Akpinar, M., Can, O., & Mermercioglu, M. (2017) Assessing the sources of competitiveness of the US States. *Competitiveness Review: An International Business Journal*, Vol. 27, No. 2, 161-178, http://dx.doi.org/10.1108/CR-02-2016-0014.

Purpose – This study aims to test the emerald model on the regional basis for the identification of the most important sources of competitiveness in the states of the USA.

Design/methodology/approach – Using the emerald model and its assertions, data is collected over the period 1998-2013 from 47 states in the USA. Multiple regression analysis is performed with a lag structure of four, six and eight years as alternative time intervals to explain the dependent variable.

Findings – The empirical results support the emerald model except for its R&D attractiveness dimension in its ability to explain competitiveness in the states of the USA. In the longer term (eight-year lag), cluster attractiveness has the highest impact followed by environmental attractiveness, ownership attractiveness, educational attractiveness and talent attractiveness. Comparison of regression models with different time lags indicates that once the very early phase is over, the impacts of most attractiveness dimensions become rather consistent across time and do not disappear.

Originality/value – The study contributes to the literature on the measurement of regional competitiveness by performing an overall assessment of the emerald model and by analysing the impacts of the model's dimensions on competitiveness over time. On the other hand the identification of the sources of regional competitiveness paves the way for a more efficient allocation of resources regarding policies and improvement programs.

Keywords: Regional competitiveness, economic development, emerald model, state, USA

1. Introduction

It is widely argued that competitive locations deliver competitive advantages for firms by enabling them to succeed in global markets and thus enhancing the region's prosperity (Garelli, 2014; Porter, 2001). Respectively, the significant impact of a location's competitiveness on both businesses and residents has attracted the attention of regional policy makers as well as the International Monetary Fund, the World Bank, the Organisation for Economic Cooperation and Development, and the European Union (EU) through its Lisbon strategy (Bristow, 2010). Accordingly, the measurement of a nation's competitiveness has become a focus of economic research in the last decades, and a variety of competitiveness indices have been introduced to rank countries such as the global competitiveness index by the World Economic Forum (Sala-I-Martin et al., 2014) and the world competitiveness ranking by the Institute for Management Development (IMD) World Competitiveness Centre (Garelli, 2014). In the meantime, based on the idea that each region within a country can have different characteristics and competitiveness levels, several researchers attempted to create regional indices (see Charles and Zegarra, 2014; Huggins and Izushi, 2008; Huggins et al., 2014; Kitson et al., 2004).

Despite growing interest in competitiveness, there are debates on what it means and implies (Aiginger and Vogel, 2015; Huggins et al., 2014; Krugman, 1994; Porter, 2003). Competitiveness is defined as "*the ability of firms in the region to compete in international markets while simultaneously expanding the wealth and living standards of citizens*" (Cho and Moon, 2005; Huggins et al., 2014; Kao et al., 2008; Porter, 1990) or as "*the set of institutions, policies and factors that determine the firms' productivity levels in a region*" (Sala-I-Martin et al., 2014).

Garelli (2014) conceptualizes competitiveness in terms of aggressiveness (i.e. the ability of firms in the country to export) and attractiveness (i.e. the ability to attract foreign direct investments (FDI) to the country). Sölvell (2015) reserves the term "competitiveness" for firms in referring to their static competitive advantages and uses the term "attractiveness" when referring to locational advantages. On the other hand, Krugman (1994) argues that it is dangerous to consider nations or regions in competition with each other. In addition to differences in definitions, conceptualizations and the high number of indices, the literature is also in need of studies to understand and test the sources of competitiveness. Such understanding can enable the identification of the key determinants of regional competitiveness and encourage policies and programs to promote its enhancement. This is the gap that this study aims to address.

This study contributes to this need by testing the impacts of the dimensions of the emerald model by Sasson and Reve (2012) on regional competitiveness with the aid of longitudinal data from 1998 to 2013 obtained from 47 states in the USA. The emerald model, providing an explanatory model for the analysis of the attractiveness of localities with six dimensions (educational attractiveness, talent attractiveness, R&D and innovation attractiveness, ownership attractiveness, environmental attractiveness, and cluster attractiveness) and a moderating variable (knowledge dynamics) is adopted from among existing models and indices (see section 2.1 for a review) because it is relatively easier to operationalize. The research question is: "*which are the most influential dimensions of the emerald model on competitiveness in the states of the USA?*" and it aims to identify the more influential sources of competitiveness. The emerald model was originally developed to study a location's attractiveness for inbound FDI (ibid.), and was also used to study the competitiveness of industries (see Sasson and Blomgren, 2011; Vinje and Nordkvelde, 2011) and clusters (see Akpinar and Mermercioglu, 2014). However the model is yet to be tested on the basis of regions. Hence, the testing of the model in the context of the USA and US states will be the second contribution of this study. Earlier studies suggest that it may take from four to eight years before the impacts of competitiveness initiatives are observed (see Fritsch and Mueller, 2008; van Stel and Storey, 2004; van Stel and Suddle, 2008). Accordingly multiple regression analysis is conducted taking into account time lags of four, six and eight years between the dependent and the independent variables. Running the model with different time lags will reveal whether different dimensions of the emerald model require different durations to materialize their impacts. As this has not been studied earlier, it will be the third contribution of this study.

The study focuses on states as they differ in terms of economic performance and endowments and there are rich data sources at the state level (Audretsch and Feldman, 1996; Porter, 2001). Furthermore, policies are set at the state level in the USA, and increased emphasis on state-level capabilities and skills as well as possible collaborations among key actors in the states also make them a critical setting to assess competitiveness (Bristow, 2010). This choice, however, creates a limitation in testing the emerald model, especially regarding the moderating variable knowledge dynamics, which addresses knowledge spillovers that underlie innovations and new business formation. It is measured at region/cluster level taking into consideration the degree of competition and cooperation among firms, linkages between firms, and labor mobility. However, the state is too large a unit to study spatial processes such as knowledge dynamics (Krugman, 1991; Runiewicz-Wardyn, 2013); and most regional indicators fail to capture the processes by which knowledge is created and diffused (Huggins and Izushi, 2008). Despite these warnings we checked to find suitable measures for knowledge dynamics at state level, but there weren't any. Therefore, we decided not to include this variable in our study but suggest testing it in future research. The USA provides an interesting research context as the world's most productive large economy and the largest market for sophisticated goods and services has been losing competitiveness in the 2000s, and as a result US firms have been moving their operations out of the country (Pisano and Shih, 2009; Porter and Rivkin, 2012a; Porter and Rivkin, 2012b). Hence, findings from this study can help generate recommendations to reverse this trend.

