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# Determinants of Competitiveness in European Regions: A Test of the Emerald Model

Murat Akpınar, Özge Can, Melike Mermercioglu

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**Abstract:** This study assesses the impact of the dimensions of the emerald model on regional competitiveness and contributes to the competitiveness literature in moving ahead to establishing causal links with its determinants. Data is collected from 2000 to 2011 for 97 NUTS-1 regions in Europe, and multiple regression analysis is performed. The results suggest that in the long term (eight-year time period) ownership attractiveness is the most influential dimension of the model, followed by talent attractiveness, educational attractiveness, R&D and innovation attractiveness, cluster attractiveness in technology & knowledge-based sectors, and environmental attractiveness. Cluster attractiveness in all sectors does not have a significant impact, while knowledge dynamics has a negative impact on competitiveness.

**Keywords:** competitiveness, emerald model, regional development, regional competitiveness, Europe

## 1 Introduction

Competitiveness has gained popularity among politicians, academics, policy makers, businessmen and the media despite some theoretical debates on its real meaning (Huggins *et al.*, 2014), misunderstandings about what it implies (Krugman, 1994; Porter, 2003a), and referrals to its different aspects (Stojčić, 2012). The International Monetary Fund (IMF), the World Bank, and the Organisation for Economic Co-operation and Development (OECD) have all been urging governments to reform their business climates to stimulate competitiveness, and the European Union (EU) identified the improvement of regional competitiveness as one of the primary pillars of its Lisbon Strategy (Bristow, 2010). It is widely argued that competitive regions deliver advantages for firms to succeed in global markets, to enhance the prosperity of their citizens, attract high levels of inbound foreign direct investments (FDI), and excel in exports of traded goods (Garelli, 2014; Porter, 2003b). Competitive regions display high levels of cluster development, which may have positive impacts on new business formation, employment, start-up survival, and salary growth (Delgado *et al.*, 2010; Porter, 2003b). A variety of competitiveness indices have been introduced to rank countries and regions, including the global competitiveness index by the World Economic Forum (Sala-I-Martin *et al.*, 2014), the world competitiveness ranking by the Institute for Management Development (IMD) World Competitiveness Centre (Garelli, 2014), and the world competitiveness index of regions by Huggins *et al.* (2014). In addition, the diamond model by Porter (1990) and the emerald model by Sasson and Reve (2012) have been used to understand the competitive advantages of countries and regions. However, competitiveness literature is yet to establish causal effects between the determinants of these models and competitiveness. This study aims to contribute to this need by testing the impacts of the dimensions of the emerald model on competitiveness with

the aid of longitudinal data from 2000 to 2011 obtained from 97 NUTS-1 regions in Europe. There have not been any attempts so far to test the extent to which each dimension of the emerald model has an impact on a region's competitiveness. This study is the first attempt in this direction and will contribute to the development of the emerald model and competitiveness literature. By identifying the more influential determinants of regional competitiveness, it will also help generate recommendations for European policy makers and regional development agencies. Thus the research question is: What are the impacts of the dimensions of the emerald model on competitiveness? In accordance with the argument that it may take from four to eight years before the impacts of regional initiatives are observed on competitiveness (Fritsch and Mueller, 2008; van Stel and Storey, 2004; van Stel and Suddle, 2008), multiple regression analysis is conducted taking into account time lags of five and eight years between the dependent and the independent variables. Running the model with different time lags will reveal how fast the impacts of the different dimensions of the emerald model are observed, and how sustainable they are in the long term.

The rest of the paper is organised as follows. Following this introduction, relevant literatures are reviewed, and the applied theoretical framework is outlined with its corresponding hypotheses in section 2. Following the description of the methodology in section 3, the results are shared in section 4. The paper ends with a discussion of results, practical implications, limitations of the study, and avenues for future research in section 5.

## **2 Theoretical Framework**

### *2.1 Competitiveness and its measurement*

Studies relate competitiveness to the productivity of local firms as well as to the importance of policies in creating and maintaining a competitive environment for firms (Kao *et al.*, 2008; Önsel *et al.*, 2008). It is defined as “the ability of producing goods and services that meet the test of international markets while simultaneously expanding the real incomes of its citizens” (Cho and Moon, 2005; Huggins *et al.*, 2014; Kao *et al.*, 2008; Porter, 1990) or “the set of institutions, policies and factors that determine the firms' productivity levels in a region” (Sala-I-Martin *et al.*, 2014). Improvement of the living standards is a common theme in competitiveness studies (Huggins *et al.*, 2014; Kao *et al.*, 2008; Porter, 2003a). The capability of firms to compete successfully in global markets depends on the efficiency of public institutions, the excellence of the educational, health and communications infrastructures as well as the political and economic stability of the home country and the region (Önsel *et al.*, 2008). As such, regional competitiveness has gained an emerging new role (Ketels, 2013), and interest has grown in the identification of its key determinants and in the policies to promote and foster them (Kitson *et al.*, 2004).

