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VALIDATING THE EKD4SFCA METHOD USING DATA OF THE LONG-TERM CARE SECTOR

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Abstract

This paper builds upon previous work presented on the Advances in Business-Related Scientific Research Conference 2013, in Rome, "Identifying Target Geographic Areas for New Market Entrants" (Polzin et al., 2013). It presents a case study that validates the Extended Kernel Density 4-Step Floating Catchment Area (EKD4SFCA) method that was adopted to identify the target markets for entrant firms.

More specifically, it applies the method in a construct validity exercise, based on the analysis of sensitivity to change, documenting changes on the measures of interest after an intervention. We test the sensitivity of the results produced by the EKD4SFCA method to

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change caused by a hypothetical intervention, namely the introduction of a new facility, owned by a new competitor in the market.

The results indicate that the method attains construct validity, such that it behaves as it is expected when changes in the data occur.

Keywords: Spatial analysis, Competition assessment, Long-term care, Public financing of care provision

Topic Groups: Research methods, Industry, area or region specific studies, Organizations and financing

1. INTRODUCTION

The EKD4SFCA method presented for the first time in Polzin et al. (2013) is a 2SFCA-based method that incorporates the Herfindahl-Hirschman Index (HHI) and a dominance identification method in the Extended Kernel Density 2-Step Floating Catchment Area (EKD2SFCA) method (Polzin et al., 2014), combining access analysis with competition assessment in an innovative way.

As we recall, another innovation embedded in the EKD4SFCA method is the adaptation and extension of the HHI index and of the dominance identification method of Melnik et al. (2008) for their application with small geographic units, a distance decay function and floating catchment areas. In particular, the widely known HHI is adapted to be calculated without fixed, predefined geographic boundaries, but with floating isochrones constructed with small geographic units. This way, fine spatial resolution results can be obtained, providing more detailed information for decision making and strategic geographic positioning of facilities or supply points.

The EKD4SFCA method enables the detection of geographic areas to improve the access of their residents to facilities and the identification of targets for new facilities, making it possible for business organizations to enter a market with a reduced risk of having to deal with entry barriers and fierce competition of incumbent firms.

Another use of the method, as seen in this new paper, can be to improve the allocation of public financing to firms, in order to improve the access of populations to products and services with scarce supply, and to identify where public admainistrations can explore competition between firms to attain more efficient publicly financed prices. Public bidding for contracting firms in competitive markets identified with the EKD4SFCA method can profit from the existing competitive pressure to establish lower prices than it would be possible without competition.

The objective of this paper is to assess validity of the EKD4SFCA method. We present a case study using data of the Portuguese long-term care sector. In this case study, we test the sensitivity of the results produced by the EKD4SFCA method to change caused by a hypothetical intervention in the data.

2. THEORY

2.1. Access analysis

We consider access as the ability of a population to use health care, while access barriers or facilitators affect this ability (Gulzar, 1999). There are two approaches for access to health care analyses: the realized access approach, which focuses on utilization patterns, and the potential access approach, which considers the potential barriers to utilization and measures access as potential utilization (Cooper et al., 2009; Joseph and Phillips, 1984). This paper focuses only on potential access analysis.

Potential access refers to barriers to health care utilization and is defined as the presence of enabling resources, which are resources that are required for utilization to take place (Andersen, 1995; Higgs, 2004). The analysis that considers enabling resources can identify deprived populations, that is, populations that face potential access barriers.

2.2. Competition assessment

Many studies, reports and competition authorities' guidelines establish that competition between business organizations (companies or firms) promotes productivity and efficiency. Among other benefits for industries, firms, markets and consumers, competition has been proved to spur innovation and to improve the quality of the provided products and services (CC, 2013; EC, 2004; Gaynor et al., 2012; Ikkersheim and Koolman, 2012; Motta, 2004; OECD, 2011, 2012; OFT, 2007).

The degree of competition in a market is indicated by its market concentration. Market concentration metrics capture the market structure and its calculation depends on the number of firms that are active in the market and their respective market shares. Hence, the measurement of concentration at different time moments can reflect changes in the market concentration as a result of firms' entries, exits and mergers.

Excessive market concentration reflects weak or lack of competition and may produce negative effects, such as, for example, excessively high prices, low quality products, diminished variety of products, inexistence of freedom of choice, restricted access of firms to essential resources or infrastructure, and predatory pricing (CC, 2013; EC, 2004; Gaynor et al., 2012; Ikkersheim and Koolman, 2012; Motta, 2004; OECD, 2011, 2012; OFT, 2007).

In highly concentrated markets, entrants typically have to face a high initial investment in the supply capacity and sometimes also high advertising costs, in order to be able to compete with the well-established incumbents. Besides, these highly concentrated and weakly competitive markets can be dominated by incumbent firms, who can make entry unprofitable or unsuccessful.

A firm can only be dominant if it has substantial market power, and firms usually have greater market power, that is, they face less competition, in more concentrated markets (Nakamba et al., 2002).

Competition assessment is used to evaluate if there are competition risks in a market.