The rest of the paper is organized as follows. Following a literature review, hypotheses from the emerald model are developed in section 2, and the methodology is described in section 3. The results are presented in section 4 and the paper ends with a discussion in section 5.

2. Theoretical Framework

2.1 Models and indices of competitiveness

There is growing interest in the identification of the sources of competitiveness as well as policies to promote and foster them (Ketels, 2013; Kitson et al., 2004). Competitiveness is about the productivity of firms, their capability to innovate and upgrade, and the policies in creating and maintaining a competitive environment for them (Kao et al., 2008; Porter, 1990).

In the diamond model by Porter (1990), competitiveness is determined by the quality of factor conditions, the quality of demand conditions, the context for firm strategy and rivalry, and the strengths of related and supporting industries. In the case of small regions, the diamonds of neighboring regions can also contribute to competitiveness (Cho and Moon, 2005; Moon et al., 1998; Rugman and D'Cruz, 1993). The diamond model in essence is easy to understand, but the four determinants represent a diversity of sub-determinants, which are difficult to measure. For example, factor conditions address human resources, physical resources, knowledge resources, capital resources and infrastructure; and demand conditions imply the segment structure of demand, the existence of sophisticated and demanding buyers, anticipatory buyer needs, the size of demand, the number of independent buyers, the growth rate of home demand, early home demand, and early saturation (Porter, 1990). Equally challenging is the context for firm strategy and rivalry, which covers the degree of domestic rivalry, management practices and approaches, orientations of firms toward competing globally, and motivations of individuals (ibid.).

The global competitiveness index of the World Economic Forum (WEF) evaluates competitiveness with measures about institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness, market size, business sophistication, and innovation (Sala-I-Martin et al., 2014). The world competitiveness index developed by the IMD World Competitiveness Centre, on the other hand, has more than 300 criteria that measure economic performance, government efficiency, business efficiency and infrastructure (Garelli, 2014). Both methods have been criticized for having problems in their theoretical foundations (Lall, 2001; Önsel et al., 2008), and not being equally applicable to countries with different characteristics (Cho and Moon, 2005). In addition, regions within a country are also different, thus regional competitiveness cannot be properly captured using national indices (Annoni and Dijkstra, 2013). To address this need, regional indices have been introduced, but similar to national ones, they are also complex (Charles and Zegarra, 2014; Kitson et al., 2004). For instance, the sub-regional competitiveness index by Huovari et al. (2001) has 16 variables and 15 indicators. The EU regional competitiveness index by Dijkstra et al. (2011), the UK competitiveness index by Huggins (2003), the "pyramid model of regional competitiveness" by Lengyel (2004), the rindex model based on the so-called "regional diamond" by Snieška and Bruneckienė (2009), the world competitiveness index of regions by Huggins et al. (2014), and the competitiveness index by Benzaquen et al. (2010) are difficult to operationalize.

There are a number of rankings in the USA measuring competitiveness of states on a regular basis including Beacon Hill Institute's State Competitiveness Report (The Beacon Hill Institute, 2014), Milken Institute's State Technology and Science Index (Milken Institute, 2016), and the Information Technology & Innovation Foundation's State New Economy Index (Atkinson and Stewart, 2012). These composite indices are useful in providing guidance on state-level economic performance, in highlighting progresses and gathering the attention of policy makers and other stakeholders, and in creating a consensus around the meaning and importance of competitiveness at the state level. However it is argued that that they conflate and consolidate different indicators together in a fuzzy bundle of inputs, outputs and outcomes without using a coherent conceptual framework (ibid.). As a result there are areas for development regarding the inclusion of certain dimensions and their relationships. Furthermore, as a significant part of the causal links and indices usually depend on expert opinion and data availability rather than implicit results, there is room for improvement regarding their usage as references for action policies. This makes us acknowledge the need for careful conceptual thinking on competitiveness at state-level, and for precise measurements and empirical analysis attached to more explicit causal relationships. As such, this study is also an attempt to identify the sources of state-level competitiveness in a reliable and systematic way by using a simpler framework, which is more straightforward and easier to operationalize, i.e. the emerald model presented in more detail in the next section.

2.2 The emerald model and the hypotheses

Its name deriving from the surface of a hexagon, the emerald model reveals that localities differ in their attractiveness through their abilities to attract advanced education institutions and departments, highly talented employees, advanced academic specialist and research and development projects, competent and willing investors and owners, the creation and implementation of environmental solutions and a diverse and sizeable group of related firms (Reve and Sasson, 2015). Accordingly, in order to understand and test the sources of competitiveness, the following dimensions of the emerald model are interpreted as possible determinants of competitiveness in this study, and hypotheses are developed for testing them.

1. Educational attractiveness: This dimension addresses the region's attractiveness regarding its higher educational institutions (Sasson and Reve, 2012). Policy makers recognize investment in human resources as a key driver of competitiveness (Stierna and Vigier, 2014) and human resources along with knowledge resources are identified as important factor conditions in the diamond model (Porter, 1990). Educational attractiveness is further recognized in the higher education and training pillar of the global competitiveness index by WEF (Sala-I-Martin et al., 2014) and the education sub-factor of the world competitiveness index of the IMD World Competitiveness Centre (Garelli, 2014). Based on these recognitions, the following is proposed.