Competitiveness is a complex concept that cannot be captured with a single measure (Kao *et al.*, 2008; Lall, 2001). For instance, the World Economic Forum's global competitiveness index evaluates it with 12 pillars including institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labour market efficiency, financial market development, technological readiness, market size, business sophistication, and innovation (Sala-I-Martin *et al.*, 2014). Another commonly used index, the world competitiveness index of the IMD World Competitiveness Centre, analyses the factors of economic performance, government efficiency, business efficiency and infrastructure with

altogether more than 300 criteria (Garelli, 2014). Both methods have been criticised for having problems in their theoretical foundations (Lall, 2001; Önsel *et al.*, 2008; Stojčić, 2012), and not being applicable to countries with different characteristics (Cho and Moon, 2005; Jovan and Bradić-Martinović, 2014).

Annoni and Dijkstra (2013) argue that regions within a country have different characteristics, and hence territorial competitiveness, having a strong regional dimension, cannot be properly captured using national competitiveness indices. Therefore, regional competitiveness indices have been introduced to help regional authorities to compare the relative standings of their localities and devise policy strategies accordingly (Kitson *et al.*, 2004). Similar to national ones, most regional indices are also difficult to operationalise. For instance, the sub-regional competitiveness index by Huovari *et al.* (2001) has 16 variables and 15 indicators. The state competitiveness index by the Beacon Hill Institute (2013) and the EU regional competitiveness index by Dijkstra *et al.* (2011) are also complex applications as they are the regional adaptations of the global competitiveness index by the World Economic Forum. Other regional indices include the index by Benzaquen *et al.* (2010), the UK competitiveness index by Huggins (2003), and the world competitiveness index of regions by Huggins *et al.* (2014).

The diamond model evaluates the characteristics of the business environment through the analysis of factor conditions, local demand conditions, context for firm strategy and rivalry, and related and supporting industries (Porter, 1990). The model was further expanded to the double diamond model by including international activities and the foreign diamonds (Cho and Moon, 2005; Rugman and D’Cruz, 1993), and to the generalised double diamond model by adapting the analysis for smaller economies (Moon *et al.*, 1998). The diamond model in essence is complicated as the four drivers represent a diversity of sub-drivers, which are difficult to measure. For example, factor conditions assess the qualities of human resources, physical resources, knowledge resources, capital resources and infrastructure (Porter, 1990). Local demand conditions imply the segment structure of demand, existence of sophisticated and demanding buyers, anticipatory buyer needs, size of demand, number of independent buyers, growth rate of home demand, early home demand, early saturation, and the existence of mobile or multinational local buyers (*ibid.*). Equally challenging is the context for firm strategy and rivalry, covering the degree of domestic rivalry, management practices and approaches, orientations of firms toward competing globally, motivations of individuals, and commitments of capital and human resources (*ibid.*). Hence, the model is difficult to operationalise.

The overall problem is that there is a diversity of indices for measuring competitiveness at the national and regional levels. On top of this variety, the application of these indices is challenging as they employ many variables. This creates a limitation against their usefulness for understanding the impacts of the determinants of competitiveness as they were primarily developed for measuring competitiveness and not for understanding the impacts of its determinants. Hence, a simpler framework is needed for the purposes of this study.

## 2.2 *The emerald model and the hypotheses*

The emerald model by Sasson and Reve (2012) is selected as an effective approach to assess regional competitiveness in this study. The choice is driven by the fact that it was operationalised in earlier studies to assess the competitiveness of various industries (see Sasson and Blomgren, 2011; Vinje and Nordkvelde, 2011) and to benchmark clusters (see Akpınar and Mermercioglu, 2014a; Akpınar and Mermercioglu, 2014b). Ease of operationalisation is an important criterion

behind this choice as the study covers many years of retrospective data for a large number of regions from different countries. In the model, competitiveness is analysed through the following dimensions.

