Open source GIS based strategies for firms: a spatial analysis application to the inland terminal of Livorno

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Abstract

The paper explores the use of open source geographic information system (GIS) applied to firms. Most data available in a company have a spatial dimension and even decisions in marketing and management often have a spatial dimension. The paper is focus on illustrating the variegated opportunities for an open source GIS based strategy for firms. We argue that open source GIS are today as good as its proprietary competitors, and under certain circumstances, they are a superior alternative to their proprietary counterparts. A GIS based strategy for firms, as any other new application of geographical knowledge, it is a prospect of a new area for geography studies. This paper can be considered an initial essay on the role that geographers can play in spatial analysis applied to business strategy. The application is an example of applied geography supporting firm strategies and it has the purpose to identify spatial customer potentials for a specific infrastructure, the inland terminal of Guasticce (Italy).

JEL Classification: R00, R40
Keywords: spatial analysis, open source, Geographic Information System (GIS), geography, inland port

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1. Introduction

It is argued that there is an emerging opportunity to use geographical information and to apply spatial analysis tools and that, for economic geographers, it is a prospect of a new area for academic studies (Longley and Clark, 1995). Moreover, the modern software GIS allow us to introduce a new method of working, keeping at the same time, on the same screen, different information issue from more than one data base, related to the same geographical area.

But it is too easy to image that the purpose of GIS is only to help to solve geographical problems by academic and that GIS are to geographers what computer-aided design and computer-aided manufacturing (CAD/CAM) are to engineers. GIS present also an opportunity to solve business problems by providing a capability to process the high proportion of business data that is geographic data (Grimshaw, 2000). One of the principle support offered by GIS to business organisation is helping to formulate strategies about the key issue of "where" to locate facilities or "where" to look for new customers. Linking location to information is a process that applies to many aspects of business such as choosing a site, targeting a market, planning a distribution network or delivery route, drawing up sales territory, allocating resources (Boyles, 2002).

A GIS based strategy for firms, as any other new application of geographical knowledge, more generally speak to what can be expected in the future and geography's role in addressing contemporary issues (Murray and Tong, 2008). The importance of geography's applied potential is increasingly together with the improvements in GIS softwares, especially in the area of geospatial technologies (Murphy, 2006). Geographers are using GIS and spatial analysis techniques to provide support in crucial decision making contexts in the public and private sectors (Gewin, 2004).

Following the observation of Lees, that the central goals of critical geography might be to "find new ways of opening up the academy and make academic knowledge more accessible and inclusive to people beyond its immediate confines" (1999, p. 377), than to find new fields of application for geographical knowledge can be considered crucial for the future of geography. Moreover, closer relations with firms may also allow geographers to respond to neoliberal assaults on the relevance of academic disciplines and the associated excision of "unproductive" departments from universities.

Contemporary debate on the role of geography is very rich (see, for example, Amin and Thrift, 2000; Barnes, 2001; Thrift, 2002; Turner, 2002; Harrison et al., 2004; Boshma and Frenken, 2006; Demerit, 2008; Grabher, 2009) as it is the debate about geography's practical and political relevance in terms of providing insights that satisfy diverse audiences both within and outside the academy (Massey, 1999; Elwood and Martin, 2000; Pollard et al., 2000; Martin, 2001; Clifford, 2002). But at the same time, the apparent inability of geography to use of advantage its resources and realise its potential in a range of thematic areas is a continual source of intellectual and political frustration (Pollard et al., 2008).

Even if all these issues are crucial for the future of geography, the literature exploring new applications of geographical knowledge is very poor (an example is Pollard et al., 2008), particularly concerning the private sector. We argue that geography needs to find new links and relations with firms, not only with institutions, in the sense of answering to the needs of our society and to advance a coherent approach to a considerable range of contemporary issues.

The present paper explores the opportunities of open source GIS for firms and, consequently, the role that geography can play in a new interaction process with firms. A GIS based strategy for firms is a Geographical Information System designed to provide useful location-based functions to support management decisions in private and public business firms. Geographers are used to achieve spatial analysis in their studies and their skills can be applied to support firm strategies in many different ways. Moreover, proliferation of open source GIS can help the implementation of spatial analysis tools in a large number of private and public firms, especially in those small organizations and regional government agencies that cannot afford proprietary software's costs, complexity, steep learning curves, training costs and special requirements. Moreover, we argue that open source GIS are today as good as its proprietary competition, and under certain circumstances, they are a superior alternative to their proprietary counterparts.