2.3. Validity

According to Messick (1990), validity can be defined as "an integrated evaluative judgment of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of interpretations and actions based on test scores or other modes of assessment" (Messick, 1990, p. 1). However, there is no consensus on how to assess validity. As Kaplan et al. (1976) notes, "because of the uncertainties, judgments, and assumptions that are required in assessing the correspondence between an operational measurement and a conceptual variable, different researchers have proposed many different methods – labeled with many different names – to assess validity" (Kaplan et al., 1976, p. 479).

Notwithstanding the fact that there are uncertainties, and subjective judgments and assumptions involved in the validation process, which inevitably influence the choice of the assessment methods, the most common types of validity found in the literature are content, construct and criterion validities (Haynes et al., 1995; Kaplan et al., 1976). In this paper, we verify the construct validity of the EKD4SFCA method. Construct validity is the degree to which the variance of the results of a method is consistent with predictions from the construct targeted by the method (Haynes et al., 1995).

Responsiveness or sensitivity to change is the kind of exercise that constitutes the most convincing evidence of construct validity (Burlingame et al., 2006; Vermeersch et al., 2000). This is because, in order to attain construct validity, it has to be shown that the method produces results that it is supposed to produce and that it detects real change in results, whether the change is induced experimentally or naturally (Hays and Hadorn, 1992).

Accordingly, we apply the EKD4SFCA method to data of the Portuguese long-term care sector, using number of beds as the main supply variable, instead of number of physicians, as in Polzin et al. (2013). We study the responsiveness of the method to the inclusion of a new facility. More specifically, we analyze what occurs with the introduction of the new facility and if the changes captured by the method reflect that what it was supposed to capture, in order to obtain relevant information to conclude that the method is valid, according to the construct validity definition.

3. METHODS

As in all 2SFCA-based methods, a geographic information system (GIS) is required for the application of the EKD4SFCA method. The GIS supplies the speed limit maps, the traffic rules and the centroids of the postcode areas needed to compute the travel times and to define the catchment areas.

The method is applied in four steps, as explained in Polzin et al. (2013). As we recall, the access analysis is carried out with the steps 1 and 2 of the EKD2SFCA method. The competition analysis is integrated as steps 3 and 4 of the EKD4SFCA method, involving the calculation of market concentration degrees, with the HHI, and the application of the market dominance identification method, respectively.

The first and second steps of the EKD4SFCA method are, respectively:

(1)

$$R_j^E = \frac{S_j}{\sum_{k\in\{d_{kj}\leq \mathbf{d}_{\max}\}} P_k H_k g(d_{kj}, \mathbf{d}_{\max})}$$

and

(2)

$$A_i^E = \sum_{l\in\{d_{il}\leq \mathbf{d}_{\max}\}} R_l^E Com_i g(d_{il}, \mathbf{d}_{\max})$$

where R_j^E is the supply-to-demand ratio of the method for the supply point in *j*, S_j is the number of beds of the supply point georeferenced at *j*, P_k is the population of the geographic unit georeferenced at *k*, H_k is the health needs score of the population at *k*, d_{kj} is the travel time between *k* and *j*, d_{max} is the maximum travel time, $g(d_{kj},d_{max})$ and $g(d_{il},d_{max})$ the distance decay function (quartic function, applied only after an initial catchment with no evident proximity barrier), is the sum of the step 1 ratios associated to the supply points that

$$\sum_{l\in\{d_{il}\leq \mathbf{d}_{\max}\}} R_l^E$$

are within reach of the population at *i*, Com_i refers to the commuting score of the population at *i*, and, finally, A_i^E is the access score computed by the method for *i*, namely the overall access score of the population that resides in that unit.

Steps 3 and 4 are the calculation steps that refer to the inclusion of the HHI and the method of Melnik et al. (2008), but adapted to be calculated with catchment areas and small geographic units, and extended with the inclusion of a distance decay function, as described by equations (3) and (4), respectively:

(3)

$$HHI_i = \sum_{G=1}^{N}\left[\sum_{l\in\{d_{il}\leq \mathbf{d}_{\max}\}} Q_{Gl} g(d_{il}, \mathbf{d}_{\max})\right]^2$$

(4)

$$Q_i^D = \frac{1}{2}\left\{1 - \left[\left[\sum_{l\in\{d_{il}\leq \mathbf{d}_{\max}\}} Q_{1l} g(d_{il}, \mathbf{d}_{\max})\right]^2 - \left[\sum_{l\in\{d_{il}\leq \mathbf{d}_{\max}\}} Q_{2l} g(d_{il}, \mathbf{d}_{\max})\right]^2\right]\right\}$$

where HHIi is the HHI calculated for the geographic unit i, G refers to groups of business units, namely the organizations that own the business units (G=1 is the largest group, G=2 is the second largest group, and so on, until the smallest group competing in the market i,

$$\sum_{l \in \{d_{il} \leq \mathbf{d}_{\max}\}} QS_{Gl} g(d_{il}, \mathbf{d}_{\max})$$

namely *G*=N), refers to the market share of the group G with business units that have catchments covering *i*, $g(d_{il}, \mathbf{d}_{\max})$ is the quartic distance decay function (applied only after an initial catchment with no evident proximity barrier), and Q_i^D is the dominance threshold for *i*.