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

2. Talent attractiveness: This dimension addresses the ability to attract talented people to the region, as firms need talent to improve their competitiveness (Sasson and Reve, 2012). The relevance of this dimension on competitiveness is also recognized in other frameworks, e.g., as human resources under the factor conditions of the diamond model (Porter, 1990) and as the labor market sub-factor of the world competitiveness index of the IMD World Competitiveness Centre (Garelli, 2014). Based on these recognitions, the following is proposed.

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

3. R&D and innovation attractiveness: This dimension addresses the level and growth of R&D investments to promote the region's innovation performance (Sasson and Reve, 2012). R&D and innovation's central roles to enhance competitiveness are well-acknowledged (Pisano and Shih, 2009; Porter, 2001), and their relevance is recognized in other competitiveness frameworks, e.g., 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). Based on these recognitions, the following is proposed.

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

4. Ownership attractiveness: This dimension assesses a region's provisions to support its entrepreneurial ecosystem (Sasson and Reve, 2012). The impact of this dimension on competitiveness is also recognized by other competitiveness frameworks, e.g., as capital resources under the factor conditions in the diamond model (Porter, 1990), as the sophistication of financial markets pillar of the global competitiveness index by WEF (Sala-I-Martin et al., 2014), and as the business efficiency factor of the world competitiveness index of the IMD World Competitiveness Centre (Garelli, 2014). Based on these recognitions, the following is proposed.

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

5. Environmental attractiveness: Sensitivity for environmental concerns can become a source of competitive advantage by triggering the development of specialized knowledge on sustainable technologies and business models and respectively can contribute to the innovations of more sustainable products and services (Porter and van der Linde, 1995). This dimension addresses the firms' abilities to produce environment friendly products and services with environment-friendly operations in the region (Sasson and Reve, 2012). The impact of this dimension on competitiveness is also recognized in the environment sub-factor of the world competitiveness index of the IMD World Competitiveness Centre (Garelli, 2014). Based on these arguments, the following is proposed.

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

6. Cluster attractiveness: Clusters are geographic concentrations of firms, suppliers, related industries, and specialized institutions in a particular field (Porter, 1998). This dimension addresses the strength and specialization levels of clusters in the region (Sasson and Reve, 2012). A region with strong clusters and a high degree of specialization is argued to have more potential to generate innovations and drive employment and growth (Delgado et al., 2010; Porter, 1998). The impact of clusters on competitiveness is also recognized in the determinant of related and supporting industries in the diamond model (Porter, 1990). Based on these arguments, the following is proposed.

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

3. Methodology

3.1 Data collection

In order to test the hypotheses, states of the USA are studied because data on several essential indicators is regularly collected at this level, allowing for realistic and practical inquiries with fewer limitations (Audretsch and Feldman, 1996). *The US Cluster Mapping Project* (US Cluster

Mapping, 2016) is the main data source. The initiative's open online platform integrates comparable data and metrics on state attributes and performance. Data is also collected and triangulated from *the US Census Bureau, the National Science Board*, and *the US Energy Information Administration*. The dataset covers 47 states for the period from 1998 through 2013. States of Alaska and Hawaii are excluded from the final analysis as Alaska has an overly high GDP per capita while both states indicate the lowest values in almost all other variables. Vermont is also excluded, as we cannot find reliable cluster attractiveness data for this state. All three states behaved as outliers in the empirical models showing excessive variances. The choice of the time period is driven largely by data availability while missing values for a small number of indicators are computed through extrapolation, using proportions to relevant variables.

3.2 The model and its measures

The complete model, which assesses state competitiveness (the dependent variable) in terms of the selected control variables (time, metropolitan area, natural resources, manufacturing intensity, and region) and the independent variables (the six dimensions of the emerald model) is presented below, and the measures for the variables are summarized in Table 1 and described later.

State competitiveness = a_0 + a_1 time + a_2 metropolitan area + a_3 natural resources + a_4 manufacturing intensity + a_5 region + a_6 educational attractiveness + a_7 talent attractiveness + a_8 R&D and innovation attractiveness + a_9 ownership attractiveness + a_{10} environmental attractiveness + a_{11} cluster attractiveness.

** Insert Table 1 about here **

The dependent variable: State competitiveness is measured by the *state's gross domestic product (GDP) per capita*. GDP per capita is the most widely used economic measure in the literature, especially in explaining the relationship between clusters and prosperity (Franco et al., 2014), and it is regarded as a precise measurement because it is strongly correlated to regional competitiveness (Dijkstra et al., 2011). Furthermore, GDP per capita integrates some of the other related indicators in itself such as productivity, work-leisure balance, employment rate and dependency rate (Gardiner, 2003).

The independent variables: The measures for the independent variables are selected from among the measures suggested by Sasson and Reve (2012) according to their unique explanatory power of the dimensions and the availability of data. Educational attractiveness is measured by two indicators: 1) *state funding for higher education per full-time equivalent student enrollments,* and 2) *bachelor's degrees* conferred *per 1,000 individuals among 18–24 years old*. The two measures successfully complement each other in representing educational attractiveness of a state. Talent attractiveness is measured by the *ratio of employed science, engineering, and health (SEH) doctorate holders among all workers*, and R&D and innovation attractiveness is measured by the *ratio of business–performed domestic R&D to private–industry output*. Sasson and Reve (2012) suggest the amount of inbound foreign direct investment, the amount of venture capital, and the competences of the owners as potential measures for ownership attractiveness. Based on the availability of state-level data, ownership attractiveness is measured by *venture capital disbursed per $ 1,000 of GDP*, and environmental attractiveness is measured by the *share of renewable energy in total energy production*. Finally, cluster attractiveness is analyzed by two measures: 1) *cluster strength* for all sectors (see Delgado et al., 2010), and 2) *specialization on information technologies (IT)*. In the US Cluster Mapping project, cluster strength is measured as the percentage of traded employment in strong clusters. Specialization on IT reflects the spatial concentration of IT industry alone, and it is calculated based on the *location quotient (LQ)* (Glaeser et al., 1992; Porter, 2003).