1. *Educational attractiveness*: This dimension examines the popularity of high quality educational institutions, measured by the number of students (Sasson and Reve, 2012). A region's productivity, hence competitiveness, is recognised to be related to the knowledge potential of its human capital, and a determining factor in the improvement of the knowledge potential is the existence of high quality educational institutions (*ibid.*). Accordingly, in the diamond model, human resources along with knowledge resources are identified as important factor conditions (Porter, 1990), and higher education and training is one of the 12 pillars of the global competitiveness index by the World Economic Forum (Sala-I-Martin *et al.*, 2014) and the education sub-factor of the world competitiveness index by the IMD World Competitiveness Centre (Garelli, 2014) as policy makers recognise investment in human resources as a key driver of competitiveness (Stierna and Vigier, 2014). Based on these arguments, the following is proposed.

*Hypothesis 1: The higher the educational attractiveness of the region is, the higher the region's competitiveness will be.*

2. *Talent attractiveness*: This dimension assesses the ability to attract and retain talented people in the region (Sasson and Reve, 2012). To become more competitive, industries and firms in a certain location compete to attract the most talented workers (Lèvy, 2002). Talent is reflected among the factor conditions of the diamond model (Porter, 1990) and in the labour market sub-factor of the world competitiveness index of the IMD World Competitiveness Centre (Garelli, 2014). As such, the following is proposed.

*Hypothesis 2: The higher the talent attractiveness of the region is, the higher the region's competitiveness will be.*

3. *R&D and innovation attractiveness*: This dimension measures R&D personnel, R&D investments and patents registered by firms in the region (Sasson and Reve, 2012). The acknowledgement of R&D and innovation's central roles in economic progress and competitiveness has stimulated policy makers to name the EU as the "Innovation Union" (Stierna and Vigier, 2014). Greater levels of R&D and innovation in existing firms increase their competitiveness while decreasing the probability of failure and creating an entry barrier for new firms (Gawel, 2012). The significance of R&D and innovation is further reflected in the technological readiness and innovation pillars of the global competitiveness index by the World Economic Forum (Sala-I-Martin *et al.*, 2014) and in the scientific infrastructure sub-factor of the world competitiveness index of the IMD World Competitiveness Centre (Garelli, 2014). Hence, the following is proposed.

*Hypothesis 3: The higher the R&D and innovation attractiveness of the region is, the higher the region's competitiveness will be.*

4. *Ownership attractiveness*: This dimension evaluates the attractiveness of a location's entrepreneurial ecosystem, the support it provides for start-ups and financing provided to mature industries to innovate and generate new projects (Sasson and Reve, 2012). Respectively, capital resources are among the factor conditions in the diamond model (Porter, 1990) and sophistication of financial markets is one of the pillars of the global competitiveness index by the World Economic Forum (Sala-I-Martin *et al.*, 2014). It is also reflected under the business efficiency factor of the world competitiveness index of the IMD World Competitiveness Centre (Garelli, 2014). Based on these arguments, the following is proposed.

*Hypothesis 4: The higher the ownership attractiveness of the region is, the higher the region's competitiveness will be.*

5. *Environmental attractiveness*: This dimension argues that a region with the ability to pioneer in environmental solutions will be more competitive than others (Sasson and Reve, 2012). Accordingly, environmental attractiveness assesses the region's abilities for producing environment-friendly products and services with environment-friendly operations (*ibid.*). As argued by Porter and van der Linde (1995), sensitivity to environmental concerns leads to the development of specialised knowledge in the area and contributes to the innovations of more sustainable products, services, operations and business models and hence improves the competitiveness of firms. The environment is also reflected as a sub-factor in the world competitiveness index of the IMD World Competitiveness Centre (Garelli, 2014). As such, the following is proposed.

*Hypothesis 5: The higher the environmental attractiveness of the region is, the higher the region's competitiveness will be.*

6. *Cluster attractiveness*: Clusters are geographic concentrations of firms, suppliers, related industries, and specialised institutions in a particular field in a nation, state or city (Porter, 1998). This dimension measures the level of agglomeration and specialisation of clusters in the region (Sasson and Reve, 2012). Clusters are reflected in the determinant of related and supporting industries in the diamond model (Porter, 1990), and enhancing innovation-driven clusters is articulated in the long-term vision of the Innovation Union (Stierna and Vigier, 2014). A region with strong clusters and a high degree of specialisation is argued to create externalities which generate knowledge spillovers and innovations and propel employment and growth (Delgado *et al.*, 2010; Marshall, 1890; Porter, 1998). According to Runiewicz-Wardyn (2013), there is no consensus in the literature concerning the role of externalities in explaining knowledge spillovers and innovations within clusters since knowledge spillover is an abstract concept which is difficult to measure. While Porter (2003b) differentiates between traded and local clusters and suggests that traded clusters are the ones contributing to competitiveness, a quantitative study of European regions by Franco *et al.* (2014) reveals that the correlation between cluster strength and competitiveness is insignificant or even negative, except in the case of emerging industries. The advantages of the old, successful clusters can turn into liabilities and render them vulnerable over time (Desrochers *et al.*, 2008). Taking into account these contradictory perspectives, the following is proposed.

