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Skilled Human Capital Availability and Traded Industry Cluster Strength: Establishing an Empirical Link

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Abstract

A new construct is suggested to explain the strength of certain industry clusters as a function of regionally awarded bachelor and master's degrees in fields related to those clusters in an attempt to establish an empirical link between highly skilled human capital availability and the strength of traded regional clusters. The study uses regression analysis and time series data from existing sources to determine the relationship between bachelor and master's degrees and strong traded clusters. Such a link does not exist in the literature today and could accelerate the transition of cluster theory to practical application for economic development. One potential application is a creative and innovative industry cluster design tool that provides investors and economic developers a low cost, qualitative method for identifying latent industry clusters. This, and other potential cluster development tools, assume a theoretical link between cluster success and identifiable factors of production. However, none of the cluster research to date has quantified the relationship between the factors of production, including highly skilled human capital availability, and cluster strength. Empirical evidence of a link between regionally awarded bachelor and master's degrees and the strength of related clusters in those regions would provide a justification for systematic coordination between educational program design and regional economic development policies and funding.

Keywords:economic development, strong traded clusters, skilled human capital; human capital availability

Introduction

Industry clusters are geographic aggregations of interconnected businesses and associated institutions (Faley, 2016; Porter, 1990).Ideally, a region's limited resources are targeted at firms that build, support, or grow the region's competitively advantaged industry clusters. Rather than approach economic development, particularly in fragile economies, as a series of stand-alone, single-company projects, the cluster approach allows for a strategic, systems approach to regional economic development. Industry and occupational cluster theory are extensionsof Porter's work,entitled*The Competitive Advantage of Nations* (1990), which expanded his theory of the competitive advantage of individual firms to nation states. Through an examination of ten trading nations, Porter concluded that firms and, by extension, industry clusters that both align with and reinforce local, regional,

or national economic strengths have a greater and more lasting impact on the economy than firms or clusters that do not (Porter, 1990).

Industry clusters and occupation analysis are not new concepts. Scholars have researched industry clusters for decades, particularly in developing the methodology for identifying industry clusters (Delgado, Porter, & Stern, 2014). Similarly, scholars have substantiated the value of occupation analysis for economic development long ago (Thompson& Thompson, 1987). Some work has been done to identify occupational clusters and the intersection of industry clusters, occupations, and occupational skill sets (Markusen, 2002; Feser, 2003; Feser, Renski, & Goldstein, 2008). Collectively, this work has created a substantial set of theoretical tools for more effective economic development, but examples of practical application are limited. The most recent and practical application of cluster theory is the development of tools to identify latent, but potentially impactful future regional clusters with promising potential outcomes for developing and fragile economies. Once such tool, described in "Future Industry Cluster Design Methodology"(Faley, 2016) in the *Journal of Economic Development in Higher Education*, allows the economic developer to screen and improve rough concepts for new regional industry clusters without investing an enormous amount of time and money in traditional detailed feasibility studies (Faley, 2016). International research interest in the practical application of cluster theory for economic development is evidenced by the recent publication "Main Stages of the Formation of an Economic Cluster"(Mindlin, Zhukov, Prokhorova, Shutilov, & Belova, 2016) in the *Russian International Journal of Economics and Financial Issues.*

What is lacking in the research to date are empirically based links between the factors of production and regional traded cluster strength for state and local governments to justify expenditures on economic development programs. A common thread running through all the cluster-theory analysis and application is a consensus that a steady source of industry-specific highly skilled human capital is necessary for a cluster to develop a competitive advantage and to produce the economic prosperity evidenced by existing strong regional industry clusters. This research proposes a model for understanding and quantifying the impact of the primary sources of highly skilled human capital on the creation of a strong, regional traded industry cluster. More specifically, this research seeks an empirical link between the co-location of colleges and universities and the growth of strong, traded clusters in an economic region. Quantification of this link would provide a powerful justification for systematic coordination between educational program design and regional economic development policies and funding. Further, an empirical link between educational programs and strengthening regional traded clusters begins to validate the cluster design tools that identify latent industry clusters using a qualitative or quantitative assessment of the known factors of production necessary for the development of specific industry clusters. If such a link could be established, economic developers, both public and private, could use the relative strength of the bachelor and master's degrees awarded by field of study in an economic region to indicate industries that are likely to be successful in the region. Or, if policymakers or investors have an interest in developing a specific business or industry, they could then begin to work with regional colleges and universities to create programs that would provide an ongoing source of skilled human capital needed by industries being developed. Finally, an empirical link between field of study and opportunities for local employment would help to inform the program design of regional colleges and universities, particularly with respect to building or supporting specific industry strengths.

