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Analysis

A Gravity Model to Explain Flows of Wild Edible Mushroom Picking. A Panel Data Analysis

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ABSTRACT

Picking wild edible mushrooms is becomingly an increasingly widespread activity. Recent research is reporting a change in the way pickers access this resource, particularly in the more developed countries. The latest studies focus on exploring the demand functions of harvesting, with the emphasis shifting away from analyses that address the issue from a commercial standpoint. Yet these studies fail to deal with the topic from a global perspective and provide only partial information that is felt to be insufficient when attempting to manage the resource efficiently. The present work seeks to provide an approach to the problem by applying, for the first time, a gravity model to study the system governing the sale of harvesting permits (www.micocyl.es, Castilla y León-Spain). The main advantage of this application is that, for the first time, three-dimensional panel data are used to link economic variables to climate variables and their interaction to the supply and demand of picking permits. Results show that the method provides key management information. Managing the picking of wild edible mushrooms should aim to focus more on handling the tourist flows it generates.

1. Introduction

Collecting wild mushrooms is common the world over and forms an important part of production and recreational activities in many societies (Boa, 2004). These forest resources are put to a wide range of uses and there are many examples in every continent such as Europe (Roman and Boa, 2006; Sitta and Floriani, 2008; Turtiainen et al., 2012; Frutos et al., 2012), the Americas (Starbuck et al., 2004; Montoya et al., 2008; Pérez et al., 2008; Barron et al., 2015), Africa (Dijk et al., 2003; Buyck, 2008; Tibuhwa, 2013; Nharingo et al., 2015), Asia (Christensen et al., 2008; He et al., 2011; Thatoi and Singdevsachan, 2014) and Oceania (Thomas, 2002; Pauli and Foot, 2005).

Yet despite this worldwide importance, forest resource management plans do not tend to take mushrooms into account. At most, they are considered of secondary importance compared to wood-based products (Aldea et al., 2012). Their complicated ecology (Dighton and White, 2017) coupled with complex organisational factors, which are not included when managing other forest resources (Frutos et al., 2016), have meant that legislation over control of mushrooms remains scarce.

Prominent directives in this area are the regulatory frameworks in place in the United States (McLain, 2008), Spain (Górriz-Mifsud et al., 2017a), Italy (Secco et al., 2010) or Nepal (Thapa et al., 2014), and are based on establishing permits that grant access to mushrooms depending on pickers' particular circumstances. All of the legislation in place is based on complex management systems which need to draw on information related to market conditions, and which does not tend to be available to those responsible for decision making. This might lead to inefficient decisions being taken that could compromise the long-term sustainability of the regulatory model. Moreover, these decisions must be taken bearing in mind the transversality between policies aimed at managing the resource and others, such as nature conservation, public safety or tourist policy. This complicates even further the task facing those who manage said resources, since various levels of administrative control might be involved in decision making.

To date, few studies have provided relevant information to help support management of the collecting areas. Research has tended to focus on the economic value of the wild mushrooms collected (Alexander et al., 2002; Palahi et al., 2009; Cai et al., 2011; Voces et al.,

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2012). Yet said information continues to prove inadequate vis-à-vis gaining efficiency when managing the resource in question, since aspects related to the market value of forest resource production are becoming less important. There is now a shift towards a more multifunctional approach to forest management, where recreational aspects are coming to the fore (Sisak et al., 2016). As a result, analyses of the demand functions of harvesting wild edible mushrooms using environmental valuation techniques are gaining in importance (Starbuck et al., 2004; Frutos et al., 2009; Martínez De Aragón et al., 2011). Arguably, the studies to have provided most information aimed at filling this gap are those published by Frutos et al., 2016 or Górriz-Mifsud et al. (2017b). Whilst the former studies model willingness to pay for permits to collect wild mushrooms in Andalusia (Spain) and the explanatory variables involved, the latter explore the link between collecting, forest ownership and options to control the activity in Catalonia (Spain).

However, the main limitation of these studies is that they are partial models that only explore the drivers of the harvesting demand function, yet overlook other factors that might also have a bearing on pickers' decisions. For instance, they fail to take account of determinants on the supply side of picking such as the physical infrastructure (potential and actual) of the area, or how this may be influenced by external factors, such as the climate, as well as public and private investment aimed at adapting it to their use, or changes in the provision of tourist infrastructure.

Yet where almost all the studies cited do concur is in the importance of approaching picking as an activity that embraces a strong tourist motivation component, with mycotourism being an emerging activity (Büntgen et al., 2017). The use of general distribution models that take account of aspects such as origin and destination are emerging as suitable explanatory tools for describing the flows of individuals (Cesario, 1973). What is required is a model able to explain mushroom pickers' movements based both on the push of the origin and the pull of the collecting areas that are the destination. Gaining an insight into how and why mushroom pickers make their decisions might prove important when implementing key measures that can ensure long-term sustainability.