The control variables: In order to rule out alternative state-level influences on the dependent variable, there are controls for metropolitan areas (measured by the *number of high-population metropolitan areas within the state*), manufacturing intensity (measured by the *ratio of manufacturing jobs to all jobs*), and natural resources (measured by the *state's total energy production in billion Btu*). There are also controls for time (measured by the *given year*) and region (measured with dummies for *Northeast, Midwest, South, and West*). The reason for using region dummies is to control for all unobserved regional influences (such as historical, political, and cultural), that can shape a given state especially regarding different institutional, social capital and cluster structures that might associate with our regression variables.

We believe the inclusion of the above controls as well as our large cross-section data with wide-area coverage helps to deal with possible endogeneity issues as it has been raised in the literature as a concern particularly for the use of specialization variables (e.g., Storper, 2010; Arezki et al., 2009). Besides the isolation of our measurement for the cluster attractiveness variable from the dependent variable measure (former is based on employment figures while the latter on GPD value) and the theoretical validity of emerald model's dimensionality (as it treats cluster effect as a unique factor separate from others), the presence of state-specific factors such as metropolitan density and state natural resources as catch-all variables and the region fixed effects in our empirical analysis ensures that important unobservable variables that could directly explain both the level of specialization and GDP per capita in a state are accounted for.

3.3 Data analysis

We follow a standard multiple regression model with OLS estimation to test the effect of each emerald dimension on state-level competitiveness. This approach allows us to include state-specific as well as time-specific effects. No panel or time-series specification is made, as the study does not have an aim to reveal underlying trends, growth patterns or evolution across time. We run separate models with alternative forward lagged dependent variables; an analysis strategy which enables to observe what extent proposed effects are sustainable over time and offers a more appropriate examination of causal links to competitiveness.

The literature suggests that it may take from four to eight years before competitiveness outcomes of present-day investments can be observed (Fritsch and Mueller, 2008; van Stel and Storey, 2004; van Stel and Suddle, 2008). Accordingly, we determine four and eight years of time lags to represent the short-term and the long-term for competiveness to develop. Applying a longer time lag would decrease our sample size and affect the reliability of the study negatively. Aiming to understand how the impacts of the dimensions change from four to eight years, we also run the model with six year time lag. We could also run the model with five and seven year time lags, but there was no need after checking the trends with the three proposed forward lags.

Based on these arguments, three separate models are run with four (Model-1), six (Model-2) and eight (Model-3) year forward lags for our dependent variable. This time-lag design enables testing and comparing the contributions of the theoretical framework in a more reliable way as it helps to rule out probable reverse-causation situations. In the first step of each model, we include only the control variables (the base model), while explanatory variables are introduced in the second step (the complete model). The unit of analysis across all models is a state-year.

It is important to detect the presence of possible autocorrelation in the data where the error terms can be correlated (violation of independent errors assumption). In order to check for it, we run the Durbin-Watson statistic. Test results indicate no possibility of an autocorrelation in the data as the test statistics in each model is between 1.50 and 2.50 and very close to 2.00 (see Table 3).

Heteroscedasticity can affect the validity or power of statistical tests when using OLS regression. Indeed, while our data is normally distributed across models, minor traces of heteroscedasticity were observed in the residual plots. An appealing method of removing this adverse effect on inference is to employ heteroscedasticity-consistent standard errors (HCSE) to OLS parameter estimates which allow to make sound estimations regardless of the type of heteroscedasticity present in the data (White, 1980; Hayes and Cai, 2007). Thus, we compute and report heteroscedasticity-consistent standard errors (HCSE) to ensure statistical validity of each regression model.

4. Results

4.1 Descriptive statistics

** Insert Table 2 about here **

The means, standard deviations and correlations of all variables are represented in Table 2 for Model-3 (also available for Model-1 and Model-2 upon request). There are significant variations among states in most variables. The average GDP per capita is $ 40,369. On average, 49.14 out of 1,000 young people between 18-24 years receive a bachelor's degree in high education while state support for higher education per full-time equivalent student is $ 6,723. On average, 0.39% of all workers are composed of science, engineering and health doctorate holders, implying a rather high degree of qualification within the workforce. On the other hand, business-performed domestic

R&D constitutes only 1.7% of the private-industry output, and venture capital disbursed per $ 1,000 is only $ 2.17. On average 31% of energy production comes from renewable sources, and the mean energy production of a state is 1,151 million Btu. Finally, mean cluster strength is 42.2%, and mean IT specialization is 0.99.

The pairwise correlations in Table 2 indicate that GDP per capita significantly correlates with several explanatory variables, the proportion of SEH degree holders in all workers, business R&D expenditures, and venture capital representing the highest ones among model predictors. Regarding control variables, one can identify a link between geographical regions and the dependent variable: a Southern state associates with lower and a Northeastern state with higher GDP per capita.

4.2 Testing of the hypotheses

** Insert Table 3 about here **

Table 3 presents the results of three separate regressions with different time lags. Model-1 (four-year lag), Model-2 (six-year lag) and Model-3 (eight-year lag) are each represented in the table by one base model (with control variables only), and by a complete model (with all predictors included). While Model-3 will be the reference to test the hypotheses, the findings about the varying impacts of the dimensions over time will be provided in a comparative manner. All regressions are determined by heteroscedasticity-consistent standard errors (HSCE) computations.

An overview of the adjusted R^2 values suggests that for each regression estimation, the complete model indicates a statistically better fit than the base model. For instance, in Model-3 (dependent variable with eight-year lag), while the base model explains 37.8% of the variance in GDP per capita, the complete model makes an extensive improvement and explains 59.6% of it. Similar improvements across base and complete models are also observed in both Model-1 and Model-2. When we observe the R^2 values and compare the efficiency across the three complete models, we again find a significant improvement of the amount of explained variance in competitiveness. That is, while Model-1 explains 55.8% of state-level competitiveness, Model-2 explains 59.9% of it, and this goes up to 61.3% in Model-3, implying that higher possible performance outcomes can be gained in longer periods compared to shorter ones.

