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Trends in hunters, hunting grounds and big game harvest in Spain

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Abstract

Aim of study: Game species are considered a scarce natural resource and therefore they are subject to economic analysis. Current studies on factors affecting big game trends have mostly emphasized the impact of ecological supply variables. This study intends to expand this analysis by considering two important supply and demand economic parameters.

Area of study: We use big game hunting in Spain from 1972 until 2007 as a case study since it has an important role in the European hunting activity.

Material and methods: Different linear models were fitted to explain big game harvests as a function of two parameters not previously used: hunting grounds areas and big game firearm hunting licenses.

Main results: Our main results show that up to 1989 the decrease in the area of open access territories significantly explains the increase in big game harvests, and that afterwards, once the hunting property rights were strengthen in most of the Spanish territory, the number of big game firearm licenses best explain big game harvests increments.

Research highlights: This work shows an upward trend in Spanish harvests of big game, which can be attributed in part to (1) a shift to the right of big game demand, measured by an increase in big game firearm licenses, and (2) a change in the nature of big game supply (from a backward to an ordinary upward supply curve) due to the strengthening of hunting property rights of Spanish hunting grounds.

Key words: hunting license; firearm license; hunting bag; hunting sector; property rights; wildlife.

Introduction

Since the beginning of human history, game species have been considered a scarce natural resource (Ortega y Gasset, 1972). Available information indicates that excessive hunting pressures have contributed to gradual population declines of wildlife or even extinction of certain species in many areas since ancient times (Hughes, 1994). Hunting practices, as well as the quantity and trophy-quality of game animals being hunted have varied over time and space (Hudson *et al.*, 1989). In addition, a significant diversity of game management models, adjusted to natural conditions (wildlife and habitat), socioeconomic, and institutional conditions and situations, have been inherited from the past (Anderson, 1985; Roth and Merz, 1997; Wolfe, 1970).

During recent decades, in most industrialized countries a new set of factors affecting both the demand and the supply of hunting have been identified. Socioeconomic factors linked to hunting demand are numerous; the process of urbanization, the increase in per capita income, and the changes in values and lifestyle (Heberlein and Ericsson, 2005; Heberlein *et al.*, 2002; Sharp and Wollscheid, 2009). These, in turn, have increased the demand for commercial hunting, national and international hunting tourism and hunters' preferences toward big game hunting trophies (Bauer and Giles, 2002; Lovelock, 2008; Robinson and Bennett, 2000; Sharp and Wollscheid, 2009). Supply side factors affecting hunting are related to the transformation of agricultural practices, institutional changes, and biological factors. First, the transformation of traditional agriculture and abandonment of marginal agricultural land since the second part of the 20th century (Cochrane, 1998; Shultz, 1953) in addition to new improved silvicultural practices have produced a change in suitable habitat for game species in most developed countries (Acevedo *et al.*, 2011; Delibes-Mateos *et al.*, 2009; McShea *et al.*, 1997; Virgos, 2002). Secondly, public policies have increased hunting rights and game preservation (Rosser, 2009). Finally, biological factors,

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such as small game diseases and changes in natural predators have pushed some small game species to worrying ecosystems' levels (Virgos *et al.,* 2007), and contributed to generally increase big game populations (Liberg *et al.,* 1994). The combined effects of these external and internal forces have contributed to creating a new big game hunting situation in most industrialized countries. Big game species are being raised increasingly under domesticated (game farming) or semi-domesticated systems (game ranching) (Hudson *et al.,* 1989) and their populations have significantly grown, achieving densities that often exceed environmentally sustainable levels (Côté *et al.*, 2004; Mysterud, 2010).