In the final part, we report about a geospatial analysis applied to a new logistic infrastructure. In this case study geographers maximise their skills on GIS and spatial analysis to support the management of the company in their decision on marketing. The aim of the application is to solve a typical spatial analysis problem: to find potentials spatial customers for the new logistic infrastructure.

This paper is organised as follow: in section 2, the GIS open source are introduced, in section 3, the potentialities of GIS based strategies for business are explored. In the same section, we report the case of applied spatial analysis to the logistic infrastructure of the inland terminal of Guasticce in Livorno (Italy).

2. The open source GIS

Since 1980s, technological change has had a profound effect upon all significant world economy organisations, particularly through the continuing fall of computer technology prices. These changes have been accompanied by massive investments by computer software industries, which have induced hardware developments to improved methods of manipulating information and have created "users friendly" ways in which the wider community can access information. Together, hardware and software developments have fostered large changes in the way in which information may be input, storage and analysed using powerful database management systems. GIS must be considered a database management system with only a difference: information has a link with a unique point on the surface of the earth.

But what is a GIS really? There are probably many definitions and many other applications for GIS. In this article we consider a GIS a particular kind of software program that runs on personal or network computer. In other words we will consider only the so called "desktop GIS" which are "mapping software installed onto and runs on a personal computer, allowing users to display, query, update, and analyze data about geographic locations and the information linked to those locations" (ESRI 2008).

A desktop GIS allow to locate, handle and integrate the wide variety of information that is being generated and being made available for everyone. However there is still a significant expense associated with the use of purely closed source or proprietary software solutions for spatial information systems that limits the uptake of these technologies by smaller organizations, firms, students. Open source software has the potential to make powerful software available to these organizations for free (Reid and Martin, 2001). So, for example, many indigenous groups in South America have embraced GIS technology and have begun to use maps as tools in their fight for land and marine resources, as well as greater political autonomy (Steinberg et al., 2006).

But it is important to remark that "free" is first of all a matter of liberty, not only of price. The General Public License (GPL), which is today the most widely used license for Open Source and Free Software, protects and grants the four freedoms below:

- The freedom to run a program, for any purpose in any place (firm, university, home, public company).
- The freedom to study how the program works, and adapt it to your needs. Access to the source code is a precondition for this possibility.
- The freedom to redistribute copies.
- The freedom to improve the program, and release your improvements to the public, so that the whole community benefits. Access to the source code is a precondition for this criterion as well.

So, when we advance in downloading an open source GIS you can choose to install on your personal computer not only the binary, executable files, but also the program code written in the specific programming language. As Stallman (2007) notes:
"When we call software "free", we mean that it respects the users' essential freedoms: the freedom to run it, to study and change it, and to redistribute copies with or without changes. This is a matter of freedom, not price, so think of free speech".
Full access to the source code is particularly important for GIS because the underlying algorithms can be complex and can greatly influence the results of spatial analysis and modelling (Mitasova and Netler, 2004). At the same time some users can really help to improve the desktop GIS in fact, there is a number of specialists willing to test, analyze and fix the code, while an average user will only use the software for his particular spatial analysis. In other words the freedom to use the software give us a full range of possibility but at the same time allow to take advantage of the different backgrounds and expertise of these users/developers which contribute to faster and more effective software development.
Briefly, Open Source GIS Software (OSGS) are programs whose licenses give users the freedom to run the program for any purpose, to modify the program, and to freely redistribute either the original or modified program without further limitations or royalty payments (Anderson and Sanchez, 2003).
According to Lowe (2002), the market of OSGS is growing thanks to small organizations and regional government agencies that cannot afford proprietary software costs,

