The Evolving Connection of Transit, Agglomeration and Growth of High Tech Business Clusters

Prepared by:

Glen Weisbrod (corresponding author)
Economic Development Research Group, Inc.
155 Federal Street, Suite 600, Boston, MA 02110 USA
Telephone: (617) 338-6775, x202
Fax: (617) 338-1174
Email: gweisbrod@edrgroup.com

Chandler Duncan
Economic Development Research Group, Inc.
155 Federal Street, Suite 600, Boston, MA 02110 USA
Telephone: (617) 338-6775, x203
Fax: (617) 338-1174
Email: cduncan@edrgroup.com

Susan Jones Moses
Susan Jones Moses & Associates
47 Glen Street, Rowley, MA 01969
Telephone: (617) 340-0407
Email: info@smoses.net

Word Count: 6998
(Excluding Title Page and References)

Revised, March 14, 2014

ABSTRACT
While much of the literature on spatial agglomeration, public transit and the economy has focused on broad-brush analysis and generalized relationships, this study focuses on one specific element of the economy – the development of high-tech, knowledge-based industries that account for a disproportionate share of national economic growth. It examines how these industries are clustering in large metropolitan areas, and specific suburban and urban locations within those metro areas. It then shows how their high rates of employment growth are bumping up against the capacity constraints of local road networks, and leading businesses in these clusters to turn to private and public transit to enable their continued growth. The evidence indicates that (a) there are continued advantages of metropolitan concentration and highly localized clustering for these specific business sectors, and (b) while public transportation was not the cause of their clustering, most of the high tech business clusters are evolving so that bus and rail solutions are becoming enablers of their continuing and future growth.

INTRODUCTION

Background

There has been significant attention in the transportation research field regarding the extent to which public transportation investment supports economic development by enabling "agglomerations economies"—the ability of business firms to realize productivity gains because of greater market access. One line of research has showed a positive relationship between urban agglomeration measures (such as the effective density or accessibility of a region's employment or population) and productivity levels (measured in terms of average pay or value added per worker) , e.g., see Graham (*1*), Venables (*2*) and Melo et al (*3*). Other research has focused on the relationship of physical clustering of businesses and public transit availability, showing how the two are correlated (e.g., Song, *4*). In general, both lines of research have compared metropolitan areas or communities (or UK wards) to extract relationships between some combination of transit availability, urban density and productivity or wage rates. Recent studies have also attempted to establish causality, suggesting that adding more transit service to a city can induce physical clustering and increase wages (e.g., Chatman and Noland, *5)*.

Yet if we are to move beyond generalizations about cities and metropolitan areas, then it is useful to focus in on the needs for public transit and the potential economic benefits of public transit investment from the perspective of different business sectors located in different types of urban settings. While that is far too broad a topic to be tackled by a single paper, we can start a discussion on this broad topic by examining one class of business– high tech, knowledge-based industries – and note how they cluster, how they depend on the local the transportation system, and how those relationships are evolving. This focused approach can provide insight and eventually be applicable for addressing broader questions relating to three topics:

(1) How are high growth industries evolving in terms of their locations and clustering patterns within urban areas?

(2) How can we assess future transit needs and roles, particularly as business clustering patterns change and non-radial commuting movements become more important?

(3) How will the evolving changes in business location and clustering patterns shift the economic benefits and impacts of public transit investment?

This paper is a step in moving forward to address these broader questions. In contrast to much of the research literature, it focuses a very specific element of the economy– high technology, knowledge-based business clusters which are distinctly identifiable and responsible for a disproportionately large share of national economic growth. First, the paper presents data showing how particular "high tech" industry sectors are growing relative to the rest of the US, and how these sectors are clustered and how that relates to transportation access. Then, more detailed analysis is conducted for a sample of high-tech business clusters in selected cities, to observe (a) how their continued growth is coming up against the local capacity of existing transportation systems (in most cases, the road network), and (b) how that is causing business clusters to turn to transit service (both private and public) to facilitate continued employment growth.

