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Markets for waste and waste–derived fertilizers. An empirical survey☆

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ABSTRACT

If chemical fertilizers have been extensively studied, there is a dearth of empirical knowledge on markets for waste and waste-derived fertilizers used in agriculture. This paper explores the state of the art on these markets, based on a multi-disciplinary literature review (economics, law, sociology). We first examine the particularity of waste compared to products such as chemical fertilizers in both law and economics, and point out the need to develop the concept of waste from a property rights perspective. On the supply side, we note a lack of aggregate data on the quantities of different materials used in agriculture at European level and the need to benefit from longer time series for US data on organic waste materials used in agriculture. We then study the determinants of demand for waste and waste-derived fertilizers in agriculture. We specify the need to develop research on three quality features of waste: variability, interactivity and uncertainty. The case study on sewage sludge spreading in France and in Switzerland allows us to pinpoint the role of actors in the development or disappearance of these markets.

Contents

1. Introduction

Waste[1] and waste-derived fertilizers used in agriculture are a heterogeneous category of materials ranging from manure, pig slurry, urban sewage sludge, digestate from anaerobic treatment of animal and vegetable waste, green waste, agro-food waste, ash from combustion plants, dredging sludge to treated products such

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[1] We refer to the material meaning of waste, as "unwanted or unusable material, substances, or by-products" (Oxford English Dictionary, 2017).

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as compost composed of organic municipal waste, urban sewage sludge, and/or green waste. Farmers may use them as a necessarily cheaper substitute to chemical fertilizers or soil improvers.[2] Social scientists, and notably economists have addressed markets for chemical fertilizers (FAO, 2016; Lecuyer et al., 2013; Ott, 2012; Duflo et al., 2011; Heisey and Norton, 2007; Chapman and Edmond, 2000) in order to understand the determinants of global supply and demand. However, no state of the art in social sciences has been accomplished to comprehend the particularity of markets for waste and waste-derived fertilizers. This seems surprising if not paradoxical. Historically, fertilization is one of the cornerstones of agriculture as it contributes to its productivity, and waste was used in agriculture for this reason at least twenty to forty centuries ago in China, Korea and Japan (King, 1911; Parr and Hornick, 1992). Moreover, the current emphasis on circular economy and sustainable agriculture in political and scientific arenas worldwide (Stahel, 2016; Lacy and Rutqvist, 2015; OECD, 2013; Tilman et al., 2002) has still not triggered such research.

As Gregson and Crang (2010) note regarding social sciences and waste research, academia has focused on waste in terms of waste management, waste technologies such as incineration, landfilling and resource recovery. Up to now, most research has analyzed the environmental dimension of waste. In economics, research is based on pollution generated by organic materials such as animal manure (Pye, 1983; Hanley, 1990; Yadav et al., 1997; McCann and Easter, 1999) and agri-environmental policies to avoid such pollution (Bonnieux and Rainelli, 1988; Hahn, 1989; Ribaudo et al., 1999; Metcalfe, 2000; Feinerman and Komen, 2005; Sheriff, 2005; O'Shea and Wade, 2009). Monetary valuation of environmental externalities has also been addressed (Le Goffe and Delache, 1997; Butt et al., 1998; Stenger, 2000; Thornsbury et al., 2000; Soulsby et al., 2002; Cameron et al., 2004). However, little attention has been paid on the analysis of *markets* for waste and waste-derived fertilizers when these are used in agriculture.

This paper is a preliminary study to understand markets for waste and waste-derived fertilizers based on a literature review on empirical research in this field. The aim of this paper is to respond to the following questions. Is waste conceptually the same as products in an economic and legal sense? If markets for waste exist as there is an offer and demand for waste used in agriculture, do they follow the same logic as markets for fertilizers regarding their price, quality, property rights and the interaction between different actors? What are the determinants of demand and the particularity of supply compared to chemical fertilizers?