*Hypothesis 6: The higher the cluster attractiveness of the region is, the higher the region's competitiveness will be.*

7. *Knowledge dynamics*: Knowledge dynamics is the degree at which knowledge flows efficiently in the location, resulting in dynamic interactions and relationships between firms and institutions (Sasson and Reve, 2012). This dimension assesses the extent of competitive and cooperative linkages and the degree of labour mobility in the region (*ibid.*). Externalities and knowledge spillovers inside clusters (Marshall, 1890; Porter, 1998) or across diverse industries in cities (Jacobs, 1969) can foster innovations and entrepreneurship (Acs *et al.*, 2009; Alberti and Pizzurno, 2013; Giuliani, 2005). Similarly, building bridges to link the gaps among cluster members is identified as a key task for cluster managers to stimulate knowledge dynamics (Lindqvist *et al.*, 2013). Hence, the following is proposed.

*Hypothesis 7: The higher the knowledge dynamics in the region is, the higher the region's competitiveness will be.*

### 3 Methodology

#### 3.1 Data collection and the measurements

In order to test the hypotheses, necessary regional data is collected, mainly from statistics provided by the European Cluster Observatory (European Cluster Observatory, online). Moreover, the OECD Regional Statistics database is used for the measure of fine particulate matter (PM<sub>2.5</sub>) (OECD Regional Statistics, online), and Eurostat Database is used for the measure of PPP-adjusted GDP per capita (Eurostat Database, online). The dataset covers 97 NUTS-1 regions from 30 countries for the period from 2000 through 2011. The choice of the period was driven largely by data availability. EU countries as well as Iceland, Norway and Switzerland are included in the dataset, but countries such as Croatia, Serbia, Bosnia and Herzegovina, and Turkey cannot be studied due to lack of regional data. Furthermore, the region corresponds to the whole country for small countries like Luxemburg, Malta, Cyprus, Estonia, Latvia, Lithuania, Iceland, Ireland, Slovenia and Slovakia. The variables and their measures are presented in Table 1.

\*\* Insert Table 1 about here \*\*

Following the concerns of Krugman (1994), we averted from narrowing competitiveness down to productivity growth or productivity gains and measured it with *purchasing power parity (PPP) adjusted annual regional GDP per capita*. Although different measures have been offered to examine competitiveness (see Franco *et al.*, 2014 for a review), PPP-adjusted GDP per capita is the most widely used economic measure as a more precise measurement (*ibid.*). We believe that this measure can capture the wealth and standard of living of a region in its entirety. Approaching competitiveness in such a way can make it more appropriate and relevant for all stakeholders in the region.

The measures for the independent variables are selected from among the measures suggested by Sasson and Reve (2012) for each dimension of the emerald model. Availability of data for the measures as well as independence from the dependent variable are the key criteria in the selection process. Educational attractiveness is measured by the percentage of *students in tertiary education* among 20-24 year-olds to represent the existence and importance of university education in the region. Other educational attractiveness measures such as students in vocational programmes and life-long learning opportunities could not be assessed due to lack of data.

Talent attractiveness is measured by *the ratio of human resources in science and technology (HRST) sectors to all human resources employed in the region*. According to the Canberra Manual (OECD/Eurostat, 1995), HRST is defined as persons having graduated at the tertiary level of education or employed in a science and technology occupation for which a high qualification is normally required and the innovation potential is high. Another way to assess talent attractiveness might be to look at the average wage levels in the region (Sasson and Reve, 2012). However, this was not possible because of its high correlation with the dependent variable.

R&D and innovation attractiveness is measured with *the ratio of the business R&D expenditure in the region to regional GDP*.

To measure ownership attractiveness, gross fixed capital formation is not used because it is part of the GDP calculation. In the absence of venture capital or other investment data, this

variable is operationalised with *the ratio of the business services sector in the region to all economic activities*. Important activities in this sector are engineering and technical services, management consultancy, commercial communications, computing services, accountancy, audit services, legal services, recruitment and personnel selection. The scope and availability of these services will be a plus to attract potential investors and entrepreneurs.

Environmental attractiveness is measured by *fine particulate matter (PM2.5)*, indicating the level of air pollution in terms of unwanted particulate matter concentration expressed in micrograms per cubic meter.