Steps 3 and 4 are used in a similar way as proposed by McIntosh and Hellmer (2012), namely considering HHI over 2000 as a necessary condition and as a sufficient condition for

$$\sum_{l \in \{d_{il} \leq \mathbf{d}_{\max}\}} Q_{1l} g(d_{il}, \mathbf{d}_{\max}) > Q_i^D$$

eventually discarding the underserved geographic areas identified by steps 1 and 2 and considering the remaining areas as targets for public biddings to explore competition and set efficient prices for public financing.

4. CASE STUDY

Long-term care can be defined as it is defined by Law in Portugal (Law N. 52/2012, of 5 September), namely as the set of sequential health or social support interventions, centered on the global recovery, understood as the active and continuous therapeutic and social support process, which intends to promote autonomy by improving the functionality of the person that is in a situation of dependency, through his/her rehabilitation, re-adaptation and social and family reinsertion.

In Portugal, around 90% of all the people that are treated with long-term care, are treated in facilities of the National Network of Integrated Long-Term Care (*Rede Nacional de Cuidados Continuados Integrados, RNCCI*) (ERS, 2011). The RNCCI was created in 2006 by the Decree-Law N. 101/2006, of 6 June, with the aim of making more dynamic the implementation of financially sustainable care units and teams, directed to the people in a dependency situation. This network includes private and public providers and its objective is, more specifically, to improve access to technically and humanly adequate care provision of the citizens with loss of functionality or in a risk situation of losing it.

Demand for long-term care in Portugal can be characterized by the most frequent patient profile that is treated in the RNCCI. Patients are mostly elderly; women; married or widows; people that attended only until six years of school; people that have worked as non-qualified workers; dependent or incapable in terms of physical autonomy; supported by family, especially for hygiene and food; people that come from natural family or living alone; and people that have a medium or high risk of falling.

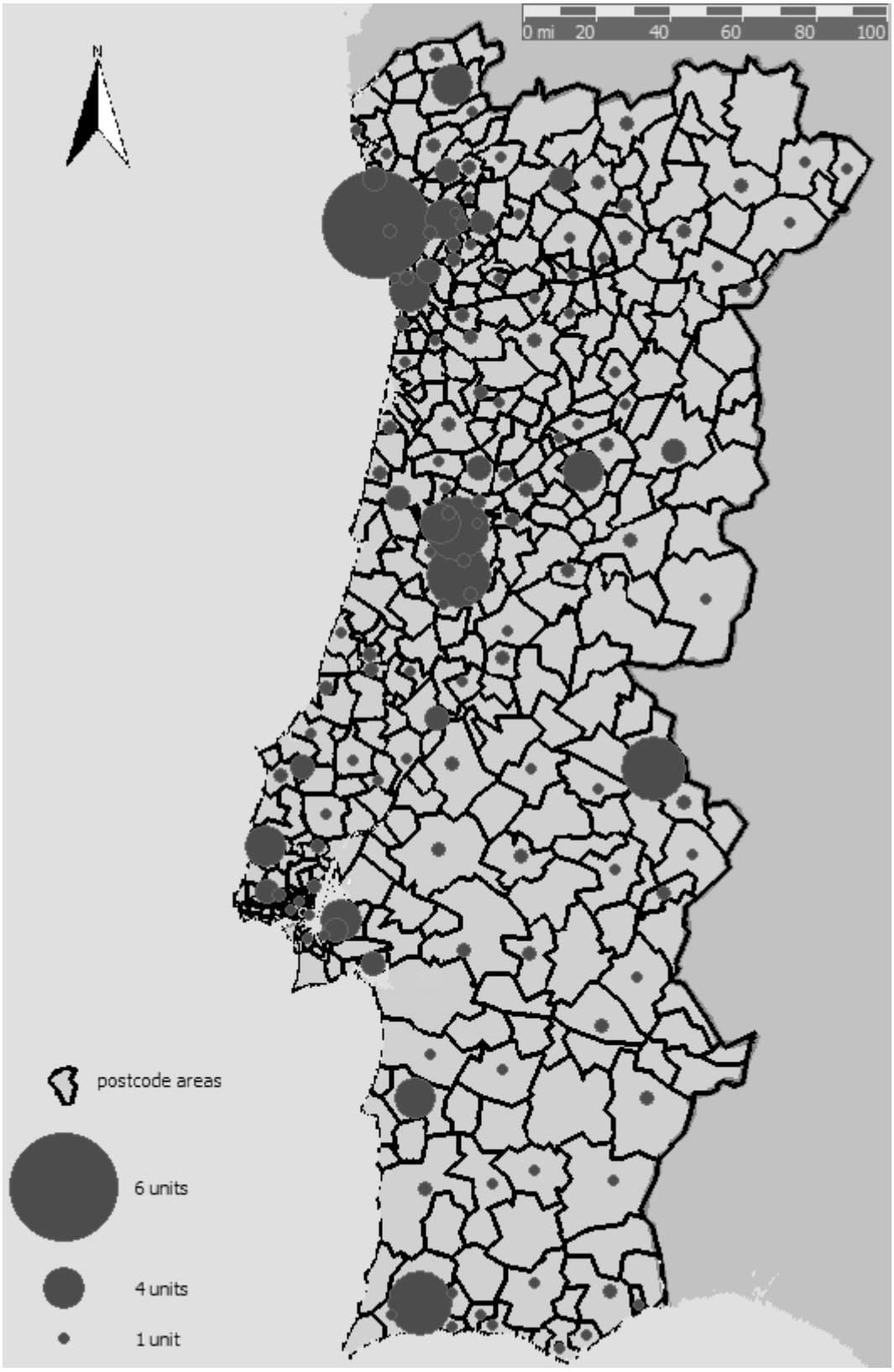
The strategic planning of the RNCCI was organized in three development phases considering originally a 10 years' time frame. Phase 1, between 2006 and 2008, had the aim of covering 30% of the existing needs. The second phase, between 2009 and 2012, had the target of attaining 60% of coverage. The third phase, from 2013 and 2016, was defined to attain the 100% coverage target, and this target shall be attained if the network of long-term care units gets to 15.308 beds in total (ERS, 2011).