HIGH TECH AS AN ECONOMIC CATALYST

Economic Role

Technology-based service industries have a notable role as a catalyst for economic development. This is based in part on the concept of "Economic Base," which has long been a central driver of regional economic development strategies. It draws on the distinction between basic" or "export-based" activities – which provide goods and services to customers outside of the region, and "non-basic" or "local-serving" activities – which provide goods and services to a region's own population. Industries such as education, health care, government, retail and personal services tend to be predominantly local-serving. In contrast, industries such as manufacturing and specialized business services tend to be predominantly export-based. The "local serving" industries are ubiquitous across all regions and account for the majority of jobs in every metropolitan area, since those industries largely serve local population needs. *(6)* However, no region's economy can exist (above a subsistence level) or continue to grow without some income flowing into the region. And that flow is provided by the "export-based" industries because they sell products or services to customers outside of the region and thus generate income flowing back into that region. And that is why economic developers seek to promote the growth and attraction of manufacturing and specialized technology services. *(7)*

Growth

Over the last thirty years, the term "high tech" has come to refer to high growth, export-based industries that depend on information and technology development. A 1982 Congressional Committee report noted the importance of high tech for national economic growth. At the time, pharmaceutical and computer manufacturing industries were at the heart of high tech.*(8)* In recent years, this label has evolved to focus more on biotech (life sciences) R&D as well as computer software and /information technology services. The former falls within the broader NAICS class of professional and scientific services; the latter falls within the broader NAICS class of information services. Due to data availability limitations, it is necessary to utilize those broader classifications for economic analysis of sub-state regions; however that more coarse level of analysis still allows key findings to emerge. A common element of these broader industry classes is that they, along with the financial services sector, share features that they are: (a) becoming increasingly global in their operations, (b) dependent on technology and knowledge for that growth, and (c) are leaders of employment growth in the US. For instance:

- At the national level, the U.S. Bureau of Labor Statistics provides employment forecasts over the 2010–2020 period. It shows that, among major industries (those with over 200,000 jobs across America), four economic sectors are forecast to be at the top in terms of both business output and employment growth over the period: (a) professional, technical & business services, (b) financial services, (c) software – information services and (d) construction. *(9)*
- A longer range forecast to 2040 is provided by Moody's Analytics, and it shows largely the same industries leading longer term growth: (a) professional & scientific services (includes computer, biotech, and environmental R&D), (b) financial services (includes credit, finance and securities), (c) information services (includes video, data, internet, software; excludes print media) and (d) business services: outsourced administrative and support services. Together, these four industry categories account for 17.5% of the U.S. economy (in terms of GDP), and are forecast to grow to 23% by 2040. The first three represent export-based industries; the fourth is a "follower" industry serves other fast growing firms. *(10)*

CLUSTERING PATTERNS OF HIGH TECH FIRMS

Concentration in Certain Metro Areas

High tech, high growth industries tend to cluster in particular metropolitan areas. Figure 1 shows how the concentration of selected industries (share of total area employment) varies among metropolitan areas across the U.S. It shows that population-serving industries, such as retail and health care, tend to have limited variation in their concentration across metropolitan areas. In contrast, export-based industry sectors (such as professional/scientific, finance and information services) have wider variation – meaning that there is a much stronger concentration in some metropolitan areas than in others. This indicates that these industries have specialized requirements causing them to locate in some metropolitan areas much more than in others. The metropolitan areas with the highest concentration of professional/ scientific services and information services are shown in Table 1.

Concentration within Metro Areas

A more direct confirmation of the clustering of high tech firms is provided by Jones Lang Lasalle, the international specialists in office markets, which published separate studies of life sciences and other high tech office clusters in the US. The reports identified the “established” and “emerging” clusters across the nation. The metro area locations of “established” clusters are shown in Table 2; it is notable that they largely correspond to the metro areas as listed in Table 1. These reports also show that these clusters tend to occur in specific parts of the metropolitan areas rather than being dispersed across those areas; the specific communities are listed below. The high tech study further noted that that the growth rate of the high tech services clusters has been 2.5 times greater than the overall average growth rate for all office markets across the US. *(11, 12)*

Further tabulations of employment by county were conducted for each of the metropolitan areas and industry groups listed in Table 1, using the same data source. The results confirmed that the clustering of high tech employment in concentrated within parts of those metropolitan areas. For instance, the Boston metropolitan area is comprised of seven counties. Middlesex county, which is to the west of the City of Boston, accounts for just 18% of the metro area employment in finance, and just 31% of the metro area employment in retailing. Yet it accounts for over 50% of metro employment in professional/ scientific/tech services and over 50% of metro employment in information services. This is because it encompasses both the Route 128 high tech corridor and the East Cambridge/Kendall Square high tech district.