Cluster attractiveness is measured separately for all clusters and technology & knowledge-based clusters using the *star rating* technique from the European Cluster Observatory. This technique measures the strength of clusters based on dimensions of size, specialisation, productivity and dynamism (Ketels and Protsiv, 2014). Clusters in a region are assigned a star for each dimension if they are in the top 20% and the star rating of the region is calculated by summing up the stars of its clusters (*ibid.*). The reason for selecting knowledge-based clusters, a representative for traded clusters, as a second measure is based on the discussion that not all clusters might contribute to competitiveness (Franco *et al.*, 2014) but mainly traded clusters (Porter, 2003b). Since there exists regional star ratings only for the years 2009, 2010 and 2011, backwards extrapolation is carried out for the remaining years using proportions to the respective employment figures.

Knowledge dynamics is measured with the *ratio of patent collaborations with foreign firms to all patent collaborations*. This measure is selected because knowledge dynamics is perceived to be a key driver of innovations (Alberti and Pizzurno, 2013; Giuliani, 2005), thus co-patenting can reflect best the quality of knowledge exchange relationships that are essential collaborations in the process of innovation.

In addition to the explanatory variables, three control variables are used to control for the *regional area* (measured by km<sup>2</sup>), the *regional population* (measured in thousands), and for the *country* (measured as a categorical variable of the region's country).

### 3.2 Data analysis

Following the analysis of descriptive statistics for all variables, a set of multiple regression models are run for testing the hypotheses by adopting a time-series design with lags of eight years between the dependent variable and the independent variables. The motivation for that is to offer a more appropriate examination of the assumed causal relationship, since present investments and policies for a region cannot lead to an enhancement of competitiveness immediately or in the short term (Fritsch and Mueller, 2008; van Stel and Storey, 2004; van Stel and Suddle, 2008). The 8-year lag model is supplemented with an alternative five-year model to trace possible differential impacts on competitiveness over time.

Five models are run in the regression analysis. Model-1 establishes the base model with the three control variables. Model-2 includes education and talent attractiveness variables besides the control variables, and Model-3 further adds R&D and innovation attractiveness and environmental attractiveness variables. Model-4 expands the analyses to include ownership attractiveness and knowledge dynamics, and Model-5 represents the full model.

In time-series measurements it is important to check for heteroscedasticity, and in this study the Durbin-Watson statistic indicates a strong possibility of a serial correlation across observation years (as the test value is 0.61, which is considerably distant from 2.0). An issue



regarding the variance of the error terms is also observed visually in the residual plots. Since this problem can decrease the validity of the statistical tests of significance, it is fixed with the calculation of the robust error terms by using the procedure developed by Hayes and Cai (2007).

## 4 Results

### 4.1 Descriptive statistics

\*\* Insert Table 2 about here \*\*

The results presented here belong to the analysis with a time lag of eight years using a sample size of 342. The average PPP-adjusted GDP per capita for a European region is €25,608, and the average population for a NUTS-1 region is 5,321,000 inhabitants. However, these variables show important variations as both PPP-adjusted GDP per capita and population level can greatly differ between two given regions. On average, 43.0% of the young population aged 20-24 receive a tertiary education, and 8.6% of all people employed in the region represent highly-skilled labour in technology- and knowledge-intensive jobs. The average R&D investment by businesses in a region is 0.9% of the regional GDP, and the average air pollution measured by PM2.5 is 16.1 microgram/m<sup>3</sup>. Business services constitute 1.6% of all sectors in a region on average, and the average star ratings for all sectors and knowledge-intensive sectors are 11.9 and 4.8 respectively. Finally, on average, 57.9% of all patent collaborations in a region are made with foreign partners. The pairwise correlations in Table 2 indicate that GDP per capita significantly correlates with all of the explanatory variables except for the star rating for all sectors in the region.

### 4.2 The impacts of the dimensions

\*\* Insert Table 3 about here \*\*

A comparison of the five models in Table 3 suggests that each successive model indicates a statistically better fit than the previous one except Model-5. With respect to the R squares and how they change, Model-2 shows a significant improvement of 0.39 over the base model, while Model-3 and Model-4 present incremental improvements of 0.04 and 0.08. It is observed that Model-5, including all independent variables, can explain more than half of the variance (0.55) in PPP-adjusted regional GDP per capita.