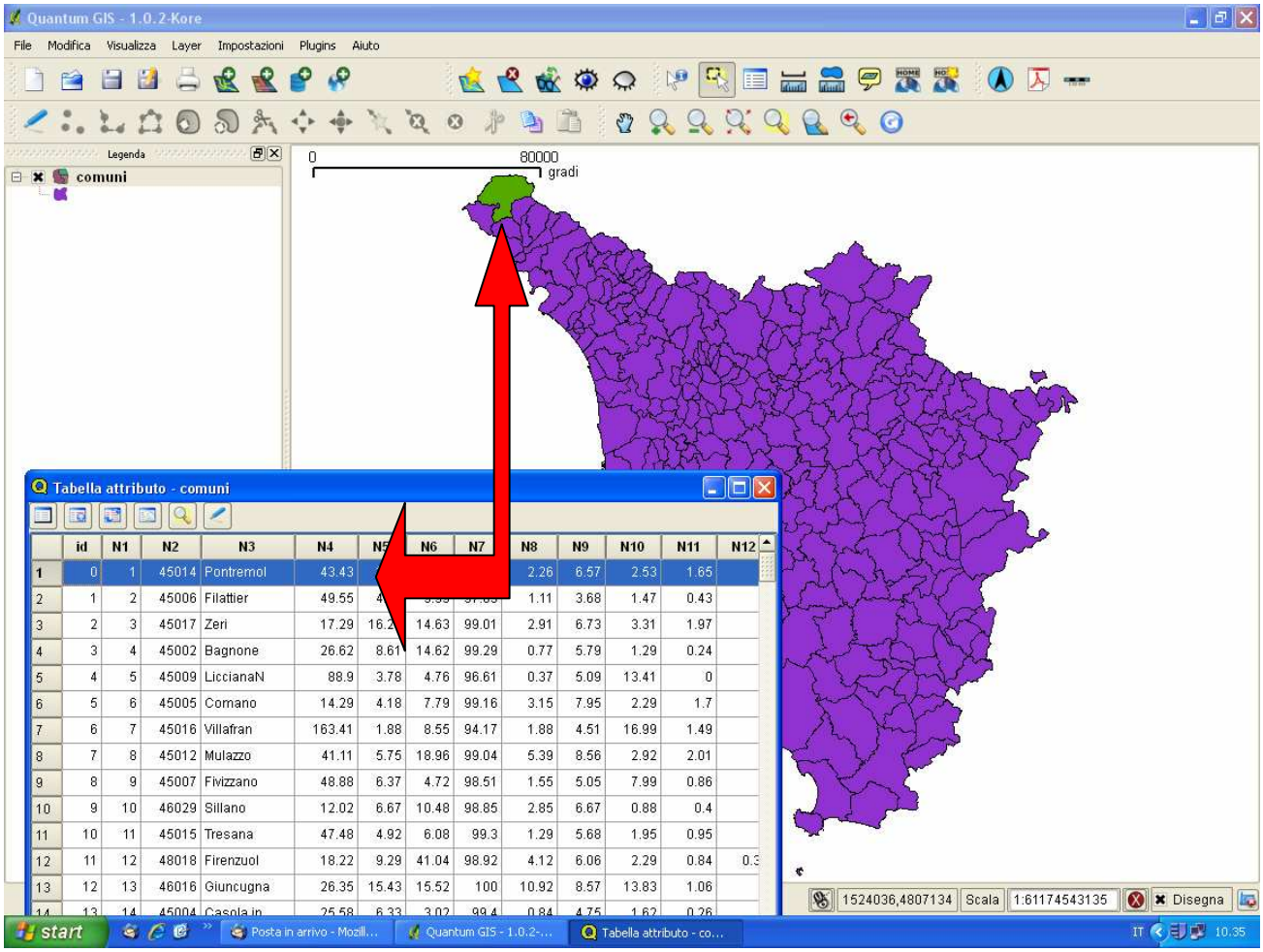
complexity, steep learning curves, training costs, and special requirements. So, if quality of OSGS is improving with the strong and free collaboration between a large number of developers from all around the world, the proliferation and circulation of them is growing consequently to the low costs of implementation.

For these reasons, and probably for many others, the development of OSGS has experienced a boost over the last few years, even in the field of desktop GIS. It is not our aim with this article to provide an overview on GIS projects which develop and maintain different desktop GIS[2]. On this section we introduce those functionalities of OSGS which can be helpful for business, convinced that on reliability, performance, scalability, security and total cost of ownership they are today as good as its proprietary competition, and under certain circumstances, they are a superior alternative to their proprietary counterparts.

