for conduit brokerage

The first structural variable for analysis is "interdependence", which is taken from Gulati (1995). Interdependence "describes a situation in which one organization has resources or capabilities beneficial to but not possessed by the other" (Gulati, 1995, 621). Interdependence describes both, the dependence of the livestock farmer on the service of the broker to collect manure, and the dependence of the arable farm on the broker in terms of providing fertilizer. Interdependence may be brought about in different ways. Large-scale livestock farms are required to look after the disposal of manure. This creates interdependence with arable farms who can apply surplus manure. Arable farms again depend on livestock farms because of the Ministry of Agriculture's plans to reduce chemical fertilizer use in the frame of the Zero Growth Policy (see Bluemling, 2017), and because they need organic fertilizer to improve soil structure, or because they grow crops according to certain standards that require the application of organic fertilizer. In the context of China, we presume that livestock farms are the driving force and assume that the stricter the regulation, the higher the interdependence between livestock farms and crop farms.

A further indicator that relates to interdependence is the dependence on the broker. Not always is a broker required to realize the exchange of resources among interdependent actors. To know about the dependence on the broker, one needs to analyze the resource that is exchanged. For example, manure needs to be transported from one place to the other, and then needs to be applied on agricultural land. Not all livestock farms or crop farms will possess suitable means of transport. A second indicator for dependence is the distance between livestock farm and crop farm, – in how far is a broker needed to bridge this distance? We presume that the more difficult it is to pass on a resource, and the larger the distance between the parties, the higher the dependence on the broker.