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Technology or policy? Drivers of land cover change in northwestern Spain before and after the accession to European Economic Community

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ABSTRACT

Major changes in land cover can result from distant political, social, and environmental forces. Over the last 50 years, many technological innovations and political changes have transformed agriculture in Europe, resulting in substantial decrease of farmland area in many parts of the continent that potentially signify a shift in European land use systems. However, the relative importance of technological advances and agricultural policy to these changes is not well understood, and our goal here was to disentangle them. Because of its unique political context, Spain offers an ideal laboratory to investigate the impacts of technological and political innovations to regime change in land systems. During the time when agricultural innovation was at its peak (1960–1980) Spain was not part of the European Economic Community (EEC). The Spanish agricultural sector then experienced a shock after joining the EEC in 1986. Using historical aerial photographs, land use maps, and Farm Structure Surveys as our reference data, we compared changes in land cover in Terra Chá, a district of Northwest Spain from 1956–1984 and 1984–2005, i.e., approximately before and after the EEC accession in 1986, using spatially explicit multinomial logit models to quantify the relative impacts of technological innovation and political change on agriculture and forest lands. In our study area much more substantial shifts in agricultural and forest land took place after EEC accession than before. The dominant shift was a substantial increase in forest cover (from 7% to 31% of the landscape) and concurrent loss of agriculture (from 45% to 38%) and shrubland (from 46% to 27%). The role of drivers acting at parcel level was constant between time periods, which suggests that accession to EEC was a strong driver of change.

Introduction

Patterns of land use changes in agrarian landscapes are the result of complex, multi-dimensional processes. Social, economic, technological, and policy issues intertwine, often acting at different scales (Baldock et al., 1996; Geist et al., 2006; Rey Benayas et al., 2007). Rapid changes in land use systems can be triggered by technological innovations (Hasselmann et al., 2010), political change (Hostert et al., 2011), and environmental forces (e.g. Wang et al., 2011; Silva et al., 2011), but the relative impacts of these forces vary across space and time. Occasionally, these triggers can result in shifts in land use systems where new modes of land use dominate the landscape. Such land use system changes can have profound impacts on the livelihood of people (Carr and McCusker, 2009), biodiversity (Reidsma et al., 2006; de Chazal and Rounsevell, 2009), and the provisioning of ecosystem services (Metzger et al., 2006).

The importance of land system changes makes it important to understand their drivers, but assessing the relative impact of technological innovation and political changes is challenging because these two typically co-occur and interact (Voss et al., 2006). Political institutions can foster innovation but also constrain it through regulation. Similarly, changes in technology influence the political realm and impact market integration (Weare, 2002). Disentangling these disparate forces, especially when they affect large areas, is thus challenging.

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In Western Europe, agricultural land systems have changed substantially since the mid-20th century due to depopulation of rural areas, the mechanization of farming operations, and European Union agricultural policy. While varying in onset and pace among regions, the overall impact has been large change to rural communities, economies, and environments (Rabbinge and van Diepen, 2000; Krausmann et al., 2008). For example, in the United Kingdom mechanization and specialization of farming, resulted in declining agricultural land area since at least the 1960s (Bibby, 2009; Angus et al., 2009), and similar patterns occurred in France (Mottet et al., 2006), or Italy (Falcucci et al., 2007).

At the same time that mechanization and specialization was taking place in the agricultural sector, the economic integration of Europe also began in earnest. Starting with the founding of the European Economic Community (EEC) in 1963 and advancing to the present day Common Agricultural Policy (CAP) subsidies, the core European countries have shared policies that regulate prices and quantity of agricultural products. Furthermore, as these policies increased trade and market integration, they further fueled mechanization and specialization. As such, the combination of mechanization, specialization, and European agricultural policies has fundamentally changed Europe's landscapes, but the relative impact of these factors is not clear.

Spain offers a unique context in which to disentangle the relative impacts of technological innovation and political changes on land systems due to its relative political isolation from 1950 to 1980. Mechanization and industrialization became common in Spanish agriculture about a decade later than in other European countries (Naredo-Pérez, 1996) when a period of considerable growth started in 1960 (Prados de la Escosura, 2002). Specialization and mechanization have thus been a feature of Spanish agriculture for 50 years leading to intensification of agricultural use in the most productive soils, and farmland abandonment in the more remote, marginal areas (e.g. Nainggolan et al., 2012; Muñoz-Rojas et al., 2011; Calvo-Iglesias et al., 2009).