Besides the overall fitness, individual coefficient values and significance levels also show important results regarding to what extent each emerald model dimension is likely to predict regional competitiveness. In Model-5, all independent variables except the general star rating of the region have a statistically significant impact on the level of PPP-adjusted GDP per capita after eight years. The ratio of students in tertiary education has a meaningful positive effect on competitiveness ( $\beta=.193$ ,  $p<.05$ ). Hence, *Hypothesis 1 is accepted*. Similarly, the ratio of HRST to all human resources strongly predicts it ( $\beta=.242$ ,  $p<.01$ ), *supporting Hypothesis 2*. The ratio of business R&D to GDP is also linked with higher GDP per capita ( $\beta=.134$ ,  $p<.05$ ). As such, *Hypothesis 3 is accepted* as well. The strength of the ratio of business services to all economic activities in a region leads to higher PPP-adjusted GDP per capita ( $\beta=.407$ ,  $p<.01$ ). This makes ownership attractiveness the most influential dimension of the emerald model and *supports*

*Hypothesis 4.* There is also *support for Hypothesis 5* as PPP-adjusted GDP per capita increases when there is a lower level of air pollution ( $\beta = -.086$ ,  $p < .05$ ).

Model-5 shows some interesting results with respect to the influences of the cluster attractiveness and knowledge dynamics dimensions of the emerald model. While the impact of general agglomeration capabilities is insignificant, the star rating for technology & knowledge-based sectors appears to be significantly predicting the future PPP-adjusted GDP per capita of the region ( $\beta = .108$ ,  $p < .05$ ). This might imply that the major support to regional competitiveness does not come from mere clustering but rather originates from agglomeration and specialisation capabilities in technology & knowledge-based sectors. Thus, *Hypothesis 6 is only partially supported*. Finally, the ratio of patent collaborations with foreign firms to all patent collaborations has a significant relationship with the future PPP-adjusted GDP per capita but in an unexpected negative way ( $\beta = -.068$ ,  $p < .05$ ), so *Hypothesis 7 is not supported*.

The results also show that the country of a region has an important effect on the competitiveness of that region. This finding implies that policies, decisions and level of prosperity at the national level can have effects on regional outcomes. While less populated regions seem to have more advantage, there is no significant effect of the land size.

The results from Model-5 indicate that, among the determinants that positively impact on regional competitiveness, ownership attractiveness is the most influential dimension ( $\beta = .407$ ), followed by talent attractiveness ( $\beta = .242$ ), educational attractiveness ( $\beta = .193$ ), R&D and innovation attractiveness ( $\beta = .134$ ), cluster attractiveness for technology & knowledge-based sectors ( $\beta = .108$ ), and environmental attractiveness ( $\beta = -.086$ ).

To better assess the effect of time on regional competitiveness and identify possible changes, the models are also run with 5-year lag forward. In this case, the results of the tests are the same, and ownership attractiveness ( $\beta = .405$ ), talent attractiveness ( $\beta = .294$ ), and educational attractiveness ( $\beta = .148$ ) are again the most influential dimensions. The order for the remaining variables is different in that cluster attractiveness for technology & knowledge-based sectors ( $\beta = .146$ ) is the fourth-most influential dimension, followed by environmental attractiveness ( $\beta = -.136$ ) and R&D and innovation attractiveness ( $\beta = .101$ ).

## 5 Discussion

This study contributes to the literature on regional competitiveness by revealing the varying influences of the dimensions of the emerald model. Earlier literature defined competitiveness and developed complex measurements, but attempts to establish cause-effect relationships with its determinants were few (Franco *et al.* 2014). This study also makes a contribution to the emerald model by testing its dimensions for the first time. Following literature review, the emerald model was selected as the theoretical framework due to its ease of operationalisation vs. other frameworks, e.g., the diamond model. This choice by no means undervalues the reviewed frameworks. On the contrary, as reviewed in section 2.2, the dimensions of the emerald model share similarities with the dimensions of other models. Finally, the study is an important empirical investigation covering 12 years of data, and taking into account time lags of five and eight years between the dependent and the independent variables.

The results suggest that the emerald model provides a good estimate of regional competitiveness except in the dimensions of cluster attractiveness and knowledge dynamics. Ownership attractiveness is the most influential dimension followed by talent attractiveness. The availability of business services and capital resources to support new business formation is