In the case of Massachusetts, further data exists to break out employment in these industry groups by town and zip code. Figure 2 shows how the relative concentration of selected technology industry sectors compares for the statewide average, for Middlesex County, and for two high tech clusters within the county. It shows that four technology industries have a substantially higher-than-average concentration in Middlesex County, though the concentration is even higher within parts of that county – engineering and scientific research are most concentrated in the East Cambridge (Kendall Square) district, while computer and technical services are most concentrated within the Route 128 technology corridor. In other words, even when there are multiple high tech clusters within the same county, these clusters have distinctive specializations.

UNDERSTANDING BUSINESS CLUSTERS

Types of Clusters

Every sector of the economy has a production function with a set of technology requirements regarding access to labor, input material and customer markets, as well as the scale at which it can profitably operate. As a result, various industries have systematic differences in how they spatially locate and the extent to which they cluster. In the 20th century manufacturing economy, industry clusters emerged around proximity to the means of production, and points of access to freight transportation. For example, steel and metal manufacturing tended to cluster near mines and railroads, while lumber and wood products tended to cluster near forests and waterways. All of these clusters depended on freight rail or truck access.

Today there are other types of clusters. The Southern Automotive Corridor ("Auto Alley") emerged along several interstate highways in the southeast US to enable supply chain and logistics efficiencies. It is defined by highway corridors that facilitate same-day parts deliveries to auto plants, yet enable manufacturers to be sufficiently dispersed to enable use of lower cost labor in rural regions. *(13)*. Within urban trade centers, regional shopping centers have emerged to take advantage of the scale economies of tapping wide residential markets, while gaining advantage from the collocation of both similar and different types of shops – which increase the attraction of comparison shopping *(14)*. And the high tech clusters of Silicon Valley (in California) and Route 128 (in Massachusetts) first emerged in the 1970's as centers for computer manufacturing industries. Both grew as office parks located along highways that enabled broad area access at the outskirts of large metropolitan areas – which also featured a high level of skilled labor and access to major universities. Today, those clusters have evolved to focus more on life sciences and information technology services, and they are complemented by other, more urban high tech clusters – which are described later in this paper.

Of course, not all industries gain productivity benefits from clustering. And there are many different types of clusters, with very different density and location patterns which reflect a variety of different industry-specific factors. Yet in each case, transportation matters because it provides desired access, connectivity and/or reliability for labor inputs, material inputs, production scale or sales to customers that cannot be accomplished as effectively elsewhere.

Cluster Benefits

These relationships and their implications for cluster development have been explained by a substantial body of both theory and empirical research In general, the advantage that occurs when businesses do become more productive by clustering is known as "agglomeration economies." The concept dates back to Alfred Marshall's work in 1890, which explained the economic advantage of businesses clustering within cities in terms of gaining access to larger size markets for labor, products and services (which lead to what economists call "increasing returns to scale"). He further explained the sources of agglomeration economies as: knowledge spillover (interaction between firms that brings technology knowledge transfer), access to labor markets (availability of a large pool of workers to maximize matching of worker skills to business needs) and access to supplier markets (availability of materials and services that maximizes matching to business needs).

A more recent line of research has attempted to distinguish between two fundamental types of agglomeration: (1) "localization economies," which are scale economies in which firms benefit from proximity to similar firms nearby, and (2) "urbanization economies," which are scale economies in which firms benefit from access to a larger and more diverse labor or customer market *(15)*. In the case of high tech office clusters, it appears that there are both urbanization economies associated with gaining for access to a large, skilled labor market ("labor market pooling") and localization economies associated with "knowledge spillovers," which come from locating in proximity to other similar firms and to universities. This is consistent with research by Rosenthal and Strange *(16)*, who found that both knowledge spillovers and labor market pooling play important roles across a wide range of industries.