The use of equilibrium models thus offers valuable information that will go beyond any simple interpretation that may be gained from the demand side. Such models provide for a study of the activity as a whole and, therefore, help when examining links that have thus far remained unexplored with other areas of policy such as tourist, infrastructure or tax related issues.

The present research seeks to provide a gravity model at a national scale, Spain in this instance, capable of offering a clear explanation of the relevant variables that determine the picking permits issued in a given collecting area, in this case the www.micocyl.es system run by the Regional Government of Castilla y León (Spain). The research also aims to assess how pickers respond to certain management decisions taken concerning the resource in question by studying the elasticities of the corresponding explanatory variables and by examining possible transversal links with other public policies. One of the principal novelties of the study involves the use of panel data, drawing on information from different mycological management areas over the period 2013–2015. An attempt is thus made to respond to the criticisms levelled at other models like the travel cost method based on the problem of stability of measures estimated using longitudinal data (Cooper and Loomis, 1990; Hellerstein, 1993).

2. Material and Methods

2.1. Study Site

The Autonomous Community of Castilla y León is located in the centre of Spain (Fig. 1). It is the largest region in the country, covering 84,226 km^2 (18.6% of the whole country) and is the third largest European NUT-2 administrative area, being similar in size to countries like Bulgaria, Hungary or Portugal.

Castilla y León has a wide variety of forest habitats and, consequently, a wide variety of wild mushrooms, estimated at some 2744 species. The most representative genera are *Agaricales* (42%), *Russulales* (8%), *Polyporales* (6%) and *Boletales* (6%). Of these species, around fifty taxa are of commercial interest due to their high market value. The average gross annual production of wild edible mushrooms, excluding truffles, is 34,000 tons, equivalent to some 80 million euros (Martínez-Pena et al., 2011). The harvesting of a wide range of edible mushroom species, including *Boletus edulis* Bull., *Lactarius deliciosus* (L.) Gray, *Amanita caesarea* (Scop.) Pers and *Cantharellus cibarius* (Fries), has been attracting greater attention amongst local populations since the 1950s.

The predominant system governing the harvesting of wild mushrooms in the region of Castilla y León (Spain), a system known as Micocyl, has been in place since 2003 (Martínez-Peña et al., 2017). It is an advanced model for managing the forest use of wild edible mushrooms. This joint bottom-up governance model today includes over 350 public forest owners (mainly local rural municipalities), and covers > 400,000 regulated hectares belonging to over 700 forest holdings spread throughout the region, split into 225 municipalities (Fig. 1 and Table 1). This regulatory system is grouped and organised into nine collecting areas managed with common aims and tools whilst also taking into account the specific features of each area.

Based on sustainability and organisational criteria, the Micocyl system (García et al., 2011) must decide for each collecting area both the total number of harvesting permits that can be issued as well as the type and cost. These decisions are taken depending on aspects such as each area's capacity (maximum number of permits per km^2), the relation between the picker and the municipality that owns the forest where the activity is to be undertaken, why the mushrooms are to be picked (whether for commercial, recreational or research purposes) or the length of time the activity will take place (Table 2).

Micocyl has succeeded in bringing together all forest owners in a sophisticated common platform that provides information and online sales of picking permits (www.micocyl.es) connected in real time with the forest agents and security forces responsible for overseeing good practices in the use of the mycological resources the permits provide for. Each collecting area establishes its own sale price for the permits as well as the different types available (Table 2). The owners' association, the body governing each collecting area, adjusts the prices intuitively with the social justification of generating a minimum revenue for use of mushrooms, which will enable management of the available mycological resources to be maintained and improved in a sustainable manner. Prices are also established following the criterion of favouring local pickers and mycotourism. To achieve this, symbolic prices ranging between 3 and 10 euros per year are applied for pickers registered as residents in the towns and villages that form part of the Micocyl system. This is coupled with reasonable prices for the majority of mycotourists, ranging between 5 and 10 euros per day and recreational use.

2.2. Data and Model

The model proposed, known as the gravity model or gravity equation model, is based on Newtonian physics. It is based on the force of attraction between two masses, modelled through the universal gravitational equation proposed by the English physicist and mathematician Sir Isaac Newton (1642–1727) in 1687 in his work *Philosophiae Naturalis Principia Mathematica*:

$$F = G * m_1 * m_2 / d^2 \quad (1)$$

where G is the universal gravitational constant, m_i the mass of bodies and d the distance separating them.

It was adapted to other disciplines in the late 19th century when Ravenstein (1885) used the gravity equation to explain population migration flows. The forces of push and pull between territories arose