included in many competitiveness frameworks (see Garelli, 2014; Porter, 1990; Sala-I-Martin *et al.*, 2014), and likewise human capital is recognised as a key regional asset (Huggins *et al.* 2014). Educational attractiveness is the third and R&D and innovation attractiveness is the fourth-most influential dimension. These are expected results as higher education and training is essential for the development of human resources (Garelli, 2014; Porter, 1990; Sala-I-Martin *et al.*, 2014), and innovations are drivers of competitiveness, while R&D is essential for innovations (Gawel, 2012; Sala-I-Martin *et al.*, 2014; Stierna and Vigier, 2014). The fifth-most influential dimension in the ranking is cluster attractiveness in technology & knowledge-based sectors. Despite this support, the impact of cluster attractiveness in all sectors is insignificant, and thus in line with Franco *et al.* (2014), who found a strong correlation between cluster strength and competitiveness only for clusters of emerging industries. It is now tested in two different studies that not all clusters contribute to regional competitiveness. Hence, the debate continues on whether externalities within specialised clusters contribute to regional competitiveness (Desrochers *et al.*, 2008). As technology & knowledge-based sectors are mostly traded clusters, our finding supports the performance difference between traded and local clusters identified by Porter (2003b). Environmental attractiveness is the sixth-most influential dimension in the ranking and our results are in line with previous studies (Sasson and Reve, 2012 and Porter and van der Linde (1995) as its significant relationship can be interpreted such that regions which achieve better environmental results are also likely to be more competitive overall. The seventh-most influential dimension is knowledge dynamics, but its impact is negative, contrasting earlier literature that suggested its relevance for driving innovations and entrepreneurship (Acs *et al.*, 2009; Giuliani, 2005). This might suggest that patent collaborations with foreign firms can benefit international firms with greater resources and appropriation capabilities and adversely affect the competitiveness of the region. This finding, however, should be approached with caution since NUTS-1 regions may be too big to study knowledge spillovers (Runiewicz-Wardyn, 2013).

The ranking of the dimensions provides a roadmap for policy makers and regional development agencies in prioritising their goals and allocating resources. Creating a business-friendly environment and attracting talent to the region should be at the top of their agendas. The results also suggest that already in the short term of five years the impacts are observed in the same manner. One exception is R&D and innovation attractiveness. It seems that the impact of this dimension grows in the long term of eight years making it the fourth most influential dimension. Furthermore, based on the results, it is recommended that policy makers approach clusters with caution as all kinds of specialisation do not contribute to regional competitiveness. Finally, policy makers may be warned that patent collaborations with foreign firms can have a detrimental effect on regional competitiveness.

The emerald model suggests a variety of measures for each of its dimensions, but the choice of the measurements in this study was limited by data availability. Furthermore, in the cases of cluster attractiveness and ownership attractiveness, backward extrapolations were made to compensate for missing data in earlier years. In future research, data for other measurements (e.g., vocational training and life-long learning measures for educational attractiveness) can be collected to test the model and to make more fine-tuned judgments on each dimension. It is recommended especially to retest the dimension of knowledge dynamics using different measures which reflect knowledge dynamics among local actors in the region. Such a test can be carried out at NUTS-3 regions, which are smaller (*ibid.*), as well as in technology and knowledge-based sectors only. In future research the emerald model can also be tested in other

regions of the world.

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## Notes

<sup>1</sup> The authors contributed equally to the development of this paper.





**Table 1** Variables and their measures

| Variable                          | Measure   |
|-----------------------------------|---|
| Regional competitiveness          | Annual regional PPP-adjusted GDP per capita   |
| Educational attractiveness        | Percentage of students in tertiary education among 20-24 year olds  |
| Talent attractiveness             | Ratio of human resources in science and technology (HRST) sectors to all human resources employed in the region |
| R&D and innovation attractiveness | Ratio of the business R&D expenditure in the region to regional GDP   |
| Ownership attractiveness          | Ratio of the business services sector in the region to all economic activities                                  |
| Environmental attractiveness      | Fine particulate matter (PM2.5) in the air (microgram/m <sup>3</sup> )  |
| Cluster attractiveness            | European Cluster Observatory star rating  |
| Knowledge dynamics                | Ratio of patent collaborations with foreign firms to all patent collaborations                                  |
| Regional area                     | Geographic area of the region (km <sup>2</sup> )  |
| Regional population               | Population of the region (thousands)  |
| Country                           | Country of the region   |

