Gravitational Models and Spatial Foresight: From Agricultural Policy to Agricultural Loss

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Abstract: This paper discusses the issue and proposes a spatial land-cover accounting methodology to assess the impacts and changes occurred in the rural world, Portugal serving as a case study. So, furthermore, this paper aims to respond from a spatial perspective to the following questions: (i) Which are the most significant changes in Portuguese agricultural systems and where did they occur? (ii) Do municipalities in Portugal show dense agricultural regions that were lost, and if so, are they related to urban regions? The methods apply gravitational models to identify the compactness of agricultural areas within the different regions and detect the most significant land use variations. By comparative analyses of the different agricultural land classes, the variations in agricultural land use changes were detected. Also, the comparison of these values in a best-fit with Euclidean distances of artificial land-use questions the consequences of land-use change in Portugal over the last two decades. Finally, this paper demonstrates that the existence of spatial inventories such as the CORINE Land Cover, currently in its third assessment, provides useful information for the assessment of agricultural land-use dynamics.

Key words: Gravitational models, spatial planning, rural, Portugal.

1. Introduction

Since June 2003, CAP has changed the way how EU supported its farm sector. A set of measures were applied to meet new market needs promote awareness of environmental impacts of agricultural production techniques, as well as of food and animal safety. These measures mean some achievements related to regional sustainability.

Some of the implemented actions of this reform are deeply related to the institutional aspects of farm payment for EU farmers. Examples are the independent of production – with limited production-related payments to avoid abandonment of production; the strengthened rural development policy; the reduction of direct payments for bigger farms; a specific mechanism for financial discipline – to ensure that the farm budget fixed until 2013 is not exceeded; and, finally, some revisions to the previous market policy of the CAP such as: i) asymmetric price cuts in the milk sector; ii) reduction of the monthly increments in the cereals sector by half, with the intervention price maintained; iii) lastly, reforms in the rice, wheat, nuts, potatoes and dried fodder sectors.

It cannot be neglected that 90 per cent of Europe (E25) is composed of rural areas – where half of the European population lives [13]. Meanwhile, rural areas have developed different specific characteristics [3] and thus have become multifunctional, multitasking entities [9] and urbanized regions [14]. For the particular case of Portugal, the CAP should have promoted the agricultural sector by achieving increases in the productivity and development of the rural areas. However, despite diversified efforts towards structural aid, we cannot regard the case of Portuguese agriculture as a fully successful example. These activities are not only decreasing as a share of GDP, but they are also decreasing in absolute terms. It is almost shocking to confirm that vegetables production has fallen by about 14 per cent, in the last decade, while livestock production increased by about 10 per cent, indicating a deep change in the productive system as a result of new trends towards northern European consumption habits. This has taken place in Portugal since the 1980s, and is due to heavy investment of European food distribution chains.

Clearly, serious problems have subsisted as structural difficulties – between 1986 and 2006, the production of the main agricultural products has decreased by 12.6 per cent – so that, in spite of the availability of public aid, agricultural productivity has increased only slowly, as a result of limited technological progress. Other expectations related to food self-sufficiency or a more balanced equilibrium in the food trade were, however, not achieved (Table 1). Also, Portuguese consumption, which is increasingly composed of imports, was more

significant in the food industry than in the agricultural production, and it has progressively developed into an increasing loss of self-sufficiency, as shown in the data below.

Table 1- Level of self-sufficiency for the food sector, for the period 1980 – 2000.

Sectors	1980	1985	1990	1995	2000
Agriculture	78.4	75.9	80.8	74.6	74.9
Food Industry	93.8	94.1	90.1	85.1	83.6
Food Sector	86.7	83.2	86.4	81.3	80.7

Source: INE, Agricultural Statistics and National Accounts

Some economic lessons and regional trends underline our analysis: after 1986, and due to the accession of Portugal in the European Community (EC), most of the agricultural commercial flows took place within the European Common Market, with two main consequences. Firstly, there was an increase in consumption levels of food and a consequent rise in associated imports. Secondly, international food distribution chains located gradually in the country and accessed a great part of the Portuguese population, starting in the big towns, but soon locating in the small ones too. Both factors drove Portuguese consumption patterns towards those of the other European countries, at a time when producers and industrialists were still not ready to move into new productive processes and new commercial chains as explained in Cunha [1] or Vaz and Urban [16].

Over time, farmers have slowly acquired a deeper understanding of the importance of commercial channels and marketing mechanisms for the whole process of agricultural and rural development. The role of national policy makers became crucial to speed up this process and facilitate the way farmers should learn to organize themselves around such common interests. A great deal of these efforts is geographically concentrated in towns or nearby, but, in our opinion, they take far too much time to spread into the peripheral hinterlands.

In this short paper we try to identify the extent to which the agricultural sector in the Algarve, Portugal replied inelastic to those above referred policy measures proposed by the European Commission and remained with no positive effects. The theoretical inspiration for the developed gravitational methods is based upon the location theory, [11, 17] and Lösch [7], much revisited in the last decades [8].