These recent trends in hunting indicate how socioeconomic and institutional forces, biological processes, and management systems are interrelated. The importance of interdisciplinary collaboration to deal with many of the problems in conservation and environmental management has been suggested among others by Milner-Gulland and Mace (1998), Mascia *et al.* (2003), Lawton (2007) and Cooke *et al.* (2009). Current studies on factors affecting big game trends have mostly emphasized the impact of ecological supply variables (Acevedo *et al.,* 2011; Delibes-Mateos *et al.,* 2009; Gortázar *et al.*, 2006; Vargas *et al*., 2007). However, institutional changes affecting the supply of big game, such as the impact of changes in hunting property rights in hunting grounds, have not normally been considered to explain big game harvests. On the demand side, hunting licenses have often been used as proxies of demand variables however they don't always distinguish between small and big game. This study intends to fill these gaps by considering two important parameters related to supply (hunting rights, measured by trends in hunting grounds) and demand of big game (using hunting and firearm licenses as a demand side index factor) to our knowledge not previously considered to explain game harvest. We use Spain from 1972 to 2007 as a case study since it has an important role in the European hunting activity. There are 46 different hunted species, around 1.5 million hunters (FACE, 2007), and more than 37 million hectares with active hunting management in 2007 (MARM, 2009). Spain ranks first in Europe in the number of red deer (*Cervus elaphus* L.) captured and third in wild boar (*Sus scrofa* L.) (Apollonio *et al*., 2010). In this study we describe trends of variables never used before to the authors' knowledge to explain big game harvests and we assess their accordance with economic theory. Consequently, we expect to improve our understanding of changes and trends in big game hunting, and their impact on variations in harvest bags.

Materials and methods

Study area background

Any analysis of Spanish hunting in the last decades must first consider the transference of legal competence for hunting from Central Administration to Regional Governments (Autonomous Communities) at the end of 1980s. Since 1989, each one of the 17 regional Governments has been enacting their own legislations about game species and their management (Gálvez, 2005). Although the new regional hunting legislations are based on the former National Hunting Law enacted in 1970 (Spanish Hunting Law of 1970), the new process of legislative changes has made the study of hunting in Spain much more difficult. It is necessary to deal first with an increasing number of different regulations, with a lack of data in some regions and periods, and finally with the absence of a national common protocol for collecting statistical information (Martínez-Jauregui *et al.*, 2011).

Data and sources for hunting statistics

Data sources used in this article come from the Agricultural Statistics Yearbook, from the Forest Statistics Yearbook, and from the Statistical Yearbook of the Ministry of Interior (MA 1973-1981, MAPA 1982-1999, MAPA 2000-2004, MARM 2009, MI 1995-2008). Although these data do have the common limitations associated with other agricultural official statistics, we believe that they provide valuable information to assess a long-term and overall picture of the hunting sector. Sources are extensively described and discussed in Martínez-Jauregui *et al*. (2011).

Information about hunter's trends is collected as a proxy of changes in hunting demand. In Spain there is no nationwide registry of hunters, therefore variables used to assess hunters trends are:

— *Number of active hunting licenses*: Defined as the sum of the number of hunting licenses issued (data available in years: 1972-2003, 2005, 2006, and 2007) plus the number of renewed hunting licenses (data available in years: 1972-1989, 2005, 2006, and 2007).

— *Number of big game firearm licenses*: Defined as rifle and shotgun with rifled barrel licenses issued and renewed. Data available in years: 1994-2007. This license is mandatory and non-transferable.

— *Number of small game firearm licenses*: Defined as smoothbore shotguns and rimfire rifles issued and renewed. Data available in years: 1994-2007. This license is mandatory and non-transferable to small game hunters (although these firearms may also be used for wild boar hunting).

Trends in hunting area and changes in hunting rights associated to these areas are used as a proxy of the supply of big game hunting. Variables used are:

— *Area (ha) of hunting states, hunting controlled zones,* and *hunting reserves* (data available in years 1975-1993, 2006, and 2007). *Hunting states* are those territories in which hunting rights belong to landowners or renters. They can be a private person, a private entity such as hunters associations, or a national, regional or local public authority. *Hunting controlled areas* include originally open-access territories that, for reasons of protection and conservation of hunting species, were subject to management schemes. Normally public authorities assigned hunting rights to local hunting societies. *Hunting reserves* include territories directly managed by national or regional public authorities with the objective to preserve and promote particular hunting species.