**Table 2** Descriptive statistics

|  | Mean  | Standard Deviation | 1.      | 2.      | 3.      | 4.      | 5.      | 6.      | 7.      | 8.     | 9.     | 10.    | 11.    |
|--|-------|--------------------|---------|---------|---------|---------|---------|---------|---------|--------|--------|--------|--------|
| 1. PPP-adjusted GDP / capita (Euro)  | 25608 | 9888               |         |         |         |         |         |         |         |        |        |        |        |
| 2. Regional area (1000 km <sup>2</sup> )   | 50512 | 62863              | -.072   |         |         |         |         |         |         |        |        |        |        |
| 3. Regional Population (1000)  | 5321  | 3455               | -.029   | .151**  |         |         |         |         |         |        |        |        |        |
| 4. Country   |       |                    | -.194** | .076    | .045    |         |         |         |         |        |        |        |        |
| 5. Students in tertiary education (% of 20-24 year olds)                               | 43.0  | 16.4               | .274**  | .323**  | .085    | .126*   |         |         |         |        |        |        |        |
| 6. Ratio of HRST to all human resources (%)  | 8.6   | 3.0                | .612**  | .091    | -.148** | -.010   | .302**  |         |         |        |        |        |        |
| 7. Ratio of business R&D to GDP (%)  | 0.9   | 0.8                | .477**  | .038    | .096    | -.083   | .143**  | .550**  |         |        |        |        |        |
| 8. Fine particulate matter - PM2.5 (microgram/m <sup>3</sup> )                         | 16.1  | 4.8                | -.234** | -.430** | .103    | -.132*  | -.201** | -.441** | -.219** |        |        |        |        |
| 9. Ratio of business services to all economic activities (%)                           | 1.6   | 1.9                | .409**  | -.099   | .591**  | .180**  | .094    | .360**  | .330**  | -.090* |        |        |        |
| 10. Star rating for all sectors  | 11.9  | 6.5                | .016    | .012    | .590**  | -.033   | .193**  | -.168** | .067    | .352** | .323** |        |        |
| 11. Star rating for technology & knowledge-based sectors                               | 4.8   | 3.9                | .414**  | -.189** | .445**  | -.141** | .218**  | .323**  | .523**  | .180** | .540** | .590** |        |
| 12. Ratio of patent collaborations with foreign firms to all patent collaborations (%) | 57.9  | 14.3               | .197**  | -.095   | .049    | -.186** | .090    | .257**  | .290**  | -.038  | .171** | -.056  | .266** |

N = 342.

All correlations are calculated with 8-year lag variables.

\*\*  $p < .01$  level (2-tailed).

\*  $p < .05$  level (2-tailed).

**Table 3** Multiple regression estimates

|   | <b>Model 1</b>        | <b>Model 2</b>       | <b>Model 3</b>        | <b>Model 4</b>        | <b>Model 5</b>        |
|---|-----------------------|----------------------|-----------------------|-----------------------|-----------------------|
| <b>Control variables</b>  |                       |                      |                       |                       |                       |
| Regional area   | -.047<br>(.01)        | -.180**<br>(.01)     | -.211**<br>(.01)      | -.107*<br>(.01)       | -.083<br>(.01)        |
| Regional population   | -.004<br>(.00)        | .072<br>(.00)        | .050<br>(.00)         | -.251**<br>(.00)      | -.270**<br>(.00)      |
| Country   | -.154**<br>(54.73)    | -.149**<br>(42.32)   | -.151**<br>(41.76)    | -.279**<br>(41.77)    | -.269**<br>(44.35)    |
| <b>Independent variables<br/>(measures)</b>                           |                       |                      |                       |                       |                       |
| Educational attractiveness  |                       | .183*<br>(26.63)     | .196**<br>(26.07)     | .224**<br>(24.07)     | .193*<br>(26.54)      |
| Talent attractiveness   |                       | .562**<br>(136.45)   | .411**<br>(170.63)    | .234**<br>(179.72)    | .242**<br>(201.42)    |
| R&D and innovation<br>attractiveness                                  |                       |                      | .205**<br>(560.85)    | .181**<br>(526.33)    | .134*<br>(617.93)     |
| Environmental attractiveness  |                       |                      | -.096**<br>(98.01)    | -.084*<br>(90.34)     | -.086*<br>(104.05)    |
| Ownership attractiveness  |                       |                      |                       | .431**<br>(310.23)    | .407**<br>(330.99)    |
| Knowledge dynamics  |                       |                      |                       | -.056*<br>(26.49)     | -.068*<br>(28.37)     |
| Cluster attractiveness for all<br>sectors                             |                       |                      |                       |                       | -.007<br>(92.17)      |
| Cluster attractiveness for<br>technology & knowledge-based<br>sectors |                       |                      |                       |                       | .108*<br>(179.72)     |
| Constant  | 28455.54<br>(1242.51) | 8016.95<br>(1606.83) | 13279.67<br>(2765.14) | 22419.11<br>(3036.05) | 22850.24<br>(3313.23) |
| <i>R</i> <sup>2</sup>   | .027                  | .424                 | .463                  | .539                  | .549                  |
| <i>F</i> change   | 4.82**                | 127.83**             | 7.51**                | 23.96**               | 1.47                  |
|   | N= 380                | N= 376               | N= 372                | N= 366                | N= 342                |

All independent variables are calculated with 8-year lags.

Heteroscedasticity-consistent standard errors are shown in parentheses.

\*\*  $p < .01$  level (2-tailed).

\*  $p < .05$  level (2-tailed).