Aside from the contemporary relevance of this topic, this article is necessary for the following analytical and methodological reasons. Markets are often viewed as an ideal-type in social sciences (Geiger et al., 2012). Another way to analyze markets is to base oneself on stylized facts, so as to enrich theory on markets. Secondly, waste in itself is a fundamental research field and its importance is increasingly understood by scholars in social sciences (O'Brien, 2007; Lupton, 2011; Evans et al., 2012). Contrary to goods with positive value, waste is not wanted by its owner. It has not been *a priori* created for a given market. We put waste at the heart of the analysis in a law and economics approach, based on stylized facts from multi-disciplinary (economics, law, sociology) and empirical research. Understanding markets for waste used in agriculture allows us also to examine the emergence and disappearance of markets for waste from both theoretical (property rights approach) and empirical perspectives (case study of sewage sludge spreading markets in France and in Switzerland). A property rights approach allows us to understand when exchange emerges, and when waste is only destined to be abandoned. The case study on sewage sludge pinpoints a novel form of market collapse.

This article stems from a multidisciplinary collective expertise on the use of fertilizing residual materials used in agriculture and forestry that was managed by INRA, CNRS and IRSTEA and commissioned by the French Ministries of Agriculture and the Environment. Thirty experts from France, Belgium, Canada, and Switzerland, were mobilized for their skills on this topic in agronomy, chemistry, microbiology, ecotoxicology, economics, sociology and law from 2011 to 2014 in order to prepare a report on the state of the art on this field. The present author was responsible for the economic literature survey on residual materials. This article is based on a survey of the literature through different data bases (Business Source Premier, CAB International, Econlit, Factiva, Francis, Google Scholar, JSTOR, ProQuest, Scopus, Web of Knowledge, Web of Science) conducted from December 2012 to March 2017. Grey literature was also included so as to complete this literature review, notably through the United States Department of Agriculture (Economic Research Service), UNIFA (*Union des Industries de la Fertilisation*, French Union of Fertilizer Industries), INAO (*Institut National de l'Origine et de la Qualité*, French National Institute for Origin and Quality) and Nexis data bases. A total of 3000 documents (books, scholarly articles and grey literature) were explored for the purpose of this article.[3]

Our research is mostly based on manure and urban sewage sludge because the literature mainly focuses on these two waste materials. Moreover, three developed countries were selected to develop economic aspects of these waste materials: France, Switzerland and the U.S.A. These countries were selected for the following reasons. France and Switzerland were chosen as the sewage sludge spreading markets of these two countries have developed in two opposite directions. France's spreading market developed albeit controversy over their health and environmental consequences whereas Switzerland's spreading market was banned, and the comparison of these two countries seemed essential in understanding the interaction and relative power[4] of different actors in shaping how these markets evolved. In order to compare this data with another developed country, we chose the U.S.A. This country has the most developed statistics from the USDA regarding quantities of waste and waste-derived fertilizers spread in agriculture since 1986. The USDA also provides interesting documents on the organization of manure markets. This article is confined to an applied economics perspective on markets for waste and waste-based fertilizers used in agriculture, both regarding offer (quantities produced, economic costs of recycling in agriculture) and determinants of demand (price, quality and other factors). This article shall therefore not address monetary valuation of environmental externalities. We share Mittelhammer's conception of applied economics that cannot be confined to be "exclusively the act of applying an existent body of economic theory to real-world economic problems" (Mittelhammer, 2009, p. 1169). According to us, applied economics also addresses real-world economic issues, through empirical data and case studies that can enrich and provide new insights to economic theory[5] and public policy.

[2] We refer here to landspreading, that can be defined as "land treatment resulting in benefit to agriculture or ecological improvement" (recovery operation code R10), according to the EU Waste Framework Directive 2008/98.

[3] Among these 3000 documents, 177 were selected for this article.

[4] We define power as the potential of an actor to influence other actors' decisions (Vahabi, 2004). See also Lukes (2005).

[5] For more information on different concepts of applied economics, see Backhouse and Biddle (2000).