Among the control variables, natural resources, measured by total energy production, significantly predicts competitiveness (β= .214, $p< .01$ in Model-3). While year fixed-effect and the number of big metropolitan areas in the state have no significant impact, manufacturing intensity has a negative impact (β= -.315, $p< .01$ in Model-3). The region where the state is located also has a significant impact on competitiveness.

With respect to the test of the study hypotheses, most of the independent variables have a statistically significant influence on the level of GDP per capita in Model-3. With respect to educational attractiveness, state higher education funding has a meaningful positive effect on competitiveness (β=.169, $p< .01$). Yet no significant relation of bachelor's degrees conferred can be found. Hence, *Hypothesis 1 is partially accepted*. Talent attractiveness has a significant effect on GDP per capita: higher share of science, engineering and health doctoral degree holders increases the competitiveness of the state (β= .167, $p< .05$). Hence, *Hypothesis 2 is accepted*. There is no significant impact of R&D and innovation attractiveness on GDP per capita. Hence, *Hypothesis 3 is rejected*. On the other hand, the amount of venture capital disbursed leads to higher GDP per capita (β= .175, $p< .01$). This *supports Hypothesis 4*. Environmental attractiveness also predicts higher GDP per capita (β= .261, $p< .01$). Hence, *Hypothesis 5 is also accepted*. For cluster attractiveness the two measures yield different results: whereas cluster strength for all sectors has a very significant and positive influence on competitiveness (β= .299, p< .01), there is no significant impact of IT specialization. Since the model yields a favorable outcome with respect to the overall agglomeration-effect predictions, *Hypothesis 6 is largely supported*. Based on the results of Model-3, the influential dimensions of the emerald model can be ranked according to their impacts on competitiveness from high to low in the order of cluster attractiveness (measured by cluster strength), environmental attractiveness, ownership attractiveness, educational attractiveness (measured by state higher education funding per student), and talent attractiveness.

Even though we determined Model-3 (eight year lag) as our benchmark model, it is also essential to make comparisons across the three models so that one can be able to assess differences over time in the impact of each emerald dimension. A comparison of the results from Model-3 with those from Model-1 and Model-2 allows us to conclude that the hypotheses' inferences are rather consistent over time regarding the substantial impact of educational attractiveness, ownership attractiveness, environmental attractiveness, and cluster attractiveness while R&D and innovation attractiveness remains insignificant across all periods. The only noticeable temporal difference in the analyses is the non-existing effect of talent attractiveness for the shortest period (four-years) whereas a significant impact is still observable in both six and eight-years lag structure. Remarkably, all significant attractiveness dimensions except ownership have largest coefficient sizes in Model-2 (six-year lag). It is probable that the highest possible impact of the overall attractiveness of a region is reached around such a particular point in time. From this point on, the continuing overall effect might become less pronounced and sparkly but more stable and predictable.

We suggest these findings imply that once the positive influences of essential educational, environmental, innovation and agglomeration policies are established and brought into force at the regional level, they do not easily disappear. It can also be claimed that the real impact of diverse factors on competitiveness start to grow after an initial phase of three-year time where they are first introduced. This is also consistent with what Fritsch and Mueller (2008) found in their analysis of German regions where a positive long-term effect on regional development starts only after three-four years. Even though our study cannot detect what happens before four years and after eight years, the presented lag structure lends itself nicely to the examination and comparison of the extent to which competitiveness factors change or persist across distinct periods.

5. Discussion

This study contributes to the literature on competitiveness in three ways. First of all, there have been few attempts to establish cause-effect relationships for competitiveness (Franco et al., 2014), and this study contributes to understand the extent to which the dimensions of the emerald model are influential on competitiveness. This in turn can enable wise allocation of resources in policies and programs to enhance competitiveness especially in the case of regions and states. Secondly, this is the first test of the emerald model in the USA and on the basis of states. Based on findings from the study, the emerald model is not only validated but also improved by demonstrating the varying temporal impacts of its dimensions on competitiveness. Finally, the study makes a significant temporal contribution by covering 16 years of data from 1998 to 2013, and taking into account time lags of four, six and eight years between the dependent and the independent variables. Applying time lags enables a more meaningful measurement of causality than competitiveness studies with cross-sectional designs, and offers the opportunity to understand how the impacts of the independent variables change over time.

The results are in line with earlier literature regarding the impacts of environmental attractiveness (Garelli, 2014; Porter and van der Linde, 1995), ownership attractiveness (Garelli, 2014; Porter, 1990; Sala-I-Martin et al., 2014), and talent attractiveness (Garelli, 2014; Porter, 1990). Whereas the finding on cluster strength supports earlier findings on the positive impact of clustering (Delgado et al., 2010; Porter, 1998), the finding on IT specialization is against expectations from earlier studies (Franco et al., 2014). Therefore, further research is recommended in this area to understand better the contradictory results regarding the impact of IT specialization. Regarding educational attractiveness, findings suggest that whereas state higher education funding has a positive impact on competitiveness, bachelor level education has no impact. This is an interesting result, which demands further enquiry. Future research could test the impacts of master and doctoral level education on competitiveness. The impact of R&D and innovation attractiveness being insignificant in all models is a big surprise, contrasting with earlier literature (Garelli, 2014; Pisano and Shih, 2009; Porter, 2001; Sala-I-Martin et al., 2014). This may suggest that R&D investments necessitate longer durations to have an impact on competitiveness. Further research on this dimension using other measures and longer time periods is recommended.

A limitation of this study is the exclusion of the moderating variable, knowledge dynamics, in the emerald model since we could not find a proper measure to study it at state level. This is not a surprise since earlier research also suggests that the state is too large to study spatial processes, which address knowledge and labor flows between firms (Krugman, 1991; Runiewicz-Wardyn, 2013). We recommend future research on this moderating variable, but in smaller units of analysis such as particular clusters. It is also proposed to test the emerald model in future research using different measures for competitiveness. A new approach involves the concept of 'Beyond GDP' goals, including the distribution of income and ecological sustainability as competitiveness outcomes, and defines competitiveness as the ability of a location to deliver 'Beyond GDP' goals for its citizens today and tomorrow (Aiginger and Vogel, 2015).