Supporting this view, Audretsch and Feldman *(17)* examined the location of innovation activities across the US and found that the location of university R&D, industry R&D and skilled labor were all critical determinants. They also found that "industries in which knowledge spillovers are more prevalent—that is where industry R&D, university research and skilled labor are the most important— have a greater propensity for innovative activity to cluster than industries where knowledge externalities are less important." Melo et al *(18)* conducted a meta analysis of agglomeration studies and reported that localization economies are strongest for manufacturing, while urbanization economies are generally more important for knowledge intensive services. Ellison et al *(19)* examined the extent to which various industries agglomerate, and concluded that industries with similar labor mixes benefitted the most from clustering, suggesting that labor market pooling was a again common factor.

Based on the existing body of research, it appears that there are good explanations for why the high tech clusters listed back in Table 2 are all in specific parts of medium or large size metropolitan areas, and are generally in proximity of major universities or research institutions. Finally, it should be noted that clustering occurs despite the concentration of traffic that it creates. A study by Ciccone and Hall found that agglomeration more than offsets congestion effects in urban areas. The research specifically looked at the effect on increasing returns caused by the intensity of labor and capital relative to physical space. They found that the concentration of economic activity can account for as much as 50% of the variation in business productivity. They concluded that the ability to sustain increasing concentrations of economic activity is an important factor in growth for the economies of U.S. cities.*(20)*

CASE STUDIES OF THE TRANSPORTATION NEEDS OF BUSINESS CLUSTERS

The Transportation Challenge

Technology-oriented business clusters, by their very existence, draw commuters from a wide labor market area and bring them into an area that has a concentration of business activity. And if a cluster is to maintain relevance as a business location, then it must maintain the productivity advantage that makes it attractive. Of course, the growing concentrations of workers in such clusters also introduce a formidable and growing challenge to transportation agencies seeking to provide adequate capacity to serve these critically important places.

Since technology-oriented businesses typically require specialized worker skills and draw from a large labor market of skilled workers, they have traditionally located along major highways and locations where highways intersect. (Silicon Valley and Rt. 128 are classic examples of such clusters.) While these locations have served them well, every highway has a capacity limitation, and road widening to add lanes cannot be continued forever. Inevitably road congestion will become a limiting factor if those clusters continue to increase employment. That can present a problem, for firms reliant on highly concentrated knowledge clusters may not be able to simply move to less crowded or congested locations without risking loss of proximity to counterparts, or loss of other advantages offered by the existing cluster's business environment. This same issue of transportation access capacity also holds also for the newer technology research clusters which are located in more urban environments where transit access already exists.

Case Study Selection

To examine this issues, eight detailed case studies of "high tech" office clusters were developed. These studies developed profiles of employment patterns, commuting patterns, road capacity and expected growth patterns for each cluster. The clusters that were studied are: Silicon Valley, Midtown/ SOMA in San Francisco, Atlanta's Emory/CDC Corridor, Kendall Square and the Rt.

128 Corridor in the Boston area, the Deerfield business cluster in the Chicago area, the Denver Technology Center and Seattle's South Lake Union cluster. Information about these clusters is presented in Table 3.

Case Study Summaries

For each case study, interviews were conducted with staff of the local Metropolitan Transportation Organization (MPO) to gain information about existing high tech clusters, their locations, business composition, employment and traffic conditions, as well as projected growth in the future. As shown in Part 1 of Table 3, all of the selected clusters are centers of research innovation and product development for biotechnology, computer, internet or related products and services. They have disproportionately high levels of jobs in information technology, professional and scientific services, as well as some manufacturers of related computer and health care products. These technology-based clusters that were selected represent a range of regions across all four time zones of the US. And they represent a range of locations within metropolitan areas – from urban districts to suburban office parks. They also represent variation in cluster evolution, ranging from newly emerging clusters (started under ten years ago) to more mature clusters (started over 25 years ago).