Finally, *Number of harvests* is defined for red deer, wild boar, and other big game (as Roe deer (*Capreolus capreolus* L.), Spanish ibex (*Capra pyrenaica* Schinz), Fallow deer (*Dama dama* L.), Mouflon (*Ovis aries musimon* Pall), etc.). Data available in years: 1972-2007 (with the exception of 2004).

Analysis

Hunters

We expanded data available on the *Number of active hunting licenses* (1972-1989, 2005, 2006 and 2007) to the rest of the unknown years (1990-2004) to be able to interpret the all period trend of hunters (big and small game). To do so we fitted a generalized additive model, using non parametrical smoothers, splines, and the library mgcv in R 2.3.1 (R Development Core Team, 2006; following Crawley, 2007). We inferred the data using a model where the dependent variable was the *Number of active hunting licenses* and the independent variable the year.

To identify general trends between big game and small game hunters, data series on firearm licenses were studied. Two linear regression models were fitted to study time tendencies where the dependent variable was the *Number of firearms* (big and small game firearms separately) and the independent variable the year. Data availability precluded from expanding the model to the early years of the period studied.

Hunting grounds

The Spanish Hunting Law of 1970 included two main types of hunting grounds covering both public and private areas: (1) *Hunting grounds of common use*: these territories can be classified as open-access harvesting. Landowners often could not restrict the entry of hunters (no exclusion to hunting rights), and hunting could be practiced by everyone during permitted seasons with no other limitations besides the possession of valid hunting and firearms licenses and other basic legal restrictions. (2) *Hunting grounds subject to special arrangements*: These included hunting grounds subject to hunting control schemes in which landowners or renters have exclusive hunting rights. This type of hunting ground included several types of *Hunting states* in which hunting rights belonged to landowners or renters, *Hunting controlled areas*, and *Hunting reserves*. After 1989, regional hunting legislations introduced a larger number of hunting grounds denominations. However, they can be grouped in the previous classes (Martinez-Jauregui *et al*., 2011). The analysis is descriptive on the trend of the area they occupy. We expanded data available on the total area of the *Hunting grounds subject to special arrangements* to the rest of the unknown years to be able to interpret the whole period trend of hunting grounds. To do so we fitted a generalized additive model, using non parametrical smoothers, splines, and the library mgcv in R 2.3.1 (R Development Core Team, 2006; following Crawley, 2007). We have excluded year 2007 in the model since it has been identified as a failure in the statistics and its removal changed significantly the shape of the curve (Martinez-Jauregui *et al.*, 2011). The *Hunting grounds of common use* territories are identified as a residual of the Spain's total hunting area minus area cover by *Hunting grounds subject to special arrangements*.

Big game harvests

Information about harvests of game animals is gathered annually in the official Spanish statistics. In particular, there is information on the harvests of the following big game species: *red deer and wild boar,* and the remaining big game species are grouped as *other big game*. To present the data of harvest trends for each species or groups of species over time in Fig. 3 we analyzed records of harvest bags as a function of year using generalized additive models (following Crawley, 2007, and using splines and the library mgcv in R 2.3.1). We fitted three different linear models to explain big game harvests (the sum of red deer, wild boar and other big game): (i) Model 1: Model fitted to the whole period studied where the variables *Year, Number of active hunting licenses*, *Area of hunting grounds subject to special arrangements* and their interactions were considered as potential explanatory variables. However, due to the high correlation of the first two variables (Pearson's rho = 0.92; t = 13.78, df = 34, p-value < 0.01), they could not be fitted in the same model. The final model was chosen following the *Parsimony principal* which considers the best compromise between the variance explained and the model complexity. (ii) Model 2: It was fitted following the procedure described for model 1 but for the years before 1989. (iii) Model 3 was fitted for the rest of the period. In this case explanatory variables used were *Year, Number of big game firearm licenses*, and *Area of hunting grounds subject to special arrangements*. We did not use the *Number of active hunting licenses,* since we considered that the *Number of big game firearm licenses*, available in this period, was best to describe big game harvests (see the opposite trend shown between *Number of active hunting licenses* and big game firearm licenses in Fig. 1). Again the first two variable (*Year* and *Number of big game firearm licenses*) could not be fitted in the same model due to the high correlation found (Pearson's rho = 0.97, t = 13.25, df = 12, p-value < 0.01), and the final model was chosen following the *Parsimony principal*. One reason for the consideration of the last two models was the transference of legal competence for hunting from Central Administration to Regional Governments (Autonomous Communities), which coincide approximately with the end of the effect of the process of the strengthening property rights in hunting areas initiated by the Spanish Hunting Law of 1970 (see Fig. 2). Another reason was that data on firearm licenses is available only after 1994.