However, in August 2012 there were still only 5.916 beds. Thus, the development process of the network is still ongoing, such that the application of the EKD4SFCA method can be useful to indicate the appropriate geographic distribution of supply, identifying deprived regions in terms of access, which shall be the priority regions in the evolution process of the RNCCI. Besides, since the EKD4SFCA method includes competition assessment, it can also indicate where public financing can profit from public bids, to set efficient prices. Until this moment, prices are administratively set (ERS, 2013).

4.1. Application of the EKD4SFCA method

While there are different kinds of long-term care supply teams and units, including different kinds of inpatient units, outpatient units, hospital teams and home visiting teams, our focus is the application of the EKD4SFCA method to all 268 long-term care inpatient units that existed in 2012, namely convalescence, medium-term and rehabilitation, long-term and maintenance, and palliative care, and we represent the supply capacity by the number of beds. Figure 1 presents the geographic distribution of the 268 inpatient units. The data set used in this paper consists of official data of August 2012 from the public unit that was responsible at the time for administering the network (*Unidade de Missão para os Cuidados Continuados Integrados*).

Figure 1: The geographic distribution of the 268 units



Steps 1 and 2: Access analysis

Regarding step 1 of the method, the health needs index was constructed considering variables that reflect the demand for long-term care, characterized by the most frequent patient. The following variables were considered: proportion of people aged 65 years old and above, age dependency ratio (the relation between the people aged 65 and above and the people with ages between 15 and 64), female population aged 65 and above, the proportion of widowers, and the proportion of people aged 15 and above without any level of education. In addition, as mentioned before, the supply capacity was measured in terms of number of beds, which can be considered a more exact supply metric than number of physicians, since it avoids multiple counting of resources, as in the case of physicians, who can work in more than one facility.

The results obtained with the five selected indicators satisfied the necessary criteria to construct an index with principal components analysis (PCA) using the first component: one factor with an eigenvalue greater than one (4.254) with a high percentage of the total variance explained (85.077%) and an adequate value for the Kaiser-Meyer-Olkin statistic (0.798).

In order to rescale the standardized health needs principal component scores, we applied the thresholds defined by Polzin et al. (2014). Accordingly, we converted the health needs standardized principal component scores from zero to one to the scale from one to 1.167, in a proportionate way, and the scores higher than one were transformed to values above 1.167, considering a linear extrapolation of the scale. The negative scores between -1 and zero were converted to a scale from 0.876 to one, and scores lower than -1 were rescaled to linearly defined values below 0.876. Applying these scale transformations in the validation exercise, we obtained health needs scores varying from around 0.79 to 1.70.

Finally, the commuting index in step 2 was the same as the one used by Polzin et al. (2014). Table 1 presents the distribution of the long-term care access scores calculated with steps 1 and 2 of the EKD4SFCA method across the three levels: low, medium and high. We used 60 minutes as the maximum travel time threshold, since this travel time was considered to be a reasonable maximum reference for palliative care, which is the kind of long-term care that values more proximity (Cinnamon et al., 2008; Schuurman et al., 2010).

Table 1: Distribution of the long-term care access scores across the three access levels

Statistic	**Cluster**		
	Low	**Medium**	**High**
Number of areas	100	236	124
Population covered (%)	23.1	60.1	16.8
Mean access score	0.22	0.49	1.31

The two bounds of the three access levels defined by the k-means clustering algorithm were 0.31 and 0.77 beds per 1,000 inhabitants. Hence, for scores until 0.31 we identified a low access level, for scores until 0.77 we identified medium access, and scores above 0.77 were high access scores. As can be seen in Table 1, there are 100 low access postcode areas with 23.1% of all population, with a mean access score of 0.22 beds per 1,000 inhabitants. As a

reference for comparison, we note that the targeted ratio of the RNCCI is 1.82 beds per 1,000 inhabitants.

