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Effects of no-tillage on agricultural land values in Brazil

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ABSTRACT

Agricultural land prices may be determined by both productive and speculative factors. Among productive factors, investment in soil conservation in areas destined for agricultural activity is recognized as a positive contributor to land value. No-tillage, or no-till, is a farming system that integrates fundamentals of conservation agriculture and offers a number of advantages in agricultural production. No-tillage systems are associated with a range of positive impacts on land prices, leading this type of soil management system to predominate in Brazil. The object of this study is to verify whether no-tillage systems increase agricultural land prices in Brazil. To this end, data are drawn from the 2006 Agricultural Census, administered by the Brazilian Institute of Geography and Statistics (IBGE), including data on soil management systems (no-tillage, minimum tillage, and conventional tillage), as well as state, regional, and national land prices in Brazil. Results indicate that agricultural lands under temporary crop cultivation that are planted using no-tillage systems are of greater value than lands planted under other soil management systems. This increase in value associated with no-tillage may be observed in the Brazilian States with the highest levels of agricultural production, including Paraná, Rio Grande do Sul, São Paulo, Mato Grosso do Sul, Mato Grosso, Goiás, and Bahia. These results should constitute an important factor in agricultural producers' decision-making regarding the adoption practices proposed by conservation agriculture.

1. Introduction

Soil, the substrate of terrestrial ecosystems essential to agricultural activities, is a priceless natural resource for humanity, underpinning our very existence through food, feed, fiber, and timber production (Robinson et al., 2017). It is a strategic and limited resource of enormous social, economic, and environmental importance. Soil is a fine, fragile layer covering the surface of the earth, which takes millions of years to form but may be degraded and lost to erosion[1] in just a few years of use. Thus, the conservation of soils on agricultural lands should occupy a central place in the economic debate.

Although erosion is a natural process, anthropogenic action (inadequate soil management by human actors) can accelerate erosion processes, over time resulting in degradation of the soil's productive potential. This degradation occurs mainly because erosion alters the chemical, physical, and biological characteristics of the soil (Lal, 2000; 2006), contributing to declines in its fertility (Pimentel et al., 1995; Morgan, 2005). In this manner, erosion reduces soil's capacity to produce food, forages, fibers, and biomass for energy production.

Erosion makes soil progressively less productive, as it reduces soil structure and degrades organic matter and nutrients (Durán Zuazo and Rodríguez Pleguezuelo et al., 2008). These losses may be exacerbated by conventional tillage, which involves tillage the soil surface with the objective of eliminating or burying vegetation cover. This technique typically employs disc plows, moldboard plows, and harrows. As a consequence of conventional tillage, the soil surface is left unprotected and exposed to the elements, leaving it more susceptible to erosion.

Focused on better control of erosion processes, conservation agriculture emerged as a technological system that has as its objective the optimization of natural resource use through integrated management of soils, water, and agro-ecosystem biodiversity that is compatible with the use of external inputs (Kassam et al., 2009). Conservation agriculture contemplates, among other practices, the reduction or elimination of tillage, the preservation of residual biomass on the soil surface, maintenance of permanent soil cover, increases in biodiversity through the cultivation of multiple species in rotation or intercropping, use of green fertilizers, diversification and complexification of agricultural production systems such as agro-pasture systems, agro-forest systems, and agro-pasture-forest systems, integrated management of pests, pathogens, and weeds, precise use of pesticides and herbicides,

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[1] Soil erosion process consists of the detachment and sloughing, transport and redistribution, and deposition of particles caused by water or wind action. Water erosion is caused by rain and surface runoff. Soil erosion by water is one of the major threats to soils in Brazil. Soil degradation caused by erosion is a widespread problem and currently one of the biggest challenges in modern-day agriculture (Londero et al., 2018).

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careful control of agricultural implement traffic, use of mechanical practices to control erosion, and shortening of the interval between harvest and replanting by means of the harvest-plant process (Ward et al., 2016). This package of practices seeks to enhance the sustainable productivity of agricultural systems, as well as to prevent pollution and soil degradation. Through the continued application of these conservationist techniques, agricultural soils may potentially become more stable and productive. In Brazil, the conservation approach to agriculture is best represented by the system of no-tillage, which is considered to be a system with the capacity to improve the sustainability of agricultural development.

No-tillage is a differentiated soil management system that seeks to diminish the impact of agricultural activities. Under this method, plant residues from previous crops are left on the soil surface, guaranteeing coverage and protection from erosion processes. Furthermore, the soil is only manipulated at the moment of planting, when a groove is opened in the soil in order to deposit seeds and fertilizers. Among the benefits of these methods, according to Paterniani (2001), Fidelis et al. (2003), Hobbs et al. (2008), Silva et al. (2009), Lal (2015) and Fuentes-Llanillo et al. (2018), are reductions in production costs and environmental impacts, improved water retention and infiltration in the soil, reduction of erosion and nutrient loss through wind action, reduction in the risk of river siltation, improvements in soil capacity to maintain organic materials for longer periods, reduction in soil compaction, reduced fuel consumption by mechanical implements, reductions in required agricultural operations, reductions in climatic risks that may affect production and harvest, improvements in water-use efficiency, improvements in soil buffer capacity, increases in organic content of soils, increases in worm and microorganism populations, increases in stores of N, P, and K in soils, reductions in the toxicity of Al, Mn, Cd, and pesticides, the possibility of more opportune planting times, and allowance of more time for other farm activities. Furthermore, no-tillage involves lower costs of production, contributes to carbon sequestration, and requires less use of tractors. Brazil is a world leader in the use of no-tillage systems (Bolliger et al., 2006; Derpsch et al., 2010). This soil management system is employed on more than half the total area planted with temporary crops in the country (Fuentes-Llanillo et al., 2013).