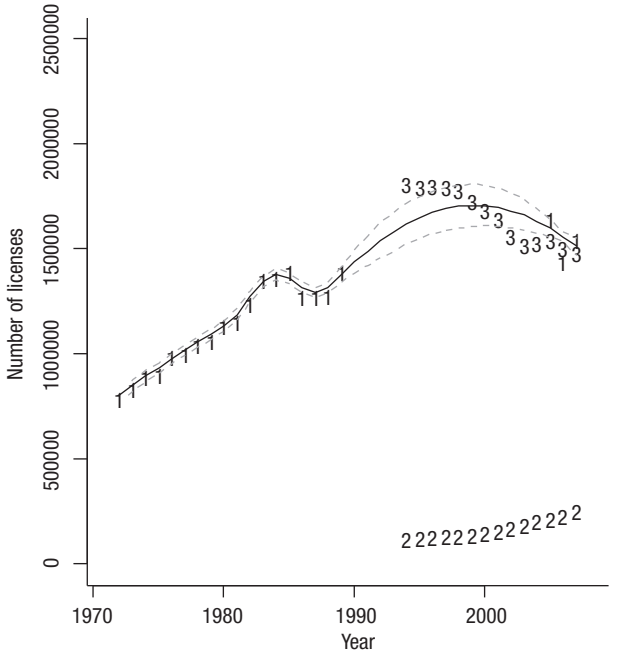

Figure 1. Trends in the Number of active hunting licenses ("1"), the Number of big game firearms licenses, ("2"), and the Number of small game firearms licenses ("3") in Spain between 1972-2007. The numbers represent data collected in the official Spanish statistics, while the lines show the predictions and confident interval band of the generalized additive model fitted to data.

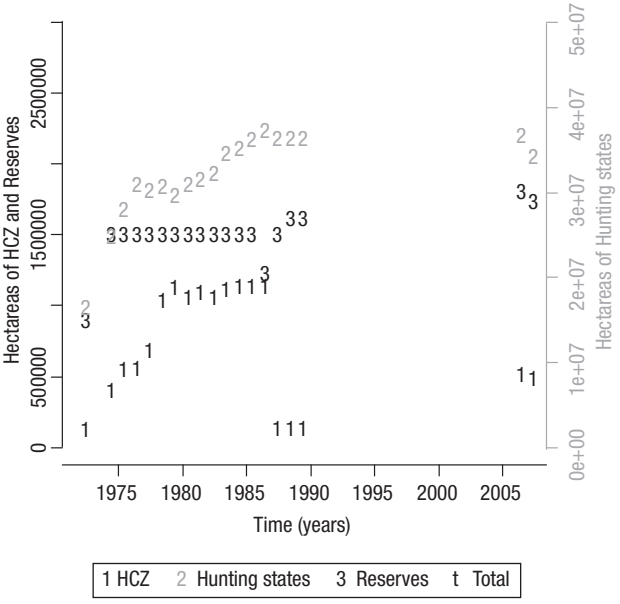

Figure 2. Trends in the area of *Hunting grounds subject to special arrangements* in Spain (t), according to the type of terrain: *hunting controlled zones* (HCZ) (1), *hunting states* (2) and *hunting reserves* (3). The numbers represent data collected in the official Spanish statistics, while the lines show the predictions and confident interval band of the generalized additive model fitted to data.