Steps 3 and 4: Competition assessment

In steps 3 and 4 we used the supply capacity (number of beds) to calculate the market shares. It was possible to identify 309 postcode areas with high market concentration (HHI>2000), and 279 of them were dominated, including 44 of the 100 low access areas, as can be seen in Table 2. The low access areas are the selected areas to identify target markets, namely the low access areas that present the lowest risk of occurrence of competition problems.

Table 2: Results of the EKD4SFCA method

Competition assessment	**Low access areas**	**Pop. covered (%)**
Areas with HHI>2000 and dominated areas	44	6.3
Market targets	56	16.8
Total	100	23.1

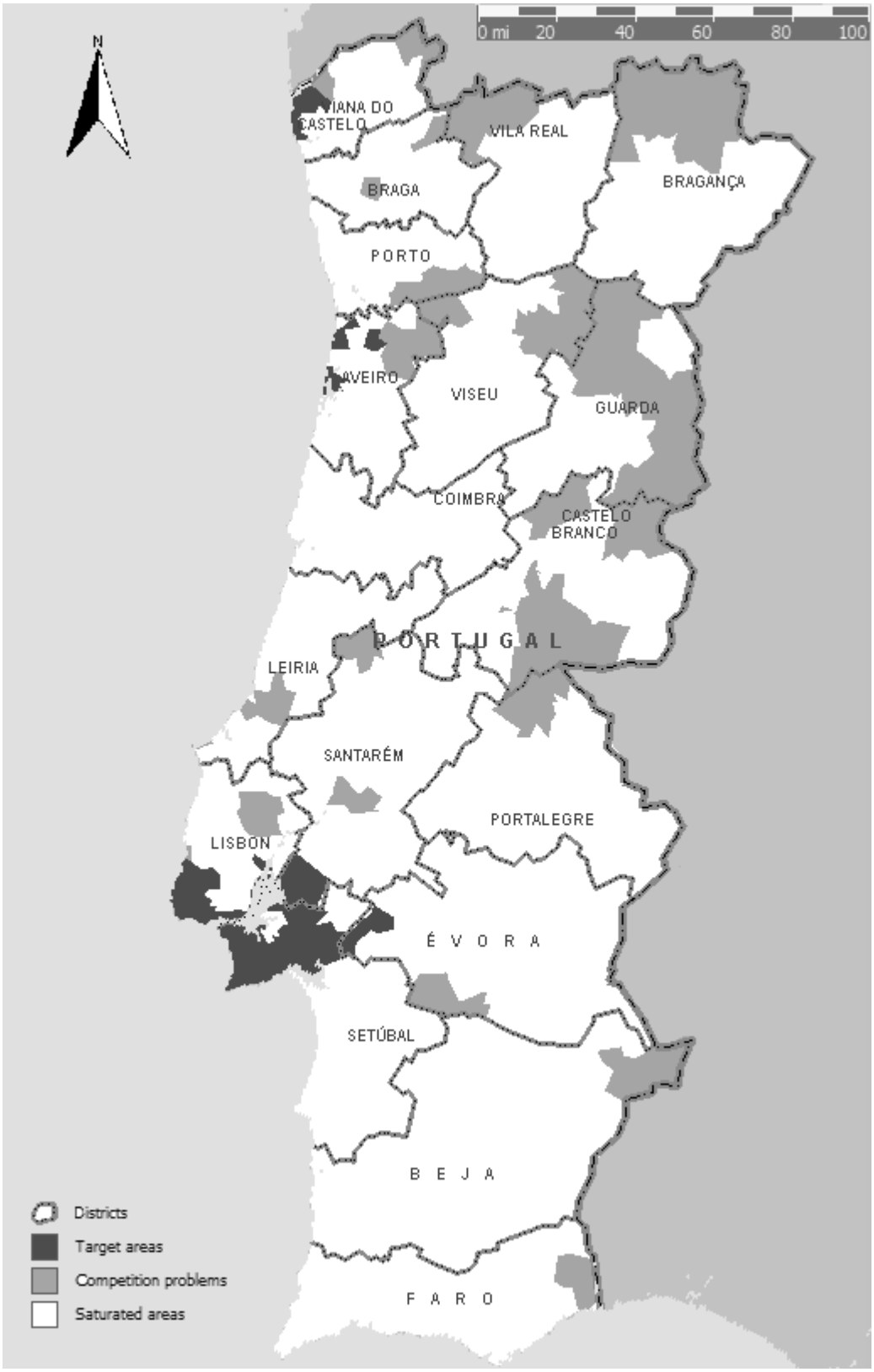
The remaining 56 areas are the market targets for public administrations to promote financing for new supply points.

These targets represent 12.2% of the 460 postcode areas, in 14 of the 18 districts of continental Portugal, and encompass a population that corresponds to 16.8% of the total population (almost 1,692,000 residents).

Figure 2 shows these results presenting the dark shaded areas as the target areas, the light shaded areas as the relatively underserved areas with potential competition problems, and the white areas as the areas that have the highest supply-to-demand ratios.