Background

Cluster theory (Porter, 1990) provides a relatively new explanation for why some businesses, industries, economic regions, and nations do better than others. Research has quantified the existence and competitive advantage of clusters so convincingly that the U. S. Economic Development Authority has funded the U.S. Cluster Mapping Project (CMP) in conjunction with Harvard Business School (HBS). The CMP's mission is to gather and make available reliable and consistent data on the economic performance of 51"traded" clusters and 16 "local" clusters in 179 separate economic regions that encompass the entire fifty United States(but exclude Puerto Rico and the U.S. Virgin Islands) (HBS, 2010, 2018, U.S. CMP, 2018).

Cluster theory and research to date have producedconvincing justification for enhancing strong clusters or arguing for the support needed for infant clusters to develop and flourish. Cluster theory has the potential to be an even more powerful economic development tool if the cluster theory and data can be used in a predictive way

to pinpoint the potential for new cluster development.

Emerging Cluster Development Tools

The implications for economic development have always been at the forefront of the industry and occupational cluster research and analysis (Cortright, 2006; Delgado, Porter & Stern, 2014;Delgado & Stern, 2014; Porter, 1998, 2014; Rosenfeld, 2002). Though many have talked and written about the implications of cluster theory and the CMP for economic development, only recently have researchers developed tools, methods, or processes that investors, economic developers, or policy makers can use to put cluster theory to work. Developers need to envision and nurture currently latent economic clusters in their region in addition to attending to current economies. But before these future clusters can be developed, they need to be designed (Faley, 2016). Not every industry cluster has an equal probability of success in every region. Successful clusters emerge from a region's unique combination of the four corners of the Porter Diamond which are (1) factor conditions, (2) demand conditions, (3) supporting and related industries, and (4) firm strategy, structure, and rivalry (Porter, 1990).

Faley (2016) suggested a methodology to assist in the early-stage design of future regional economies that allows the economic developer to screen and improve rough concepts for new regional industry clusters without investing an enormous amount of time or resources on a full-blown Porter Diamond analysis of a regional cluster or traditional feasibility studies. An early-stage screening and reformulating mechanism provides the opportunity to explore a wide array of regional options before investing in the detailed assessment of a few (Faley, 2016, p. 4).

Validating Predictive Cluster Tools

The transformation of theory into a practical tool that can be used with confidence to inform economic development decisions to pursue or abandon an industry or occupational cluster depends on empirical evidence of the extent to which specific factors of production drive the emergence of strong traded clusters in economic regions. Porter argued (1990, 2000, 2003) that a pool of specialized, highly skilled talent is necessary to create a competitive cluster with the ability to trade outside of its economic region. It is these traded clusters that increase productivity, create a competitive advantage, and drive prosperity. Research shows that clusters exist, they accelerate growth and prosperity through increased employment and entrepreneurship, and they prove to be resilient in general economic downturns like the Great Recession (Porter, 2009; Delgado, Porter & Stern, 2012, 2015). However, there is no empirical evidence to date to link any of the factors of production to strong traded clusters that are the basis of current economic development theory.

One of the primary Porter Diamond factor conditions necessary for competitive advantage is a steady source of highly skilled human capital. If traded cluster strength is a function of the availability of relevant skilled human capital, we should be able to measure, for example, the effect of a greater concentration of finance degrees on the strength of a financial cluster. Additionally, a higher technology degree concentrationshould strengthen a technology clusteranda higher chemical engineering degree concentrationshould strengthen an oil and gas production cluster.Thislevel of quantification could have a significant impact on the allocation of limited economic development resources in both the public and private sector. Quantifying the link between regional post-secondary fields of study and regional economic development could drive empirically based coordination between economic developers and university faculty and administration on a regional level, particularly those involved in academic program design. This would lead to a more efficient allocation of resources for both economic development and regional colleges and universities.