Results

Hunters

As shown in Fig. 1, our model estimated increasing probabilities for the *Number of active hunting licenses* from 1972 to 2000. After 2000, the probability of the *Number of active hunting licenses* declined ($p < 0.001$; R-sq.(adj) = 0.967), indicating a steady reduction in the total number of hunters. The probability of the number of firearms licenses used for big-game hunting has increased significantly ($p < 0.01$, Adjusted R-squared = 0.931), from 132,618 licenses in 1994 to 265,428 in 2007. On the contrary, we found a decreasing probability of the number of firearms mostly used for small game from 1,821,846 in 1994 to 1,497,056 in 2007 (p-value < 0.01 and Adjusted R-squared = 0.923). In any case, the firearms licenses figure indicates that, at the end of the study period in Spain, small game firearms licenses were still much more numerous than big game firearms licenses.

Hunting grounds

Data on *Hunting grounds subject to special arrangements* (*Hunting states*, *Hunting controlled areas*, and *Hunting reserves*) show a substantial increase during the period 1972-1986 (from 17.49 million hectares to 39.64 million of hectares, Fig. 2) at the expense of open-access grounds (*Hunting grounds of common use)*. The area under *Hunting grounds subject to special arrangements* in 1989 is similar to that of 2003 and the predictions of the model show a more or less stable situation (p-value < 0.01, Adjusted R-squared = 0.99). Within *Hunting grounds subject to special arrangements*, *Hunting states* is the predominant territory type in terms of the area occupied. *Hunting reserves* occupy the second largest area, followed by *Hunting control areas*.

Big game harvests

Fig. 3 shows the trends of harvests (generalized additive model predictions, p-value < 0.01, R-sq.(adj) > 0.9) of the main big game species recorded in Spain from 1972 to 2007. A significant growth in the harvest of *red deer*, *wild boar,* and *other big game* can be observed.

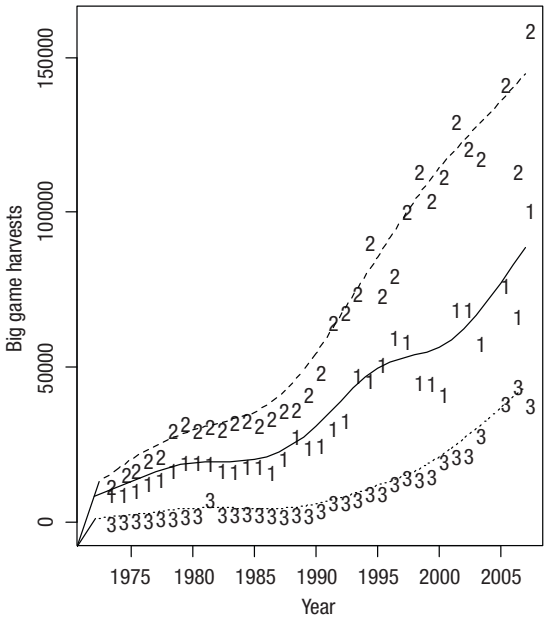

Figure 3. Trends in the number of red deer (1), wild boar (2), and other big game (3) harvests between 1972 and 2007 in Spain. The numbers represent data collected in the official Spanish statistics, while the lines show the predictions of generalized additive models fitted to data.