However, many of these technological changes took place while Spain was politically and economically isolated. Spain did not join the EEC until 1986, more than 20 years after most of the other major European economies. Although mechanization and specialization were certainly present when Spain joined the EEC, the new political situation resulted in a major transformation in agricultural markets and concurrently in the agricultural landscape. This event was particularly disruptive because it coincided with major changes in the European Union's (EU's) CAP in the mid-1980s and early 1990s. Specifically, the CAP moved away from its original aim of price support and focused more on limiting the production of goods which were overly abundant. While the original policy instruments that provided price support remained in place after 1992, they were much reduced in importance and complemented by other measures (Baltas, 1997). These additional measures included: (a) compensation for price cuts in the form of payments based on historic acreage or livestock numbers, but severing the link to the quantities produced; (b) measures to limit land use (i.e., set-asides of arable land and stocking rate criteria) and retention of earlier supply management measures such as the milk production quotas (established in 1984); (c) agri-environmental and afforestation regulations and subsidies, and support for early retirement.

Because of its unique history, Spain is an interesting natural experiment in which to research the roles of agricultural innovation and market integration in regime shifts of land use systems. Spain's political and economic isolation during the period of innovation (roughly 1950–1980) offers the chance to observe the impacts of these technological innovations relatively separate from the impacts of economic integration. Likewise, Spain's accession to the EEC in 1986 is an excellent point to look at the impact of economic integration on land cover change, since many major technological changes had already taken place by then, and the accession exposed Spanish farmers rapidly to a large number of market changes.

Our goal was thus to understand the relative impacts of landscape shifting forces – technological and political innovation – on agricultural and forest lands in a district of Northwest Spain, Terra Chá.

Our specific questions were:

1. Which were the main land cover transformations before and after integration to the EEC?
2. How did these transitions and their drivers differ between the pre and post EEC accession periods?

Methods

Study area

We studied land cover change in the district of Terra Chá, located in the northwest of Spain, in the autonomous region of Galicia. The district comprises nine municipalities (Fig. 1) and covers a total area of 1822 km^2, from 1950 to 2005. The study area consists of a central plain (Terra Chá is Galician for "flat land"), surrounded by mountains some of which mark the border with neighboring districts. Climate is generally maritime, although short episodes of drought are not infrequent during summer.

Agricultural production in the mid-20th century was dominated by a two-year rotation including wheat, turnips, potatoes, and maize for human consumption. Integral to the system were also extant shrubland areas which were grazed, but also periodically harvested and mixed with manure to create fertilizer. By the early 21st century, most family farms specialized in dairy production, and the dominant agricultural system became a combination of permanent pastures and corn for forage.

As in most other rural areas of Spain, depopulation took place during the whole study period (from 76,000 inhabitants in 1950 to 46,000 in 2005). The number of farms decreased from 16,000 in 1962 (INE, 1964) to 10,700 in 1999 and 5580 in 2009 (INE, 2013), with many small farms ceasing to exist in particular after 1989 (Corbelle-Rico and Crecente-Maseda, 2008). Nevertheless, by 2005, the average farm size was only 11 ha (including parcels not used for crops or pastures), and farmland was highly fragmented, with a total number of 440,000 parcels according to cadastral data, resulting in a mean parcel size of only 0.5 ha.

Land cover data

We used two types of historical land cover data. First, we mapped land cover types by interpreting historical aerial photographs from 1956 and 1984 (corresponding to series B and D of the Spanish National Photogrammetric Flight at 1:30,000 scale). The dates in which both photographic datasets were originally acquired are placed slightly earlier than the economic boom of 1960 and the access to EEC in 1986, which we think can help to better identify their actual impacts. Second, we used a land cover map (*Mapa de Cultivos y Aprovechamientos*, MCA) published by the Spanish Ministry of Agriculture in 2010. For our study area, this map depicted land cover in 2005. Aerial photographs were scanned, orthorectified, and prepared as a mosaic for the entire study area. Land cover for 1956 and 1984 was determined by visual interpretation of the aerial photographs, while land cover in 2005 was automatically taken from the MCA land cover map.

From the land cover maps, we drew a stratified random sample of 2638 points that were at least 500 meters apart to limit spatial autocorrelation. Sampled plot allocation was proportional to the area of each municipality. For each point, land cover was classified