The goal of this research is to quantify the importance of local colleges and universities as a regional source of highly skilled human capital availabilityby addressing the following primary research question: Does the concentration of bachelor and master's degrees awarded in a region by field of study make a significant contribution to traded cluster strength in those clusters that depend on employing people with degrees in those fields of study?In other words, do industry clusters benefit from being close to colleges and universities with strengths in related disciplines? By including all regional sources of human capital in a model to explain traded cluster strength, this research also addresses the following secondary research questions: How much does

domestic or international labor migration between economic regions account for the availability of highly skilled human capital for strong industry clusters? How much is an industry cluster responsible for the development of its own highly specialized source of human capital?

Methodology

This study focused on quantifying the impact of local colleges and universities as a regional source of highly skilled human capital availability toanswer the research question: Does a high concentration of bachelor and master's degrees awarded by colleges and universities in a region make a significant contribution to regional traded cluster strength in clusters that depend on people with those degrees? However, this question cannot be answered in isolation since regional colleges and universities are not the only source of highly skilled human capital for employment in industry clusters. Therefore, this study suggests a new construct to explain the strength of certain strong traded clusters as a function of various sources of highly skilled human capital including regionally awarded bachelor and master's degrees in fields related to those clusters, net domestic migration, net international migration, and cluster generated expertise on a regional basis. The model is designed to explain the strength of degree-related traded clusters, in other words, those that rely on people holding bachelor and master's degrees in fields of study that are necessary for the work that is being done by the strong traded cluster. Strong traded clusters that do not rely on human capital with bachelor and master's degrees such as clusters that depend on specialized technical and vocational training, are not included in this research.

A model of regional traded cluster strength expands the scope of the research beyond a singular focus on the role of regional colleges and universities to provide a more systematic understanding of what each of the sources of highly skilled human capital contributes to regional traded cluster strength. An estimation of this model not only addresses the primary research question but also the secondary research questions by quantifying the contribution of each of the sources of regional highly skilled human capital to traded cluster strength.

Research Design and Model Specification

The model suggested in this research is an equation where traded cluster strength is a function of related degree concentration, net domestic migration, net international migration, and cluster generated expertise. The terms region and regional used here and throughout the study are synonymous with the 179 U. S. Bureau of Economic Analysis (BEA) defined Economic Areas (EAs). The research model for regional traded cluster strength is expressed as the following equation:

$$\begin{aligned} \textit{Traded Cluster Strength}_i = b_o & \\ & + b_1(\textit{Degree Concentration}_i) \\ & + b_2(\textit{Net Domestic Migration}_i) \\ & + b_3(\textit{Net International Migration}_i) \\ & + b_4(\textit{Cluster Generated Expertise}_i) \\ & + e_i \end{aligned}$$

Where i is the number of observations,b_o is a constant and e is an error term that represents the variation in regional traded cluster strength not explained by the model.Usingthis equation for the model, the alternative hypothesis (H_1) and the null hypothesis (H_0) are stated as follows for any given economic region:

- H_1: There is a significant positive relationship between degree concentration, net domestic migration, net international migration, cluster generated expertise and traded cluster strength.
- H_0: There is no relationship between degree concentration, net domestic migration, net international migration, cluster generated expertise and traded cluster strength.

This study uses ordinary least squares (OLS) multiple regression analysis to estimate the model defined above. Independent variables that represent various sources of skilled human capital availability in an economic region are used to estimate a model that predicts the strength of traded clusters, the dependent variable.

Data Sources

The study usesdata from the U.S. Cluster Mapping Project (CMP)for the dependent variable, regional traded industry cluster strength, and three of the independent variables: net domestic migration, net international migration, and cluster generated expertise. The CMP is a national economic initiative that provides over fifty million open data records on industry clusters and regional business environments in the United States to promote economic growth and national competitiveness. This data includes time series data on the fifty-one traded clusters in 179 economic regions.

Data from the U.S. Department of Education Digest of Education Statistics is used to develop a measure of the concentration of post-secondary education degrees by field of study, the first independent variable in the model. The National Center for Education Statistics (NCES) is the primary federal entity for collecting and analyzing data related to education in the U.S. and other nations. NCES is part of the U.S. Department of Education and the Institute of Education Sciences. NCES fulfills a Congressional mandate to collect, collate, analyze, and report complete statistics on the condition of American education, conduct and publish reports, and review and report on education activities internationally.