The OSGS runs on personal computer and in many ways they are similar to other database program as they analyse and relate information stored as records but with a crucial difference: each record in an OSGS database contain information used to draw a geometric shape (single part of a shape file) which usually is a point, a line or a polygon. That shape represents a unique place on this earth to which a variable number of data are linked. In other words, a record in a GIS describing a "where" (in figure 1 the municipality of Pontremoli in Tuscany – Italy) including not only fields of text and numeric information (name, area, population, number of firms, etc.), but also fields of spatial data enabling the computer to draw Pontremoli as a boundary of a certain size and shape. We can consider an OSGS as a spatial database that, not only stores and displays information about locations, but also link location and information, depending by the query that we want to run.

[2] For this aim you can refer to Steiniger and Bocher, 2009; Reid and Martin, 2001; Mitasova and Neteler 2004

Figure 1 Records in a map file

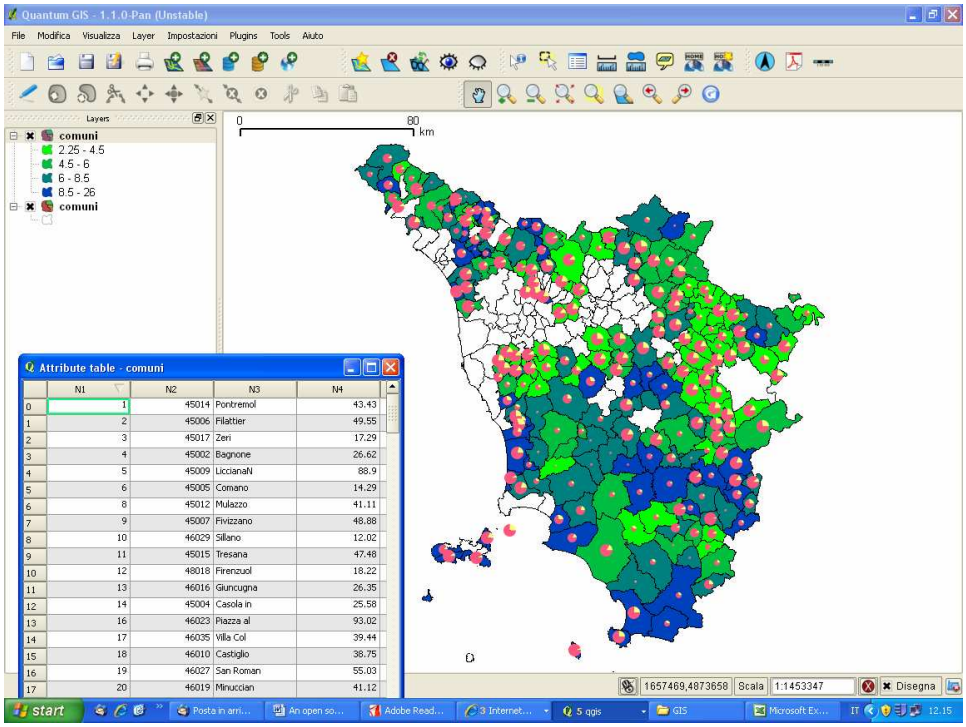


The possibility to show on a map the results of a query is an important step of any research, even in business. The visualisation of information give us an additional chance for analysing events that are located in geographical space: that's why, for example, human scrutiny is still the best to analyze and render satellite and aerial photo in the era of massive computing capability.

As a diagram (plot, scatter, flow charts) allow us to visualize and consequently to analyse quantitative information included in a table of rows and columns, an OSGS offer us the opportunity to see them in the form of a map. The difference is not only aesthetic but it is conceptual cause the way we see data has a profound effect on the connections we make and the conclusions drawn from it (Boyles, 2002). With an OSGS the users can represent the data in any field of a map view: through different shades of colours, as symbol of different size. If information in the file is changed or it is changed the query

the display on the computer is automatically updated. And if the user need to visualise different information on the same map that is possible thanks to plug in as "diagram overlay" or simply adding multiple layers of data to the same display. This let every user create a map as rich as the data base will allow.