In the case of the San Francisco and Boston areas, two clusters were intentionally selected for comparison: (1) an older, auto-oriented technology corridor that has transformed from computer hardware to newer software technologies (Silicon Valley and Rt. 128), and (2) a newer, urban cluster with strong public transportation service that is more focused on attracting the millennial generation (Midtown/South of Market in San Francisco and Kendall Square in Cambridge, MA).

Transportation Conditions

For each case study, the authors obtained use of the MPO's transportation network model and traffic growth projections, and used them to calculate how traffic growth and delay will increase in the future. Part 2 of Table 3 shows the current and forecast future volume of commuting trips for selected traffic analysis zones in the core of each cluster, and it also shows how traffic growth will affect peak volume/capacity and delay on existing access routes. In total, another 104,000 jobs are expected to be generated at these industry clusters.

In all of the clusters, auto commuting delay is expected to increase significantly by 2040 and travel demand models forecast that total automobile volumes projected for commuters would "exceed the capacity" of primary access routes if changes are not made. Of course, in the real world, traffic volumes cannot keep increasing beyond the design capacity of roads without total gridlock, so what actually happens (and what would ultimately be forecast with the travel demand models) would be a full saturation of existing roadways, leading to traffic diversion and backs up onto other facilities in the region, thus causing more congestion elsewhere.

If the eight clusters observed were to attempt to "build their way out" of highway congestion, significant expansion in the number of lanes on roads throughout the clusters would have to be considerable. Part 3 of Table 3 shows the number of lanes that would be needed simply to accommodate the 104,000 added commuting trips expected to occur in the eight clusters by the year 2040. The numbers shown in Part 3 do not include the additional lanes that might also be needed on routes throughout the region to ensure an entire uncongested trip, but rather only the lanes needed to prevent traffic from backing up on the roads that actually touch the cluster area.

While uncongested commuting conditions are not a realistic goal, this table is still useful as a way of showing the vast gulf between projected future demand and current road system capacity. It is also clear that existing level of build-out (and high demand for land) in the cluster renders widening infeasible without taking valuable properties and potentially crowding out the very high-value economic activity that makes the cluster such a valuable business location. However, there are other options for serving these added trips, most prominently public transportation.

PUBLIC TRANSPORTATION SUPPORT FOR BUSINESS CLUSTERS

Local interviews, conducted as part of the case study process, revealed that local business leaders and transportation planners in each city were already aware of the need for action to accommodate added employment growth, and that plans have already been adopted for major improvement in public transportation service for seven of the eight clusters. This includes clusters that already have some bus and rail service but have plans for further enhancement to it, and others that have no little or no public transportation but have plans to introduce new light rail or BRT service in the future.

These clusters represent a wide range of different settings, with major differences in current availability of public transportation. Two of the clusters (Kendall Square in the Boston area and Midtown/SoMo in San Francisco) are relatively new and are located in urban districts with high rates of reliance on pre-existing rail transit. The other six are located along highways at the city fringe or in a nearby suburb. Of those six, two now have light rail or streetcar service (Denver Technology Center and Seattle's South Lake Union). In addition, there are plans for high capacity transit (rail or BRT) service to be added in the future to the Atlanta Medline and Silicon Valley clusters. Upgraded bus service is also proposed for the Deerfield cluster. Only one cluster (128 Technology Corridor) has not yet developed a formal plan for significantly upgraded transit service.

Notably in all eight of the clusters, private firms have already invested funds to operate shuttle services, as a way to help attract workers and sustain their workforce accessibility despite a congested business cluster environment. In fact, the shuttle service provided by Google to connect the Mid-Town/SoMo and Silicon Valley clusters is actually larger than some public transit fleets. Firms in all eight of the clusters also indicated in interviews that they see a need for increased public transportation, and all but one (the Denver cluster) have housing planned near the cluster. Part 4 of Table 3 summarizes characteristics of the eight clusters studied.

Taken together, these eight case studies illustrate a very wide range of situations. On the one hand, they can be classified in terms of their *highway limitations*. This includes:

- Clusters where highways are limited because of build-out, space and density (no more room for highways); and
- Clusters where highway widening opportunities are effectively limited because of some combination of neighborhood impact concerns, environmental concerns or workforce preferences (workers don't want to commute long distances).