The target areas can be seen as target areas where public administrations can promote public biddings for contracting new providers and beds. More specifically, the application of the EKD4SFCA method in this case intends to identify where public administrations can explore competition between firms to obtain lower, more efficient publicly financed prices in public biddings, while at the same time promoting new supply to the most deprived populations.

Figure 2: Target geographic long-term care markets for promoting new financing



4.2. The introduction of a new facility

For the validation exercise to infer about the construct validity of the EKD4SFCA method we introduce a new facility with 40 beds in the target area of the Évora district, postcode area 7080, and analyze the changes that it produces.

Considering the variables and the calculations embedded in the model, we can expect the following changes:

(i.) The new competitor is a dominant competitor, such that the low access target area 7080 (dark shaded) becomes a low access area with competition problems (light shaded), if the new supply capacity (number of beds) is not enough to pass the threshold that separates the low access level from the medium access level (0.31 beds per 1,000 inhabitants), or a relatively high access area (white area), if the number of beds makes the supply-to-demand ratio pass the access level threshold (postcode area 7080 has an access score of 0.15 beds per 1,000 inhabitants).

(ii.) The new competitor is not dominant, then the target area continues to be a target area (dark shaded), if access remains low, or a relatively high access area (white area), if the access level rises to a higher level.

Regarding changes to other areas, we expect changes to all postcode areas covered by the new facility. These areas shall have their access scores increased, such that one or more of them can possibly increase their access level.

In terms of competition, the new facility, owned by a new competitor, shall increase competition, such that HHI values in surrounding areas shall decrease, and dominant areas can lose its dominance. However, if the new facility is an isolated area, far from other competitors, the closest areas shall suffer a decrease in competition, because the new competitor can become a dominant competitor in these areas, and will probably face weak competition from other firms in the areas that are closer to its facility.

We present next the results of the introduction of the new facility in postcode area 7080, where there was previously not any facility, and the responsiveness analysis. We begin presenting the access change and conclude analysis with the assessment of the change in competition.

Access change

After the introduction of the new facility, it was possible to identify access scores increases in 50 postcode areas of four districts, namely Évora, Setúbal, Santarém and Lisbon. This occurs because the 50 postcode areas are the areas that form the catchment area of the new facility. Following the logic, all the populations covered by the new facility get there access scores increased. Each population of the new facility's covered area has its access increased, because the step 2 calculation of the area considers now the new step 1 ratio of the new facility. The access scores of the populations that are not covered by the new facility do not change, because their available supply does not change.

The highest increase occurs in postcode area 7080, where the new facility is located, and it is an increase of around 0.46 beds per 1,000 inhabitants. As we identified, the higher the distance of the population from the new facility, the less its access score increases, and this is in accordance with the influence of the distance decay on access, which is duly captured by the method.

Focusing the analysis on the postcode areas that suffer access level changes (considering the two bounds of the three access levels defined by the k-means clustering algorithm, i.e., 0.31 and 0.77 beds per 1,000 inhabitants), these changes are somewhat perceptible when comparing Figure 3 with Figure 4 (see the districts of Évora and Setúbal), which present the results of the application of steps 1 and 2 of the method.