Fig. 2 A typical map with diagrams overlaid



To be honest, those functionalities above mentioned, are available in any kind of GIS, even in the commercial ones. To get the value added of OSGS' compared to other GIS, in addition to the free price, it is necessary to consider interoperability.

Through the 1970s and the early 1980s, most GIS were considered islands of information. They were self-contained independent systems where spatial data were manually digitalised and rarely acquired from digital source. The advances in information technology and the growing demands from GIS users to overcome the bottleneck and costs of data capture, led users to share data by transferring them from one system to the other, using either special purpose translators or a neutral format such as shape files. In any case the transfer was batch-oriented as the entire data set was converted and transferred on the file level, in the beginning via physical means and recently electronically (i.e. through Internet).

In more recent years, users began to realise the inefficient redundant data provided by the batch oriented approach and realised the need for interoperability, to connect together in a web different GIS, in order to transparently exchange data and access to services (Bishr, 1998). Interoperability could be considered as a form of a system intelligent that improve the cooperation between different information systems.

Today, research on interoperability solutions is the way to migrate away from a non cooperative system as it is the GIS market (Sondheim et al, 1999). The need to share geographic information is well documented (Bishr, 1999; Laurini, 1998; Sheth et al., 1999; Abel et al., 1998).

One important initiative to achieve GIS interoperability is the Open GIS Consortium (OGC), which is an international industry consortium of 384 companies, government agencies and universities participating in a consensus process to develop publicly available interface standards supporting technology developers to make complex spatial information and services accessible and useful with all kinds of applications. Nevertheless, data standardization is not the whole solution if an open standard is not even free. In fact, if we need to implement a standard in a software or in a web GIS it will be necessary to pay an amount, even if a small one, proportional to the number of copies circulating, but this doesn't help interoperability at all. Even on desktop GIS there are some OGC standard compliant (i.e. ArcGIS Desktop) but there are not free. Besides, the OGC has been created by the Open GIS Foundation, previously named Open GRASS Foundation, when the foundation re-focused on interoperability. GRASS (Geographic Resources Analysis Support System) is an OSGS supporting and founding its place in the Open Source and Free Software community.

Other desktop GIS, such as QuantumGIS (QGIS) are OGC standard compliant, are OSGS distributed for free and they can be used as a cross-platform for many other common GIS features and function that share the same free software philosophy. Some of the supported format by QGIS are:

- spatially-enabled PostgreSQL tables using PostGIS and SpatiaLite,
- most vector formats supported by the OGR library, including ESRI shapefiles, MapInfo, SDTS and GML,
- raster formats supported by the GDAL library, such as digital elevation models, aerial photography or landsat imagery,
- GRASS locations and mapsets,

- online spatial data served as OGC-compliant WMS or WFS.

It is clear that OSGS, as they are "open" to share knowledge, functions, library and so on, they naturally operate for a real interoperability between them. In the last few years (i.e. QGis project was officially born in May of 2002) the OSGS had a boost in number and quality of projects, so to enhance the proliferation of GIS users, especially between small or public organisation such as local and Regional Government, University, Regional Agency and so on. In every case their low cost of implementation will be a support for any kind of firm in attending their spatial strategy of growth and marketing.

3. GIS based strategies for firms

Most data available in a company have a spatial dimension. Consequently, in a dynamic perspective, even decisions in marketing and management often have a spatial dimension. Dealing with such data means dealing with a full range of information which are difficult to handle with conventional methods. For this reason, proportionally with the amount of information daily handle, the use of GIS has become strategic for a full range of firms, in every economic sectors. Specifically, if locational attributes are an important source of information for business strategies, GIS provide a unique set of techniques and methods for analysing events that are located in geographical space.

This is the reason why the most important international marketing companies, such as Nielsen and GfK, provide tools for managing business information. For example, those tools can support companies on importing customer and sales territory data and visualize it on maps or to analyse structure sales territories to ensure optimum accessibility. In the case of new business those tools lets you precisely determine the market potential on a region-by-region basis and they plan and evaluate all aspects of an existing and potential locations. They offer many other applications, proportionally with the range of geospatial data bases that they include in the tool. In conclusion they simply sell information in an easy way to be used, and their strength is probably the large amount of information included in those products so that, in a certain point of view, they sell a database.