In summary, this is the first test of the emerald model in the USA. Similar tests in other contexts are needed to increase understanding. The testing of the dimensions provides a roadmap to state policy makers in the USA in prioritizing their competitiveness initiatives. Policies to promote cluster-based development, tackle environmental issues, and support the entrepreneurial ecosystem should be at the top of their agendas. These suggestions can contribute to the regional strategies developed under the leadership of the U.S. Council of Competitiveness funded by the federal government's Economic Development Administration (see Bristow, 2010).

References:

Aiginger, K., and Vogel, J. (2015), "Competitiveness: from a misleading concept to a strategy supporting Beyond GDP goals", *Competitiveness Review*, Vol. 25 No. 5, pp. 497-523.

Akpinar, M. and Mermercioglu, M. (2014), "Benchmarking competitiveness and innovation performances in information technology clusters from Finland and Turkey", *Finnish Business Review*, available at http://urn.fi/urn:nbn:fi:jamk-issn-2341-9938-3 (accessed 21 February 2016).

Annoni, P. and Dijkstra, L. (2013), *EU Regional Competitiveness Index (RCI 2013)*, available at http://www.consiglioveneto.it/crvportal/upload_crv/serviziostudi/1381245790976_indicecompetitivitaeuropeo.pdf (accessed 21 February 2016).

Arezki, R., Cherif, R. and Piotrowski, J. (2009), "Tourism specialization and economic development: Evidence from the UNESCO World Heritage list", IMF, No. 176, pp. 1-24.

Atkinson, R. D. and Stewart, L. A. (2012), *The 2012 State New Economy Index: Benchmarking Economic Transformation in the States*, Information Technology & Innovation Foundation, Washington, DC.

Audretsch, D. B. and Feldman, M. P. (1996), "R&D spillovers and the geography of innovation and production", *The American Economic Review*, Vol. 86 No. 3, pp. 630-640.

Benzaquen, J., Carpio, L. A. D., Zegarra, L. A. and Valdivia, C. A. (2010), "A competitiveness index for the regions of a country", *Cepal Review,* Vol. 102 Dec. 2010, pp. 67-84.

Bristow, G. (2010), *Critical Reflections on Regional Competitiveness: Theory, Policy, Practice*, Routledge, London.

Charles, V. and Zegarra, L. F. (2014), "Measuring regional competitiveness through data envelopment analysis: A Peruvian case", *Expert Systems with Applications*, Vol. 41 No. 11, pp. 5371-5381.

Cho, D. S. and Moon, H. C. (2005), "National competitiveness: Implications for different groups and strategies", *International Journal of Global Business and Competitiveness*, Vol. 1 No. 1, pp. 1-11.

Delgado, M., Porter, M. E. and Stern, S. (2010), "Clusters and entrepreneurship", Discussion Paper CES 10-31, Centre for Economic Studies, available at http://ssrn.com/abstract=1689084 (accessed 21 February 2016).

Dijkstra, L., Annoni, P. and Kozovska, K. (2011), "A new regional competitiveness index: Theory, methods and findings", *European Union Regional Policy Working Papers*, No. 2/ 2011, available at http://ec.europa.eu/regional_policy/sources/docgener/work/2011_02_competitiveness.pdf (accessed 21 February 2016).

Franco, S., Murciego, A. and Wilson, J. (2014), *European Cluster Observatory Report: Methodology and Findings Report for Correlation Analysis between Cluster Strength and Competitiveness Indicators*, European Commission, Enterprise and Industry, Brussels.

Fritsch, M. and Mueller, P. (2008), "The effect of new business formation on regional development over time: The case of Germany", *Small Business Economics*, Vol. 30 No.1, pp. 15-29.

Gardiner, B. (2003), "Regional competitiveness indicators for Europe – Audit, database construction and analysis", *Regional Studies Association International Conference*, 12-15 April 2003, Pisa, available at http://94.76.226.154/Libraries/Downloadable_Files/Regional_Competitiveness_Indicators_for_Europe_PDF.sflb.ashx (accessed 21 February 2016).

Garelli, S. (2014), "The fundamentals and history of competitiveness", in *IMD World Competitiveness Yearbook 2014*, IMD World Competitiveness Centre, Lausanne, pp. 492-507.

Glaeser, E. L., Kallal, H. D., Scheinkman, J. A. and Shleifer, A. (1992), "Growth in cities", *Journal of Political Economy,* Vol. 100 No. 6, pp. 1126–1152.

Hayes, A. F. and Cai, L. (2007), "Using heteroscedasticity-consistent standard error estimators in OLS regression: An introduction and software implementation", *Behavior Research Methods*, Vol. 39 No. 4, pp. 709-722.

Huggins, R. (2003), "Creating a UK competitiveness index: Regional and local benchmarking", *Regional Studies*, Vol. 37 No.1, pp. 89-96.

Huggins, R. and Izushi, H. (2008), "Benchmarking the knowledge competitiveness of the globe's high-performing regions - A review of the World Knowledge Competitiveness Index", *Competitiveness Review,* Vol 18 No.1/2, pp. 70-86.

Huggins, R., Izushi, H., Prokop, D. and Thompson, P. (2014), *The Global Competitiveness of Regions (Regions and Cities)*, Routledge, Oxon and New York.

Huovari, J., Kangasharju, A. and Alanen, A. (2001), "Constructing an index for regional competitiveness", Pellervo Economic Research Institute Working Papers, No. 44, available at http://ptt.fi/wp-content/uploads/2013/04/tp44_10080608.pdf (accessed 21 February 2016).

Kao, C., Wu, W. Y., Hsieh, W. J., Wang, T. Y., Lin, C. and Chen, L. H. (2008), "Measuring the national competitiveness of Southeast Asian countries", *European Journal of Operational Research*, Vol.187 No. 2, pp. 613-628.

Ketels, C. (2013), "Recent research on competitiveness and clusters: what are the implications for regional policy?", *Cambridge Journal of Regions, Economy and Society*, Vol. 6 No.2, pp. 269–284.