Final models found to best explain big game harvest showed that: (i) Model 1, fitted for the whole period, had *Year* (positively significant, p-value > 0.001) and *Area of Hunting grounds subject to special arrangements* (negatively significant) in the final model (Adjusted R-squared: 0.94; 31 df). (ii) Model 2, fitted from 1972 until 1989, had *Year* (positively significant, p-value > 0.001), *Area of Hunting grounds subject to special arrangements* (positively significant, p-value > 0.001), and its interaction (negatively significant, p-value > 0.001) as explanatory variables (Adjusted R-squared = 0.95, 13 DF). (iii) Model 3, fitted to the rest of the period studied, had *Number of big game firearm licenses* (positively significant, p-value > 0.001) as the unique explanatory variable (Adjusted R-squared: 0.8487, 11 DF).

Discussion

This work shows an upward trend in Spanish harvests of big game as indicated in Fig. 3. This is in line with other European and North American countries (Apollonio *et al*., 2010; Burbaite and Csányi, 2009; Coté *et al*., 2004; Gill, 1990; McShea *et al*., 1997). For example, using the red deer *Harvest growth rate* (cal-

culated for 11 European countries by Milner *et al*., 2006), the Spanish *Harvest growth rate* is only exceeded by Sweden (Spanish average Hr = 0.062, SD = 0.169, N = 32 for the period 1973-2007). From an economic perspective, this increase in big game harvests can be mainly attributed to the following factors: (1) an increase —shift to the right— of the big game demand, (2) an increase —shift to the right— of the big game supply, and (3) a change in the nature of the big game supply. Our results indicate that at least two of these factors have taken place in Spain in the period 1972-2007; there are more firearm licenses (indicating a shit in hunting demand), and there has been a change in hunting rights related to hunting areas (indicating a change in the nature of the supply of big game hunting).

Hunters

This study signals a recent decline in the total hunting demand in Spain, even though our indicator might overestimate the number of hunters due to the possibility of hunters holding more than one regional hunting license after 1989 (Martínez-Jauregui *et al*., 2011). However, the analysis of the trend in firearm licenses indicates that this decrease in total hunting can be attributed to the reduction in small game hunting, as big game hunting firearm licenses have increased while small game firearm licenses have decreased. This can explain the unexpected absence of the variable *Number of active hunting licenses* in Models 1 and 2 fitted to explain big game harvest. The reduction in the number of total hunters in Spain is in line with the decline in the number of hunters in other countries of southern Europe (FACE, 2007). Other industrialized countries such as Canada and the United States, have also experienced a recent reduction in the number of hunters. In the United States, the decline in the number of hunters has taken place among small game hunters (as in Spain) while the number of hunters of big game which dominates the United States hunting scene has remained fairly stable (Sharp and Wollscheid, 2009).

To explain the possible causes of these trends in hunting demand, it is useful to begin characterizing current Spanish hunters into two major types (following definitions of ECHB, 2007): *resident hunters* and non-resident *tourist hunters*. The group made by *resident hunters* is the largest and they generally practice a type of hunting that does not require large economic expenditures mostly linked to small game (Ortuño, 1970; López, 1986). This is confirmed by the large amount of small game firearm licenses (Fig. 1). In Spain, rural migration has disrupted rural societies causing a progressive loss of rural culture, which in turn has diminished the recruitment of *resident hunters* (López, 1997) as shown by the trend of small game firearm licenses in Fig. 1. Furthermore, remaining *resident hunters* have been facing a progressive reduction in open-access hunting grounds (*Hunting grounds of common use)*, as well as an increase in commercial hunting, which has greatly raised hunting costs (Metra seis, 1985; Mulero, 1991). At the same time, *tourist hunters,* more linked to big game hunting and small game commercial hunts have been rapidly increasing (ECHB, 2007; Metra seis, 1985; Mulero, 1991; Rengifo, 2008 and 2010). Our results on big game firearm licenses confirm this tendency: big game hunting demand has shifted to the right.

Hunting grounds

Our study also shows important changes in the institutional status of the hunting grounds in terms of hunting property rights which in turn have contributed to alter the nature of the supply curve of big game. From a property right perspective hunting grounds are generally classify into two main groups; (1) open-access territories were anyone can hunt (defined in the Spanish Hunting Law of 1970 as *Hunting grounds of common use*), and (2) hunting areas were a sole owner has the control of the animals and can set the harvesting level (defined in the Spanish Hunting Law of 1970 as *Hunting grounds subject to special arrangement*).