It is also possible to classify the clusters in terms *of transit availability*. This includes:

- Clusters that were started and have grown based on transit access (e.g., Kendall Square and Midtown San Francisco);
- Clusters that initially grew without transit, but cannot be sustained in the future that way (e.g., 128 Tech Corridor, Silicon Valley, Deerfield, Atlanta Medline); and

• Clusters that have invested in transit and are poised to grow (e.g., Denver Tech Center, Seattle South Lake Union).

ECONOMIC IMPLICATIONS -- ILLUSTRATION OF A METHODOLOGY

Drawing Conclusions from the Cluster Research Study

The implications of diminished access to high-value business clusters can be significant. The loss of travel time and reliability as well as reduction in workforce and business accessibility reaching these clusters can undermine the competitiveness, profitability and/or efficiency of their activities. Furthermore, given the localization economies associated with clustering knowledge-based industries in close proximity to each other, there is reason to doubt whether other business locations can replicate these benefits elsewhere within the same metropolitan area. When access to business clusters is compromised by highway delay, the affected jobs, value-added, earnings and output are placed at risk. The result is not a 100% loss to the US economy. Firms may respond to transportation capacity constraints in a variety of ways, which may include a combination of: (a) curtailing expansion at current sites, (b) relocating abroad and (c) relocating to other locations in the US. However, this study did not examine the availability of alternative sites elsewhere in the US or abroad.

Extrapolating from the Case Studies

To draw further conclusions from the case studies, it is first useful to note that high growth, technology-oriented clusters are -- by definition -- areas of high employment growth. As a result, their employment growth will inevitably bump against the limitations of road capacity on access routes. Not surprisingly, that is exactly what has occurred in all eight of the case studies. Because they represent knowledge-based industries that depend on interaction and collaboration, the options of moving to multi-shift operations, satellite locations or telecommuting are sometimes seen as less desirable paths, leading to productivity losses. As a consequence, efforts are now underway to enhance public transportation service to most of the clusters studied.

In these situations, the value of adding public transportation service may be measured in terms of the added employment growth that they enable. In the eight case study zones, it has been calculated that forecast growth of 104,000 new jobs (a 32% increase in employment for the study area zones) by the year 2040 could be jeopardized by lack of road capacity, and unlikely to occur without introduction of public transportation or some other steps to enable greater commuting volumes.

Expanding to Full Case Studies

Further adjustment must be made to these numbers, for as noted in the separate volume of case study details, the employment zones selected for analysis were actually a subset of the full cluster areas. In each case, the broader cluster area is between 1.3 and 3.6 times larger (in total employment) than the traffic zones studied. This provides a basis to extrapolate the regional access capacity constraint to the full cluster areas of influence (which is reasonable because the same access routes are involved). Altogether, the employment growth that is at risk because of roadway limitations (and potentially enabled if there is sufficient public transportation service) is on the order of 2.3 times larger. That raises the at-risk employment growth to be in the range of roughly 239,000 jobs.

Extrapolating to Other Clusters and Communities

The eight case study clusters are not the only technology clusters in America that are facing increasingly congested roads. In fact, the list of clusters shown in Table 2 refers to other local technology business clusters in four of the regions that were studied (Denver/Boulder, Boston, Seattle and San Francisco Bay/Mid-Peninsula), plus established biotech or computer technology office clusters in seven other metropolitan areas that were not studied (Austin, New York City, Portland, Philadelphia, Raleigh Durham/ Research Triangle, San Diego and Washington, DC region). In addition, the two Jones Lang Lasalle cluster reports that were cited in that table's footnote provide information on emerging urban office clusters for technology industries in five more cities (Baltimore, Las Vegas, Los Angeles, Minneapolis and Phoenix).

While the other technology office clusters have not been extensively studied, it appears that many of them have also been facing increasing traffic congestion. This includes the Research Triangle Park area in NC, Bellevue area outside of Seattle, suburban Washington DC region (I-270 Corridor in Maryland and Dulles Corridor in Virginia), Rt. 202 Corridor in the Philadelphia area, and Sunset Hwy in the Portland, OR area, and many others.