Kitson, M., Martin, R. and Tyler, P. (2004), "Regional competitiveness: An elusive yet key concept?", *Regional Studies*, Vol. 38 No. 9, pp. 991-999.

Krugman, P. (1991), *Geography and Trade*, MIT Press, Cambridge, MA.

Krugman, P. (1994), "Competitiveness: a dangerous obsession", *Foreign Affairs*, Vol. 73 No. 2, pp. 28-44.

Lall, S. (2001), "Competitiveness indices and developing countries: An economic evaluation of the global competitiveness report", *World Development*, Vol. 29 No. 9, pp. 1501-1525.

Lengyel, I. (2004), "The pyramid model: Enhancing regional competitiveness in Hungary", *Acta Oeconomica*, Vol. 54 No. 3, pp. 323-342.

Milken Institute (2016), *State Tech and Science Index*, available at http://statetechandscience.org (accessed 21 February 2016).

Moon, H. C., Rugman, A. M. and Verbeke, A. (1998), “A generalized double diamond approach to the global competitiveness of Korea and Singapore”, *International Business Review*, Vol. 7 No. 2, pp. 135-150.

Önsel, Ş., Ülengin, F., Ulusoy, G., Aktaş, E., Kabak, Ö. and Topcu, Y. I. (2008), “A new perspective on the competitiveness of nations”, *Socio-Economic Planning Sciences*, Vol. 42 No. 4, pp. 221-246.

Pisano, G. P. and Shih, W. C. (2009), “Restoring American competitiveness”, *Harvard Business Review*, Vol. 87 No. 7/8, pp. 114-125.

Porter, M. E. (1990), *The Competitive Advantage of Nations*, Free Press, New York.

Porter, M. E. (1998), “Clusters and the new economics of competition”, *Harvard Business Review*, Vol. 76 No. 6, pp. 77-90.

Porter, M. E. (2001), *Clusters of Innovation: Regional Foundations of U.S. Competitiveness*, Council on Competitiveness, Washington, DC.

Porter, M. E. (2003), “The economic performance of regions”, *Regional Studies*, Vol. 37 No. 6/7, pp. 549-578.

Porter, M. E. and van der Linde, C. (1995), “Green and competitive: Ending the stalemate”, *Harvard Business Review*, Vol. 73 No. 5, pp. 120-134.

Porter, M. E. and Rivkin, J. W. (2012a), “The looming challenge to US competitiveness”, *Harvard Business Review*, Vol. 90 No. 3, pp. 54-62.

Porter, M. E. and Rivkin, J. W. (2012b), “Choosing the United States”, *Harvard Business Review*, Vol. 90 No. 3, pp. 80-93.

Reve, T. and Sasson, A. (2015),"Theoretical and methodological advances in cluster research", Competitiveness Review, Vol. 25 No. 5, pp. 524-539.

Rugman, A. M. and D'Cruz, J. R. (1993), "The double diamond model of international competitiveness: Canada's experience", *Management International Review*, Vol. 33 No. 2, pp.17–39.

Runiewicz-Wardyn, M. (2013), *Knowledge Flows, Technological Change, and Regional Growth in the European Union*, Springer, Heidelberg.

Sala-I-Martin, X., Bilbao-Osorio, B., Blanke, J., Hanouz, M. D., Geiger, T. and Ko, C. (2014), "The global competitiveness index 2014-2015: Accelerating a robust recovery to create productive jobs and support inclusive growth", in Schwab, K. (Ed.), *The Global Competitiveness Report 2014-2015: Full Data Edition*, World Economic Forum, Geneva, pp. 3-52.

Sasson, A. and Blomgren, A. (2011), *Knowledge-based Oil and Gas Industry*, Research Report 3/2011, BI Norwegian Business School, Oslo.

Sasson, A. and Reve, T. (2012), "Competitiveness as industrial attractiveness: Operationalizing the emerald model", Microeconomics of Competitiveness Research Workshop, December 10, 2012, Harvard Business School, Boston, MA.

Snieška, V. and Bruneckienė, J. (2009), "Measurement of Lithuanian regions by regional competitiveness index", *Engineering Economics,* Vol. 61 No. 1, pp. 45-57.

Sölvell, Ö. (2015), "The Competitive Advantage of Nations 25 years – opening up new perspectives on competitiveness", *Competitiveness Review*, Vol. 25 No. 5, pp. 471-481.

Stierna, J. and Vigier, P. (Eds.) (2014), *Innovation Union Competitiveness Report 2013*, Publications Office of the European Union, Luxembourg.

Storper, M. (2010), "Why does a city grow? Specialisation, human capital or institutions?", *Urban Studies,* Vol. 47 No. 10, pp. 2027-2050.

The Beacon Hill Institute (2014), *14th Annual State Competitiveness Report*, available at http://www.beaconhill.org (accessed 21 February 2016).

US Cluster Mapping (2016), available at http://www.clustermapping.us/ (accessed 21 February 2016).

van Stel, A. and Storey, D. J. (2004), "The link between firm births and job creation: Is there a Upas tree effect?", *Regional Studies*, Vol. 38 No. 8, 893-909.

van Stel, A. and Suddle, K. (2008), "The impact of new firm formation on regional development in the Netherlands", *Small Business Economics*, Vol. 30 No.1, pp. 31-47.

Vinje, V. and Nordkvelde, M. (2011), *Knowledge-based Telecom Industry*, Research Report 13/2011, BI Norwegian Business School, Oslo.

White, H. (1980), "A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity", *Econometrica*, Vol. 48, pp. 817-838.