Figure 3: Access levels before the new facility' entry

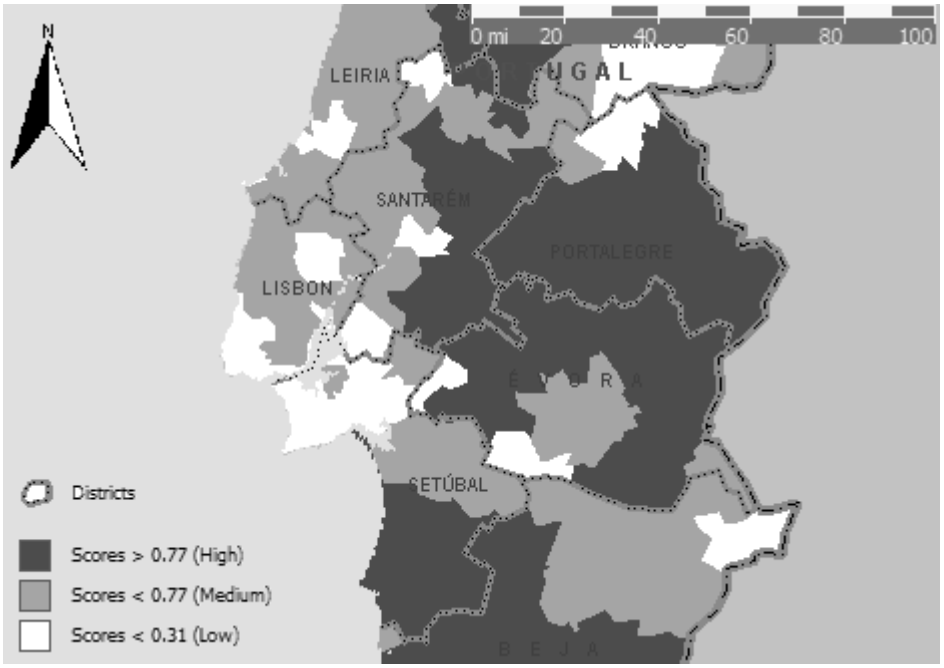
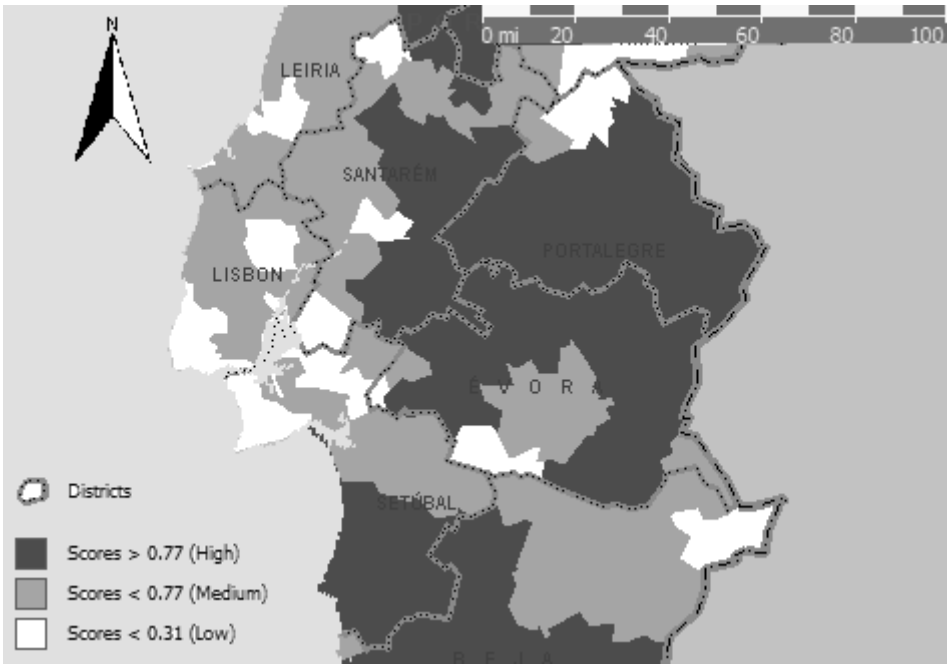


Figure 4: Access levels after the new facility's entry



When comparing the two figures it is possible to see that some regions in the districts of Évora and Setúbal change from white to light-shaded, i.e., low to medium access. These regions are formed by six postcode areas. The changes of the scores of these postcode areas and the identification of their corresponding district are presented on Table 3.

Table 3: Access score changes of the postcode areas that change the access level from low to medium (beds per 1,000 inhabitants)

Postcode areas	District	Access scores	
		Before	After
7080	Évora	0.154	0.612
2950	Setúbal	0.243	0.353
2910	Setúbal	0.231	0.311
2830	Setúbal	0.287	0.338
2840	Setúbal	0.307	0.358
2800	Setúbal	0.298	0.312

Considering these results, we understand that the method behaves as it should to measure the change to the potential access after the introduction of a new facility.

Competition change

We introduce a new facility of a new competitor in an area without other competitors in the Alentejo region, where it will face weak competition from other firms, and will have some influence in areas that are closer to its competitors. This way, we expect that the competition in the areas close to its competitors will present a stronger competition and, hence, lower HHI values and higher dominance thresholds. However, it is expected that the area where the facility is located will present higher HHI values, because this area shall be dominated by the new competitor. There shall be weak competition in this area from other competitors.

As we could identify, the areas that suffered changes in competition are the same 50 postcode areas that had their access scores changed.

The major changes are the change in postcode area 7080, with its highest market share now higher than the dominance threshold, and the change from high market concentration to medium concentration in the adjacent postcode area 2985 (see Table 4) – although, since this area was not dominated and remains not dominated after the change, this does not have an influence on the identification of target markets.