Determining the Study Population and Sample Size

The study population was limited to the fields of study for which there was data available for all economic regions over time. Since regional field of study data is not collected and available from the CMP, state data on field of study compiled by the U.S. Department of Education and reported annually in the Digest of Educational Statistics was used. The availability of field of study data reduced the total theoretical population from 9,129 traded clusters (51 traded clusters x 179 economic regions), to 4,654 (26 degree-related clusters x 179 economic regions). The 26 degree-related clusters are listed in Table 1.

Table 1

Field of Study[1] and Associated Traded Cluster[2]

Field ofStudy	TradedCluster
1. Business Management	1. Business Services 2. FinancialServices 3. InsuranceServices
2. ComputerScience and Engineering	4. AerospaceVehicles and Defense 5. CommunicationsEquipment and Services 6. Distribution and eCommerce 7. Electric PowerGeneration and Transmission 8. InformationTechnology and Analytical Instruments 9. MetalworkingTechnology 10. ProductionTechnology and Heavy Machinery 11. Transportation and Logistics 12. Upstream Metal Manufacturing 13. Video Production and Distribution
3. Education	14. Education and KnowledgeCreation
4. Humanities	15. Apparel 16. Hospitality and Tourism 17. Marketing, Design, and Publishing 18. Music and SoundRecording 19. PerformingArts
5. Natural Sciences	20. Biopharmaceuticals 21. Downstream Chemical Products 22. EnvironmentalServices 23. Medical Devices 24. Oil and Gas Production and Transportation

25. Plastics
26. Upstream Chemical Products

Sources: [1] National Center for Education Statistics, Digest of Educational Statistics; [2] U.S. Cluster Mapping Project.

The population was further reduced to only the *strong* degree-related traded clusters in 2016 in each of the 179 economic regions. A strong traded cluster in a region is a designation assigned to a cluster in the CMP when a cluster is in the top twenty-five percent of all regions measured by the ratio of the regional percent of employment in a cluster to the national percent of employment in that cluster. An average of five strong degree-related clusters were found in each of the 179 economic regions but ranged from none in a one region to as many as 11 in another. The identification of strong degree-related clusters in each economic region produced a total study population of 881 regional cluster/degree pairs for this study. A stratified random sampling method was used to select 100 cluster/degree pairs as the sample population from the total population. The stratification was based on the frequency of cluster/degree pairs in an economic region. A stratified random sample ensures that the study is not biased towards regions with greater numbers of cluster/degree pairs in the total population. If the model is reliable, its coefficients will be significant regardless of how many strong clusters there are in a region, so it is important to include cluster/degree pairs from regions where there are only a few pairs as well as regions where there are many pairs.

Data Design and Construction

Time series data was constructed for each of the 100 cluster/degree pairs to estimate the model parameters resulting in 100 independent estimates of the model parameters. Each data set contains sixteen years of data from 2001 to 2016 on cluster strength, the dependent variable, and the four predictors, or independent variables: regional degree concentration, net domestic migration, net international migration, and cluster generated expertise. Traded cluster strength and regional degree concentration are calculated variables while net domestic migration, net international migration and a proxy for cluster generated expertise are used exactly as they are reported in the CMP.

This research uses the CMP definition and calculation of traded cluster strength, which depends on the relative concentration of jobs in an economic region. The CMP gives this relative concentration of jobs the term Specialization. Specialization is measured by the value of the cluster's Location Quotient. A Location Quotient is the ratio of the regional percent of employment in a cluster to the national percent of employment in that cluster. If the ratio of cluster jobs in the region is greater than the ratio of cluster jobs in the nation overall, the region, by CMP definition, is specialized in that cluster and is designated as a strong traded cluster in that region. Following is the CMP equation for Location Quotient, which is the measure of a traded cluster strength (TCS) used in this study:

TCS = (Regional traded cluster employment/
Total regional employment)/
(Total cluster employment in the United States/
Total of all traded cluster employment in the United States)

A TSC greater than 1 indicates a higher-than-average cluster employment concentration in a location and is indicative of cluster strength. The CMP calculation of TSC in 2016 was the basis for determining the total population for the study as described earlier. CMP time series data for the four variables in the equation above was used to construct the Location Quotient for each of the 100 cluster degree pairs for each year from 2001 to 2016.