2. Methods and Material

2.1. Integration of the law of universal gravitation

Universal gravitation theory has a solid role in Theoretical Physics. Newton's law of universal gravitation describes an attraction of two objects within a generated mass, and the equation is described as:

$$F = G\frac{m_1 m_2}{r^2}$$

where, F is the attraction between two objects, circumscribed by G as the gravitational constant, and related to m_1 and m_2 represent the masses of two points, in relation to their distance, r. The spatial explicitness of this model is appreciated by the relationship of both points, m_1 and m_2, which are related to a given distance in Euclidean space. The Euclidean distance result, is of easy interpretation from one cell to another, and therefore may be adaptable for spatial analysis. Furthermore, the costs of those cells in r^2 may also convey to form a specific distance between two cellular inputs described by distance buffers with specific weights. Thus, similar to the original formula of the universal gravitation, adaptation to geographical space Tobler's [12] first law of geography, the integration of costs for proximity may be considered. Our model proposes an adaptive integration of:

$$F = C\frac{a_1 a_2}{r^2}$$

in which F continues attraction but between cities, C is constant and a_1 and a_2 become defined as the agricultural weight of two cities.

2.2. An exploratory exercise to the case of Algarve

Composed by a total of sixteen municipalities, the Algarve occupies the southern part of Portugal. This area is longitudinally crossed by a highway and benefits from an international airport in the administrative capital, Faro. There is a dichotomy in the development across the region: The less developed municipalities, dependent of traditional and barely commercialized activities prevail are located in the interior. In general, such activities are structurally weak, little profitable and the produced commodities have few added value; Closed by, but in the littoral, another set of municipalities have experienced a spectacular growth in the last decades.

Tourism was the driver of the economic structure in such towns and there are few

opportunities for a diversification of the economical activities. Land prices have risen frenetically and civil construction also accompanied, as usual the growth of the tourist sector. The employment integrated unskilled immigrants from different nationalities who contributed until the last two years to strength the labor force, also in the agricultural sector. With the last financial crises, unemployment affected Algarve more seriously than any other Portuguese region.

Because the Algarve presents an very asymmetric distribution of agricultural land-use the sample is quite interesting and a closer analysis on the Agricultural land preemption loss (Table 1) may produce useful insights such as how much variation of preempted land varies in time and which are the prospective trends for the future, when expecting continuous urban growth and further urban sprawl [7].

2.3. Agricultural weight factors

The Table 2 shows the loss of agricultural land in the Algarve between 1994 and 2007 in hectares.

Table 2: Variation of preemption loss of agricultural land in the Algarve (year/ha)

	Preemption of RAN
1995	836077
1996	183595
1997	107814
1998	130046
1999	945024
2000	1970425
2001	215916
2002	532361
2003	2217138
2004	919086
2005	3722864
2006	2042763
2007	1594594

Much of this loss was a result of direct impact of urbanization in peripheral areas, as well as rural abandonment followed by wildfires which took place. This is a direct result on the application of policies which justify in the context of the Portuguese land-use directives, to use agricultural land when needed, in context of modernization and creation of infra-structures. The agricultural preempted land inventory however, is strongly linked to the importance of sustainable development, and although there has been a tendency of increasing preempted land loss in the Algarve, as Vaz [10] have argued, this is a direct result on increasing urban growth.

3. Conclusions

Divided into three parts, Figure 1 shows the application of the (GE) to the Algarve. While the upper left box shows the Euclidean distances from major city centers, the middle box integrates the population density per parish and the upper right box the variation of the loss of agricultural land over the study period of 1994-2007.

The resulting map (larger map on Figure 1) shows the regions which are mostly affected to the gravitational force of agricultural land loss. While this phenomenon has an increasing weight in the coastal region, the city of Loulé, Faro and Portimão are most affected.

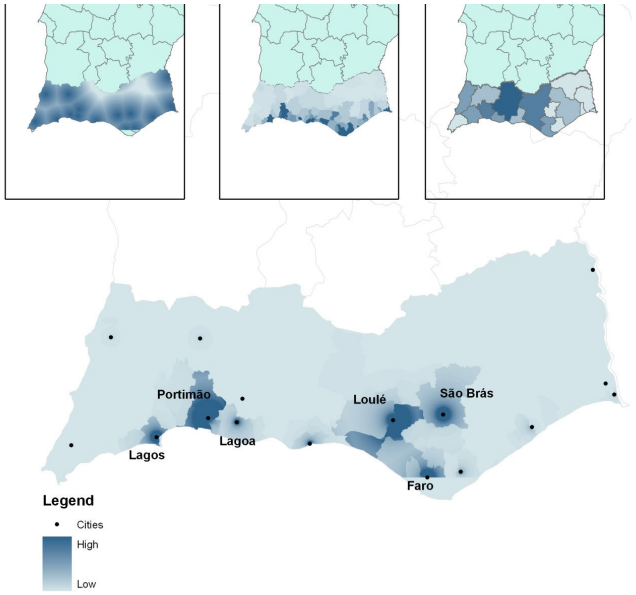

Figure 1- Gravitational Agricultural Model. From left to right: Euclidean distances from cities, population density per parish, change in agricultural land-use loss.

The effect of the gravitational force seems to exert a pressure on adjacent cities, suggesting an addictive effect on the surrounding parishes. While most city centers report some form of mild pressure, it is the direct relation to the variation of agricultural land loss that renders most likely the vulnerability of agricultural land use change. This pattern suggests a continuing increase of loss of agricultural land in the

areas of surrounding urbanization, and focuses on the asymmetry of rural and urban regions in the Algarve.

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