Everyone working on applied researches is aware about the lack of statistical data, especially on spatial data bases to support every kind of spatial analysis, but on this

paper we are not focused on this problem, as our aim is to consider OSGS as a tool for spatial analysis supporting firm managements. Many times companies have information, internal of external the company itself, but they have not tools and even skills to manage a large amount of statistical data. On this perspective we must include even local policy makers, as they do not use every time spatial analysis with OSGS to support their decision (Ashby and Longley, 2005). In other words a GIS based strategy is recommended to every decision maker, private or public, operating on a spatial context, called to answer to questions starting with "where", as for example, "where to find potential customers" or "where to open a new office/shop", but even "where localize a new hospital" or "where are citizens with those social characteristics" and so on.

A typical example of GIS supporting decision maker is that of "geodemographics", which can be considered as an application of taxonomic principles to small neighbourhood areas (usually post code areas) with the aim of developing scientifically valid intelligence about issues such as socioeconomic composition, consumption habits and attitudes to public service provision. The geographic dimension to such classification is inherently important from the end user perspective, that can be the private and the public sector, since it is key to meeting the preferences of consumers of private goods and the needs of citizens for public sector facilities (Singleton and Longley, 2009).

Anyhow an OSGS to be implemented doesn't need only IT skills but even "know how" on spatial analysis. As a consequence, geography (and geographers) can have an important role in supporting firms, offering them a full range of applications (IT and spatial analysis) as well as education and training. This is not for the future, this is today, as many geographers already use GIS to provide support in private or public decision makers (Murray and Tong, 2009). Still, the private sector hasn't traditionally offered many sources and jobs for geographers, but location-based services, mapping and the "geographic management systems" are changing the field (Gewin, 2004).

On the other hand, OSGS can help GIS to become a widespread tool, within the firms and the policy makers, and not, as it is today, a niche tool, used only by skill operators. It is apparent that OSGS, more than commercial GIS software, makes it more accessible and easy to examine spatial information. This is particularly through in the Developing Countries (DC) where generally, GIS is considered to be a top-down and elitist approach, which can disempower disadvantaged groups and further distance them from the decision-making process (Wang et al., 2009).

3.1 A GIS based strategy for the inland terminal of Guasticce (Italy)

The Department of Economic Sciences in Florence (Italy) has been applying a Laboratory of Economic Geography since three years, where students learn on the use of OSGS and on their possible application in the field of social sciences researches and in firm management. Some firms revealed to be interested in OSGS application and they asked to the Laboratory of Geography to support them in specific choices "spatially dependent". One of this firms manage the inland port of Guasticce in Livorno (Italy).

The inland terminal of Guasticce in Italy is very closed to the Port of Livorno so that it can be considered a satellite terminal as it accommodate additional traffic and serve functions that, due to the lack of space, are not possible at the port. It works even as freight distribution cluster (load center) for goods and material, usually moved with containers coming from or going to the port. It is provided of transmodal facilities so to be linked to large systems of freight circulation either through the same mode (i.e. rail-to-rail but more frequently truck-to-truck) or through intermodalism (i.e. rail-to-truck).

Considering the life cycle of this particular infrastructure (Rodrigue et al., 2009), after the planning, the setting of the facilities has taken place, even if in different expansion stages and some of them are still under construction. In the last three years the inland terminal of Guasticce has quickly developed its market potential and several new users decided to locate in the terminal, even if part of the development zone is not yet occupied. This is the reason why the management was interested in a spatial analysis of geomarketing focused on exploring new customer potentiality and, consequently, new geographical areas to be served by the inland port.

The management was interested in exploring those sector that are already served by the infrastructure and particularly the traffic of cellulose, as a consequence that the Port of Livorno is a national hub for this kind of goods.