Regional degree concentration (RDC) is the first independent variable in the model equation. RDC is determined by using the same logic employed by the CMP to construct the Location Quotient and TCS. The underlying implication in using a concentration ratio for RDC is that cluster strength over time is not simply a function of the absolute number of degrees awarded in fields related to those clusters. The model attempts to capture, and measure, the implication that it is the relative concentration of degrees awarded by regional colleges and universities related to a cluster that ultimately contributes to cluster strength. An RDC greater than 1

indicates a higher-than-average degree concentration in a region. Following is the equation for RDC which measures highly skilled human capital availability generated by regional colleges and universities:

RDC = (Regional degrees related to the cluster/
Total regional degrees)/
(Total United States degrees related to the cluster/
Total United States degrees)

Regional traded cluster employment was selected as the proxy for Cluster Generated Expertise (CGE). The criteria for selecting the proxy were data availability, consistency with the logic of cluster strength at the core of the CMP, and that the proxy is not correlated with the other three independent variables in the model. Regional cluster employment on a relative basis drives cluster strength as described above in the section on the construction of TCS. However, employment growth in absolute terms is an indication of the competitive success of a firm, industry, or cluster. According to Porter (1990, 2000, 2009), the determinants of competitive advantage are a dynamic system and employment growth, which are indicative of the self-reinforcing Porter Diamond. One of the self-reinforcing aspects of the Porter Diamond is the development and institutionalization of in-house expertise that leads to creativity and innovation. As an industry evolves, the self-reinforcing Porter Diamond holds the key to upgrading and sustaining competitive advantage (Porter, 1990).

Analysis Results

The regression results indicate a good overall fit of the model as measured by the adjusted R^2 and the F-ratio as shown in Table 2 and Figure 1. However, in contrast tothe good results for model fit, only a few of the regressions produced significant coefficients for the independent variables as measured by the T-value and shown in Appendix 1 for the entire sample population. Generally, if none of the independent variables are statistically significant, the overall F-ratio is also not statistically significant. Occasionally, the tests can produce conflicting results as in this study. The disagreement can occur because the F-ratio of overall significance assesses all the coefficients jointly whereas the T-value for the significance of the coefficients examines them individually. In other words, the overall F-ratio can find that the coefficients are significant jointly while the T-value can fail to find significance individually. The F-ratio sums the predictive power of all independent variables and determines that it is unlikely that all the coefficients equal zero. However, it is possible, as seems to be the case with the results of this study, that each variable is not predictive enough on its own to be statistically significant, except for Cluster Generated Expertise. In other words, the sample provides enough evidence to conclude that the model is significant, but not enough to conclude that any individual variable is significant (Frost, 2018).Avariance inflation factor (VIF) was calculated for each independent variable along with the average VIF for the four independent variables in a data set determine the extent to which multicollinearity could be undermining the statistical significance of the model coefficients. Only five of the data sets produced an average VIF greater than 5.0 and only one of the 100 data sets produced an average VIF greater than 10.0 which indicates that the independent variables are not highly correlated with one another.

Table 2

Variation in Traded Cluster Strength Explained by the Model

Number of Samples	R^2
32	.95
38	.75but less than .95
10	.50 but less than .75
7	.25 but less than .50
13	Less than .25%

Note: The adjusted R^2 statistic indicates the percent of variation in the dependent variable explained by the model.

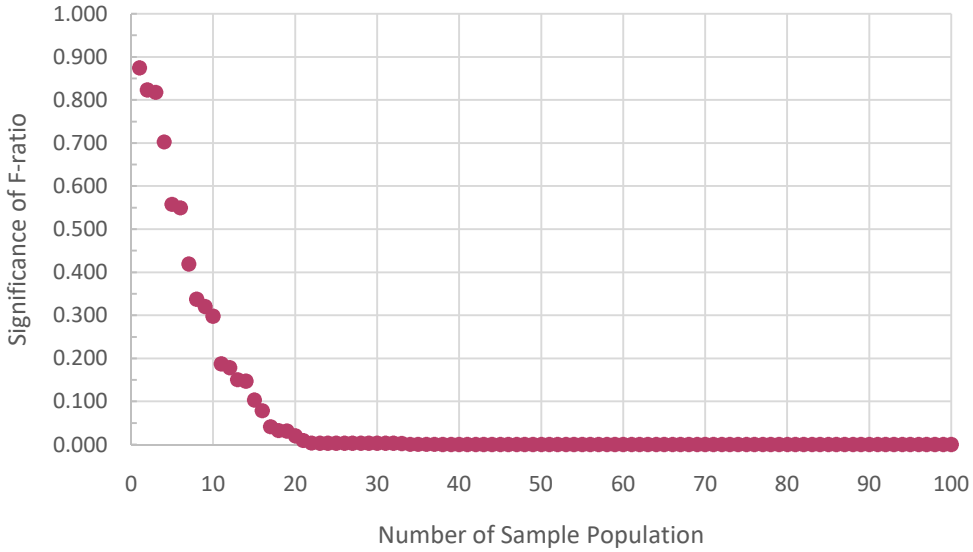

*Figure 1*shows the significance of the F-ratio in the Sample Population. The plot indicates that eighty-four cluster/degree pairs produced F-ratios that were significant at the .05 level