In Spain, the Spanish Hunting Law of 1970 provided the legal framework for reinforcing property rights over game resources to avoid the negative effects of open-access territories. Since then the number of hectares of open-access territories has been decreasing, at least until 1986 (see Fig. 2), and this has reduced the possibility of finding a "*Tragedy of the Commons*" situation in big game hunting (Harding, 1968). In the open-access case, future harvests are not normally considered by the harvester ("*a bird in the hand is worth two in the bush*"). Clark (1990) shows that in open-access territories supply curve for a harvested renewable resource such as big game has the unusual property of having a backward bending shape at high prices. The effect is that as hunting demand increases captures may increase up to the maximum sustainable yield. However, further increases in demand which increase

hunting effort beyond the maximum sustainable yield may lead to population declines, harvests reductions or even to the total extinction of the population. In the opposite case, *Hunting grounds subject to special arrangement* has been rapidly growing. In this situation, future captures are normally considered a valuable resource by the harvester in the present and in the future, and the supply curve will be similar to the ordinary upward supply curve growing asymptotically to the maximum sustainable yield as it will not be profitable to harvest beyond this point (Clark, 1990). Therefore, independently of the price or demand the harvester would never capture beyond the maximum sustainable yield each year and consequently the population will tend to remain stable. Our data show that during last decades in Spain there has been a change in the nature of the supply curve from a backward to an ordinary upward supply curve. Data show that this change started in 1972, after the approval of the Spanish Hunting Law of 1970, and was completed by 1986. This explains the unexpected negatively value of the parameter *Hunting grounds subject to special arrangement* in Model 1 and the absence of this parameter in Model 3. The small downward trend observed in 1989 and 2007 affecting all the *Hunting ground subject to special arrangement* types can be explained by a deficiency in the collection of Spanish official hunting statistics, as not all regions had declared the total area of hunting territories in the latest years of the period (see Martínez-Jauregui *et al*., 2011).

Big game harvests

The increase in big game harvests shown in Fig. 3 has coincided in time with important socioeconomic events affecting the composition of hunters and hunting grounds described above. In particular, (1) an increasing interest in big game hunting (demand side factor) at least in the period 1989-2007 (see Model 3) which could be attributed to recreational commercial big game hunting by urban *tourist hunters* (ECHB, 2007; Mulero, 1991; Rengifo, 2008, 2010)*;* and (2) the strengthening of the property rights exercised by landowners or renters over game resources in the previous period (1972-1989) described by the increment in hunting states area and the reduction of open-access harvest territories (supply side factor, Model 2). This has contributed to a reduction of the hunting territories with a backward bending shape supply curve and an increase in territories with a normal upward supply curve. The maintenance of an upward supply curve in the last period explains how the increase in big game hunters (measured by *Number of big game firearm licenses*) resulted in largest big game harvests (see Model 3).

Therefore, under these circumstances, our data and models on big game harvest in Spain in the period 1972-2007 support economic theory results (see Clark, 1990). In addition, although it is not derived from our results, we would like to point out that the abandonment of many agricultural and livestock activities in mountain areas and their replacement by more intense commercial hunting management activities (Carranza, 2010; Geisser and Reyer, 2004; Mysterud, 2010; Putman and Staines, 2004) could have shifted the upward big game supply curve to the right and therefore reinforced the effect of the increment in hunting demand on the big game harvests. Finally, although the above socioeconomic factors may have affected harvests of the two main big game species, red deer and wild board, wild boar harvests have expanded faster than red deer as shown in Fig. 3. One reason could be the wild boar "r" reproductive strategy and their generalist diet (Rosell *et al*., 2001). This indicates that both socioeconomic and biological factors need to be considered when interpreting the pattern of harvests growth.

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