Tab. 1 Traffic of goods through the inland port of Guasticce

Goods	In (%)	Out (%)
Wood	27,73	29,84
Fruit	9,72	10,45
Drinks	27,14	22,48
Cellulose	30,97	33,64
Food	2,42	2,22
Iron	0,99	0,72
Rubber	0,23	0,29
Porphyry	0,05	0,05
Chemical	0,74	0,32

Source: Interporto Toscano S.p.a., 2009

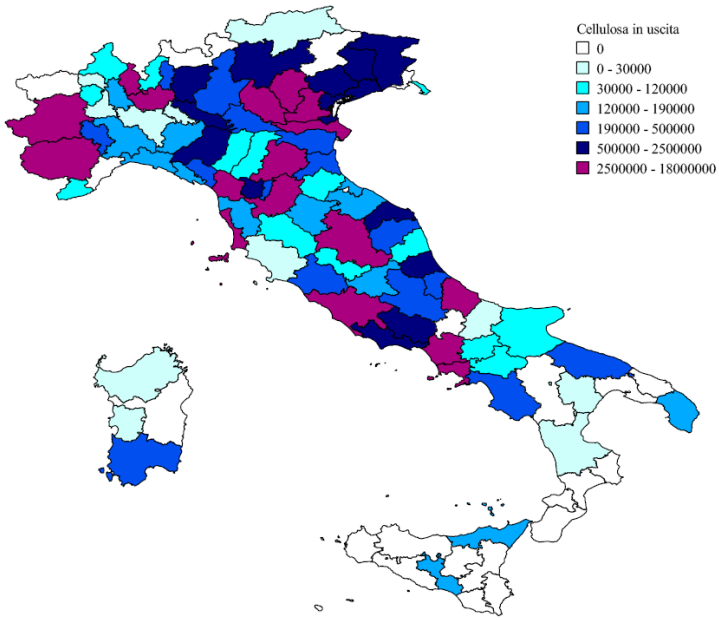
Due to the availability of a rich data base, which is a consequence of an IT project started in 2006 called Trace, it has been possible to carry on a spatial analysis on geographical origin and destination of goods in the inland port. With the Trace project it has been possible to set up a data base focused on every truck entering and going out the infrastructure. Specifically, it has been collected for every truck transiting:

- the origin (province) and destination of every truck (country for international transport);
- typology and weight of goods;
- port of origin and destination;
- inland port of origin and destination.

The spatial analysis with the OSGS tools had two different stage: first the analysis of the Trace data base on the cellulose sector related to the existing flows (in/out) in the inland port in tonnes, second, matching those results with the geographical structure of the cellulose sector in Italy in terms of sales.

The results of the first stage (analysis of the Trace data base) were particularly interesting for the destinations of the cellulose transiting in the inland port (see fig. 3), while the entering tonnes of goods were originated almost entirely by the near Port of Livorno.

Fig. 3 Destinations (province) of the cellulose transiting in the inland port in tonnes



As the Port of Livorno must be considered a national hub for the entering cellulose, the inland of Guasticce serve almost the entire Italy, with the exception of some South provinces and the two islands (Sardinia and Sicily).

The second stage of the spatial analysis considered, in terms of sales, the location of firms using cellulose in their production process. For this aim we used the AIDA database and we had to consider two ATECO sector using cellulose in their production process: production of paper products (ATECO code 17.2) and production of pulp and paper (ATECO code 17.1).

Fig. 4 Sales per province in the ATECO sectors "production of pulp and paper" (17.1)

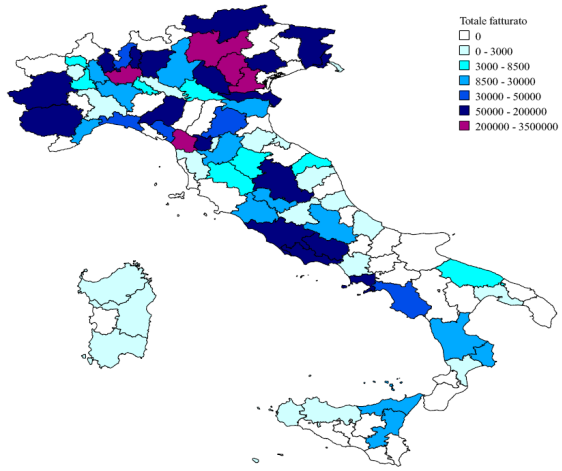
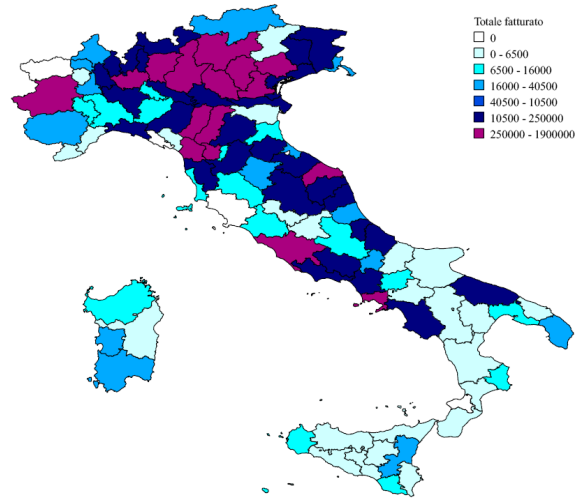