In the context of the model used for this study, it appears that Regional Degree Concentration has the least impact on established traded cluster strength while Cluster Generated Expertise has the greatest impact. Net Domestic Migration and Net International Migration have about the same effect on traded cluster strength, and slightly more effect than Regional Degree Concentration.

All the coefficients of the independent variables need to be significant if a model is to have validity and reliability as a predictive tool. Only two cluster/degree pairs produced significant positive coefficients for all four of the independent variables. There are not enough simultaneous significant T-values for the model coefficients to reject the null hypothesis and accept the hypothesis that for any given economic region there is a significant positive relationship between traded cluster strength and degree concentration, net domestic migration, net international migration, and cluster generated expertise.

Implications

The counter-intuitive result of this study, that there is no significant relationship between the concentration of degrees and strong established traded clusters in an economic region, has implications for regional economic development and the role of regional colleges and universities in that development. If regional colleges and universities do not play a significant role in providing highly skilled human capital for strong traded clusters, then what is their role? While they seem less important to the continuation of established traded clusters, are they important to the initial formation of these clusters? Perhaps the co-location of colleges and universities may have a greater impact in the development of the local clusters in a regional economy. This study looked at *strong, established* traded clusters and did not address local clusters. A local cluster is composed of industries which are present in most geographic areas and primarily sell within the regional economy. Local clusters include infrastructure businesses such as utilities, construction, logistical and commercial services, as well as quality of life businesses such as restaurants, hotels, entertainment, education, and health care. Perhaps the role for regional colleges and universities is to produce an educated pool of human capital for the developmentof local clusters that support the infrastructure and create the quality of life that makes a region attractive to the highly skilled human capital that a region must attract for the development of strong traded clusters. Perhaps traded clusters leverage transferable skills from local clusters giving colleges and universities an indirect, but essential, role in traded cluster strength.

Many of the 100 data sets developed for the regression analysis show negative net domestic migration over the sixteen years analyzed and positive net international migration. The trends observed in the data may indicate that very mobile, highly skilled international human capital has been driving traded cluster strength for at least

the last sixteen years in ways not captured by the model proposed in this study. Some suggest (Moretti, 2013) that it may be too late for all colleges and universities in the United States to be in the business of generating the world's highly skilled human capital, as it once did, but not too late for the schools that are already preeminent in their field, such as Harvard Law, MIT engineering, and NYU performing arts to maintain a competitive advantage in those fields. It is also not too late for a school to choose to specialize with the strategic objective to produce highly mobile graduates targeted for the highly skilled jobs anywhere in the world needed to create strong traded clusters.

The alternative to either providing human capital for local clusters or specializing for targeted job markets is for colleges and universities to co-locate and develop strength as an educational traded cluster. Co-located colleges and universities would need to coordinate the development of the infrastructure and quality of life local clusters that are necessary to bind together more colleges and universities to from a strong traded cluster in education such as those in Minneapolis, MN and Raleigh, NC.The consolidation of local and regional hospitals into larger healthcare systems may provide the blueprint for local and regional colleges and universities to follow to develop strength as a traded cluster in education.

Research Recommendations

The results of this study provide evidence about what does not significantly support established traded cluster strength, but not *what does* in a conclusive way. The question of *what does* can be approached by taking either a *step further in* or a *step back from* this study. One *step in* is to address some obvious data limitations by focusing on only a few region clusters. It may be possible to (1) gather degree data related to the cluster from colleges and universities in the region rather than use state data, (2) be more specific about the degrees that are important to employment in the region cluster, (3) look at migration data at the region-cluster level rather than the region level, (4) develop and test various measures for cluster generated expertise, and (5) gather more than sixteen years of time series data. More and better-defined data might result in more significant estimations of the model parameters if in fact the model is valid.