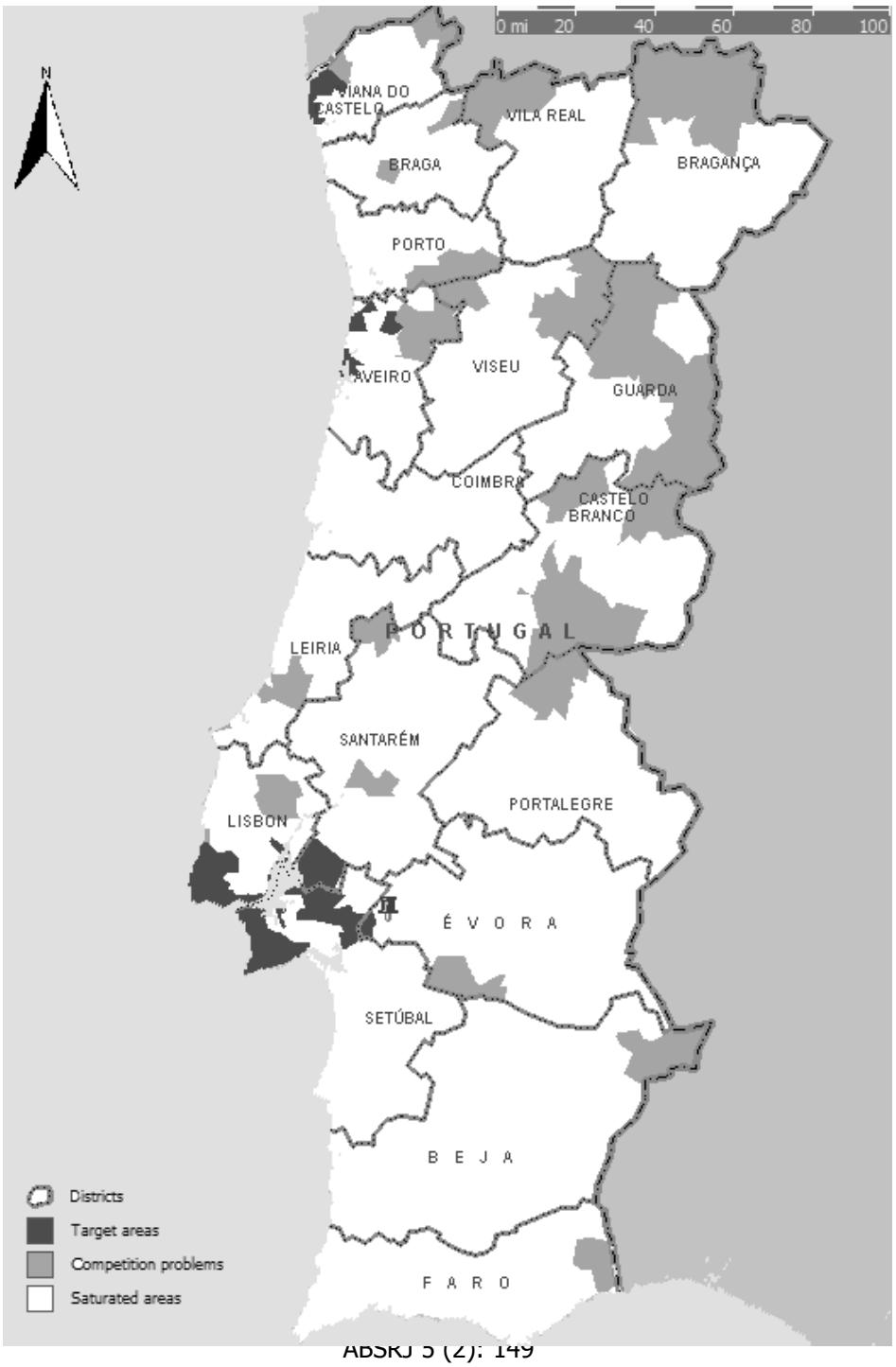
Table 4: Changes in competition

Postcode area	District	HHI		HHI change	Highest market share	Dominance threshold
		Before	After			
7080	Évora	2242.53	3038.01	795.49	49.7%	36.4%
2985	Setúbal	2427.63	1973.64	-453.99	29.7%	42.3%

To sum up, the identification of target markets is influenced by the six access level changes from low to medium. The competition changes do not affect the results of the method, because most postcode areas do not suffer changes in terms of market concentration level (low, medium or high) and the major change on 7080 does not influence the result, because this postcode area loses its status as a target market candidate, because its access level changes from low to medium.

Figure 5 presents the new target areas after the introduction of the new competitor's facility and also the location of this new facility, and the dark-shaded regions (target areas) that change to white.

Figure 5: New target areas after the introduction of the new competitor's facility



Considering these new results, the number of target areas decrease, such that a reduced set of postcode areas (the dark-shaded areas in Figure 5, compared to the results presented on Figure 2), should be targeted by public policy to increase financing to new supply to serve deprived populations. This new financing could be promoted by public biddings to set more efficient prices, profiting from the existing competition in the target areas.

We understand that the analysis of these changes presented in this subsection confirm the notion that the EKD4SFCA method is valid, according to the construct validity definition.

5. CONCLUSIONS AND IMPLICATIONS

This paper validates the EKD4SFCA method to identify target geographic areas, building upon previous work presented on the Advances in Business-Related Scientific Research Conference 2013, in Rome, "Identifying Target Geographic Areas for New Market Entrants" (Polzin et al., 2013).

To show how the method works, we present an application in the Portuguese long-term care sector in a case study. The fine-resolution results indicate that this method can be useful for government or public administrations that wish to identify in a precise way candidate regions to finance, such that access of deprived populations can be improved by promoting new supply, and exploring the existing competition between business organizations, such that efficient prices can be set in public biddings.

The exercise that we presented in the case study, of introducing a new facility, owned by a new competitor in the market, produced changes in results that we consider being in accordance with what was expected. This way, we conclude that the method attains construct validity.

We note that the new method can be adapted to be applied to any industry in which the consumers need to travel to supply points in order to obtain the relevant products or services and satisfy their needs. In particular, the health needs index introduced in our method can be substituted by an index that captures other populations' characteristics that may be of interest.

Finally, we note that a further enhancement that could be introduced would be the inclusion of the consideration of supply in Spain, close to the border with Portugal, to enhance analysis in these border regions.

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