Fig. 5 Sales per province in the ATECO sectors "production of paper products" (17.2)



Matching the two steps of the spatial analysis we have been able to localise those province potentially interested by the service of transport of cellulose but not yet well served by the infrastructure. This information can be very precious because the management is able to concentrate his marketing activities in those areas and specifically in contacting those firms (the AIDA database include the name of firms).

According with the management of the inland port, it has been decided to go on the spatial analysis, tracking down the entire production chain of cellulose, upstream and

downstream the inland port. It has been necessary to point out the name of final destination firms and the international origin of the cellulose and, fortunately, all these information are included in the transport documents.
Specifically, the further spatial analysis revealed that more than 70% come from three countries: Brazil, U.S. and Canada. The firms providing cellulose through the inland port are usually big industrial groups operating internationally that could be interested in having a warehouse in the inland terminal. On the other hand, about final destination of cellulose, the further survey revealed a certain number of firm customers of the inland terminal, corresponding to a specific target of firms. Those precious information allowed us, matching the target with the AIDA data base, to draft a list of firms potentially interested in to be served by the inland terminal. As a consequence of all the information revealed by the entire spatial analysis, the inland terminal management is considering the idea to manage themselves a load centre for cellulose, without any third part, buying from international producers and selling to national and local users. As an alternative choice they are contacting those international producers offering them to be localised in the inland port.

Conclusions

In this paper we have explored the opportunities of OSGS for firms and, consequently, the role that geography can play in a new interaction process with firms. A GIS based strategy for firms is a Geographical Information System designed to provide useful location-based functions to support management decisions.
We argue that geography is faced to a crossroad: to open its large expertise and make it available to the society (firms and institutions), in a typical interdisciplinary perspective, or continuing to complain about the marginal position in the academic panorama, focused in representing itself, and "spending large amounts of time considering histories of the discipline, circulating through the same old conferences and thereby generally confirming geography's presence as themselves" (Thrift, 2002, p. 295). Nowadays a discipline cannot work by attempting to consolidate its own territory because there are just too many other disciplines interested in its domain and, even if firms are asking for a particular kind of knowledge, very related with geography, they will listen to those

answering and not to those concerning. Geography, in a lack of humility, as many other academic disciplines, has considered supporting firms decision as a practical application, not adequate for academic minds.

Even the world of GIS is faced to a crossroad: to be useful to a strict niche of skill operator or to become an analytic tool available for a large number of firms and institutions. On this way the OSGS are a great opportunity to make spatial knowledge accessible to a large number of subjects. Even more today that OSGS are as good as its proprietary competitors, and under certain circumstances, they are a superior alternative to their proprietary counterparts.

On this perspective of "open knowledge" (in academy and in software), we are convinced that geographers, with the support of OSGS, can carve out for themselves an active role in supporting firms (and policy makers) in their management decisions, especially those based on spatial analysis. As geography is unusual in the sense of large expertise it houses, the critical issue is what kinds of virtue can be created from such richness (Clifford, 2002), with ambition and general adventurousness in the sense of Thrift (2002, p. 295).

In this paper we have explored the role of geography in supporting GIS based strategies for firms and the case study is just an example - among a large range of possible applications - of a spatial analysis with OSGS for firms. In this case the Laboratory of Economic Geography in the University of Florence (Italy) has been called to support a firm strategy with a spatial analysis. It has been tracked down the entire production chain of cellulose worldwide, upstream and downstream the inland port. The results of the spatial analysis consist in a list of companies potentially interested in having a localisation in the infrastructure or, eventually, to become a new customer using the services already offered by.

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