Another *step in* is to examine the 100 data tables constructed for this study for evidence to support alternative hypotheses regarding skilled human capital availability. For example, the data may support the implication that highly skilled human capital for strong traded clusters comes from around the world, is mobile across state and international boundaries, and is generated by extremely specialized advanced educational programs that are no longer exclusively located in the United States. The data may also support the implication that different types of human capital and where it comes from may differ depending on the life cycle of a strong traded cluster. The data shows that each of the clusters grew strong over time. Clearly, the type of human capital for cluster strength is more nuanced than hypothesized in this study. It could be that individuals from a highly specialized, relatively small, and globally mobile talent pool are needed to initiate a cluster, but that regional colleges and universities can "catch-up" with demand and supply talent after a start-up phase either directly or indirectly if traded clusters leverage transferable skills from local clusters. Finally, at some point, cluster generated expertise takes over as the source of highly skilled human capital. It is also possible that each of the traded clusters have a unique life-cycle pattern and require different sources of human capital in each life-cycle phase.

Another potential *step in* is to look at selected regional strong traded clusters on a micro level to determine what factors drive its strength over time. A mixed methods study of a successful cluster might begin by interviewing people who have insight into the dynamics of how that cluster developed and shed some light on whether regional traded cluster strength is driven by micro events instead of macro trends. The study could focus on the exact sources of highly skilled human capital employed in the cluster, which fields of study are considered when hiring, and how expertise is developed or recruited into businesses in the cluster. This work could lead to a more detailed understanding of the role of specific college and university degree programs in the development of strong traded clusters. The specific knowledge gained from the qualitative work could inform a more precise quantitative analysis of what specific degrees are related to cluster strength.

The alternative is to take a *step back* from this work and reconsider the cause-and-effect hypothesis that underlies the model proposed in this study. What if the model is reversed and degree concentration, migration patterns and cluster generated expertise are instead a function of traded cluster strength? This would mean that regional

colleges and universities develop programs in response to the highly skilled human capital demands of regional traded clusters which might support the idea that the source of skilled human capital is a function of a cluster's development life cycle. The possibility that the model may in fact be reverse was tested by running twenty of the cluster/degree pairs in the sample population with Regional Degree Concentration as the dependent variable and Traded Cluster Strength, Net Domestic Migration, Net International Migration and Cluster Generated Expertise as the independent variables. The model in reverse had less of an overall fit but produced somewhat more significant estimates of the model parameters. More work can be done with the data sets developed for this study to explore the relationships between the five variables in this study.

Another area of future research is to extend this analysis, with some adjustments to the model and data, to determine the role regional colleges and universities play in the strength of local clusters. Such work begins by developing a method for determining local cluster strength. The method currently employed to determine traded cluster strength is not applicable to local clusters.

Finally, developing measurements for the concept of cluster generated expertise is another area of future research. The results of this study suggest that cluster generated expertise may prove to be the single most important factor in determining, and sustaining, traded cluster strength over time. If cluster generated expertise is the most significant source of highly skilled human capital after an initial start-up phase, then it is increasingly important to understand how this expertise is developed, shared, and institutionalized in businesses in strong traded clusters. Regional colleges and universities may have a significant role in developing cluster generated expertise with non-degree courses and hosting cluster related symposiums, conferences, and workshops.

Conclusion

This study found no significant relationship between the concentration of bachelor and master's degrees in a region and the strength of established traded clusters in those regions. This suggests, that at least in terms of established strong traded clusters, there is no direct benefit to the co-location of traded industry clusters and colleges and universities within an economic region. This counter-intuitive result has broad implications regarding the policies of many regional economic developers. The results of this study should make us pause and evaluate the conventional wisdom that economic development is inextricably linked to the talent, skills, and degrees that individuals *within* the population obtain or possess. Many economic development programs are predicated on the assumption that the talent needed to generate the economic prosperity that comes from strong traded clusters can be "home grown" in regional colleges and universities. The overarching implication of this study is that regional economies may need to welcome and retain highly skilled human capital from sources beyond its economic borders that is necessary for strong traded clusters to take root and thrive. The additional research derived from this implication is warranted to test this hypothesis and ultimately establish an empirical link between sources of highly skilled human capital and strong traded clusters.

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APPENDIX 1

The Significance of Regression Coefficients for the Sample Population

APPENDIX 2

Variance Inflation Factor (VIF) Test for Multicollinearity