Table 1. Variables and their measurements

Variable	Type of variable	Measure
State competitiveness	Dependent	Annual GDP per capita
Time	Control	Given year
Metropolitan area	Control	Number of high-population metropolitan areas within the state
Natural resources	Control	State's total energy production (billion Btu)
Manufacturing intensity	Control	Ratio of manufacturing jobs to all jobs
Region	Control	Dummies for Northeast, Midwest, South, and West
Educational attractiveness	Independent	1) State funding for higher education per full-time equivalent student enrollments ($ per student) 2) Bachelor's degrees conferred per 1,000 individuals among 18–24 years old (%)
Talent attractiveness	Independent	Ratio of employed science, engineering, and health (SEH) doctorate holders in all workers (%)
R&D and innovation attractiveness	Independent	Ratio of business–performed domestic R&D to private–industry output (%)
Ownership attractiveness	Independent	Venture capital disbursed per $ 1,000 of GDP
Environmental attractiveness	Independent	Share of renewable energy in total energy production (%)
Cluster attractiveness	Independent	1) cluster strength for all sectors (% of traded employment in strong clusters) 2) specialization on information technologies (LQ)

Table 2. Descriptive statistics[a]

	Mean	SD	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. GDP per capita ($)	40369	6465									
2. Year			.013								
3. Metropolitan area	2.65	2.10	.230**	.007							
4. Total energy production	1151	1643	.050	-.003	-.049						
5. Manufacturing intensity	.13	.04	-.276**	-.248**	.026	.057					
6. Region: West			.000	-.008	-.111*	-.049	-.439**				
7. Region: South			-.368**	.019	.197**	.190**	.111*	-.378**			
8. Region: Midwest			.037	-.014	-.174**	-.067	.330**	-.321**	-.423**		
9. Region: Northeast			.409**	.002	.078	-.103	-.039	-.251**	-.331**	-.281**	
10. State education funding	6723	1436	.242**	-.071	.089	-.084	.089	-.309**	.150**	-.089	.253**
11. Bachelor's degrees	49.14	11.66	.239**	.056	-.223**	-.192**	.098	-.280**	-.435**	.290**	.503**
12. Employed - SEH degree	.39	.17	.487**	.048	-.321**	-.147**	.089	.173**	-.234**	-.230**	.364**
13. Business R&D	1.7	1.2	.434**	-.061	0.89	-.108*	-.321**	.167**	-.458**	-.017	.400**
14. Venture capital	2.17	3.55	.415**	-.227**	-.066	.047	-.066	.175**	-.133*	-.234**	.242**
15. Renewable energy share	.31	.32	.213**	-.006	-.005	-.445*	-.005	.027	-.141**	-.026	.174**
16. Cluster strength	42.2	13.6	.235**	-.055	-.077	.216	-.077	.038	.186**	-.207**	-.031
17. IT specialization	.99	.78	.247**	-.035	-.117*	-.057	-.117*	.449**	-.399**	-.134*	.157**

N = 355.
[a] All statistics are calculated for Model-3.
** $p <$ .01 level (2-tailed).
* $p <$ .05 level (2-tailed).

Table 2. Descriptive statistics (cont'd)

	10.	**11.**	**12.**	**13.**	**14.**	**15.**	**16.**
10. State education funding							
11. Bachelor's degree	.225**						
12. Employees with SHE	.189**	.229**					
13. Business R&D	.087	.268**	.517**				
14. Venture capital	.025	.098	.390**	.391**			
15. Renewable energy share	.095	.240**	.200*	.319**	.161**		
16. Cluster strength	.158**	-.336**	.089	.134**	.215**	-.394**	
17. IT specialization	-.170**	.143**	.288**	.461**	.329**	.482**	-.245**

N = 355.
All statistics are calculated for Model-3.
** $p <$ .01 level (2-tailed).
* $p <$ .05 level (2-tailed)

Table 3. Multiple regression estimates of GDP per capita with lags of four, six and eight years

	Model-1[a]		**Model-2[b]**		**Model-3[c]**	
	Base	Complete	Base	Complete	Base	Complete
Control variables						
Time	.133 (246.8)	.136 (214)	.070 (252.6)	.101 (205.4)	-.072 (125.8)	.001 (106.2)
Metropolitan area	.225** (119.1)	.044 (96.7)	.235** (128.5)	.032 (97.5)	.258** (171.7)	.054 (143.3)
Natural resources	.147** (.00)	.274** (.00)	.107* (.00)	.237** (.00)	.072* (.00)	.214** (.00)
Manufacturing intensity	.149 (5648)	.145 (5364)	.163 (5462.7)	.157 (4955)	-.355** (7537.2)	-.317** (7263.4)
Region	Yes	Yes	Yes	Yes	Yes	Yes
Independent variables						
Educational attractiveness (state education funding)	.	.160** (.2)		.207** (.23)		.169** (.27)
Educational attractiveness (bachelor's degrees)		-.075 (28.3)		-.035 (33.1)		.060 (33.5)
Talent attractiveness		.262 (5338.2)		.298* (5718.4)		.167* (2818.6)
R&D and innovation attractiveness		-.045 (838.1)		-.123 (848.5)		.001 (377.9)
Ownership attractiveness		.123** (90.3)		.165** (90.1)		.175** (89.4)
Environmental attractiveness		.284** (1304.9)		.267** (1306.4)		.261** (11.05.4)
Cluster attractiveness (cluster strength)		.299** (24.3)		.320** (25.3)		.299** (20.2)
Cluster attractiveness (IT specialization)		.002 (538.6)		.051 (490.1)		.068 (430.8)
Constant	31923.3 (8517.4)	18707.0 (9200.8)	32804.7 (8315.8)	15893.3 (8691.7)	41954.1 (1516.5)	23891.8 (3390.4)
Adjusted R^2	.314	.545	.306	.585	.378	.596
F statistics	35.998	43,728	28,781	42,500	31,701	35,776
Durbin-Watson test		2,132		2,131		2,063
No. of observations	535	535	443	443	355	355

Heteroscedasticity-consistent standard errors are shown in parentheses.

[a] Model-1 dependent variable: four-*year forward lagged GPD per capita*
[b] Model-2 dependent variable: six-*year forward lagged GPD per capita*
[c] Model-3 dependent variable: eight-*year forward lagged GPD per capita*

** $p <$ .01 level (2-tailed).
* $p <$ .05 level (2-tailed).