Agricultural lands are an economic asset, and their prices are determined by, among other factors, expectations of future income, which are themselves related to the productive capacity of the soil and expected returns to production (Reydon et al., 2014; Telles et al., 2016). Thus, investments in conservation management, by contributing to improvements in soil quality and minimizing damage and costs associated with soil erosion, can contribute to the valorization of agricultural lands. In other words, from the producer's perspective, soil losses from erosion tend to increase production costs over the medium and long term, since these losses will require the application of increasingly greater quantities of supplemental inputs, such as fertilizers, in order to maintain land productivity. Further costs of soil degradation will include costs of replanting, reductions in machine performance, and increases in expenses related to erosion mitigation. On the other hand, no-tillage, by contributing to improvements in the chemical, physical, and biological health of the soil, guarantees improved future productivity and reduction in the costs of production. In this context, no-tillage represents a potential boost to future land productivity, and may be a determinant of land prices, increasing the value of land where it is applied. It is important to test this hypothesis that agricultural lands planted with temporary crops under the no-tillage system, when compared with other types of soil management systems (conventional tillage and minimum tillage), are in fact more highly valued.

It is hypothesized that agricultural lands that are better conserved, and which thus offer reduced production risks, will enjoy preferential terms of trade, even in speculative markets, and that, *ceteris paribus*, these better-conserved lands will exhibit greater liquidity and higher prices. That is, conservation management, understood here as the practice of no-tillage, contributes to soil quality by minimizing the effects of erosion, which in turn improves land values.

Among studies seeking to establish relationships between conservation management, soil degradation, and agricultural land prices Ervin and Mill (1985), Fletcher (1985), Hertzler et al. (1985), Palmquist and Danielson (1989), Lloyd et al. (1991), Hallam et al. (1992), Lloyd (1994), and Smith et al. (2010). Specific to Brazil, studies related to erosion, the impact of government programs focused on soil conservation, and land values were presented by Brandão (1985) and Michellon and Reydon (2003). Nonetheless, there exist no Brazil-specific studies relating no-tillage system with the prices of agricultural lands.

The major difficulty with undertaking a study of this nature in Brazil resides in limitations in the available data that would permit the establishment of a well-identified relationship between no-tillage and prices of agricultural lands. Nonetheless, with the publication of the Agricultural Census of 2006 by the Brazilian Institute of Geography and Statistics (IBGE), data on soil management systems (conventional tillage, minimum tillage, and no-tillage) for temporary crop cultivation, as well as data on agricultural land prices, have become available. These new data make it possible to test the hypothesis described above for Brazil, its regions, and its states. In this context, the state of Paraná represents a federal unit meriting a more detailed analysis, due to its rich history of public interventions in agriculture through programs focused on soil and water conservation, its significant participation in the cultivation of temporary crops using no-tillage system, and to its important role in national agricultural production.

It is of the utmost importance that agricultural producers, as well as civil society and government, have access to the results of this study, since they may contribute to changing these agents' perception of no-tillage and its impacts on agricultural land values, primarily as compared to conventional tillage. The results of this study will constitute an important element in these agents' decision-making, and may potentially guide agricultural production toward more sustainable practices.

In this context, the present study has as its objective the verification of the relationship between no-tillage and the valuation of agricultural lands.

2. Concepts, materials, and methods

The data employed in this study were obtained from special tabulations of the 2006 Agricultural Census, from IBGE, which, for the first time in its history, dedicated a section of its questionnaire specifically to information related to types of soil preparation employed on rural establishments.

The soil management systems registered in the 2006 Agricultural Census were: (i) conventional tillage (plowing and harrowing), under which the soil is prepared by plowing or harrowing with a heavy harrow followed by light harrowing; (ii) minimum tillage, characterized by reduced use of mechanical implements, normally with chisel plows with or without subsequent harrowing, which break up the compact surface and improve drainage; (iii) no-tillage, where sowing is carried out on the residues of the previous crop by opening only a narrow furrow in the sowing row.

Only data on temporary crop cultivation are included in this study, since these are the crops types that most often require soil preparation. Temporary crops are those where the productive cycle is concluded within a short period of time (such as a season), and where a new planting must be undertaken after harvest of the previous crop. The area of annual plantings for temporary crops represents almost the entirety of land planted using soil preparation in Brazil.

With respect to the area of the agricultural establishment and its use, the 2006 Agricultural Census first asked individuals to respond to the question: "What was the total surface area and unit of measurement of the establishment on the 31st of December of 2006?" This inquiry was followed by the question: "What was the soil management system