Together, the cluster areas covered by our case studies account for approximately 39% of national employment in the set of technology office clusters covered by JLL reports. In other words, employment in the full set of recognized technology-oriented urban office clusters is 2.5 times that of our case study sites. And so the cluster employment growth threatened by road capacity limitations could be as high as 480,000, representing around $32 billion/year of income (expressed in terms of today's pay rates) by the year 2040.

Solutions

This threatened capacity shortfall could be entirely eliminated if another 25% of the employment base of these clusters were to switch to using public transportation. Other parts of a solution might include combinations of public transportation, bikeways, integrated highway corridor management, increased carpooling and increasing bikeways.

Ultimately, this form of case study analysis could inform a broader cost-benefit analysis of transportation improvements – either highway expansion or increased transit capacity. To do so, it will be necessary to more accurately determine the extent to which agglomeration benefits are likely to actually be lost if proposed or planned improvement transportation improvement is not made.

CONCLUSION

The broader implications to be drawn here are that:

1) Knowledge-based firms do concentrate in specific labor markets where there is a large and hence more diverse choice of highly educated workers as well as research resources.

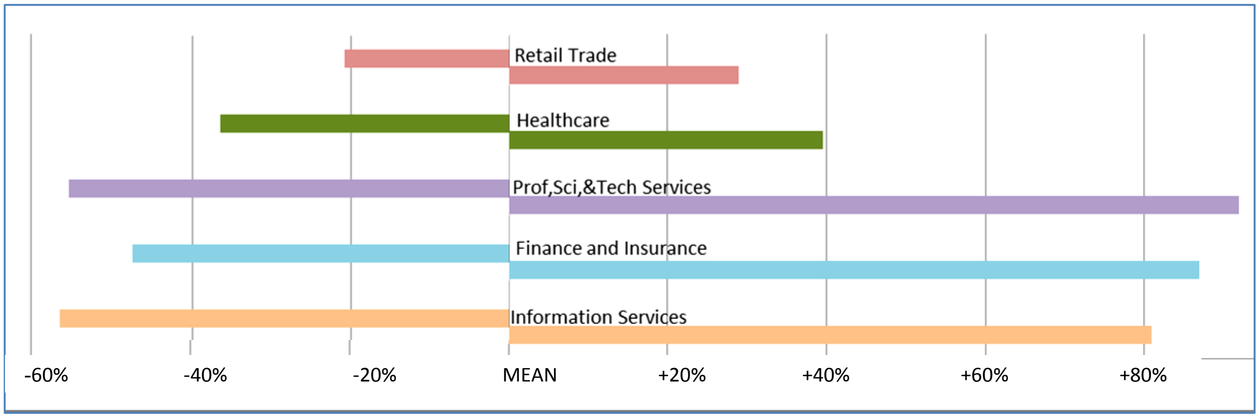
2) The consistent clustering of these firms in specific districts of cities, their willingness to support private shuttle transportation and their failure to disperse in the face of growing congestion together support the finding that there is some form of economic advantage from that physical clustering which is worth maintaining.

3) While public transportation was generally not the reason for formation of these business clusters, it has become widely seen as a necessary improvement to allow these clusters to survive and continue to grow in the face of highway congestion and capacity limitations. In most cases, steps have in fact already been taken to initiate and expand public transportation services to and at these clusters.

4) The emerging need for transportation investment to support high tech business clusters can be calculated, and the economic stakes associated with enabling or failing to support the continued growth of high tech business clusters appear to be substantial. This paper illustrates an approach for highlighting and identifying transportation needs and associated economic stakes associated with efforts to support and maintain high growth business clusters.

ACKNOWLEDGMENTS
This paper draws on work sponsored by the American Public Transportation Association, supervised by Darnell Grisby, Director of Policy Development and Research. The authors are indebted to data research by Derek Cutler, John Stevens and Mike Brown.

FIGURE 1 Concentration of Selected Industries within Metropolitan Areas, 2012 ***(range of variation from the national average concentration; middle 90% of cases)*.**



Source: analysis of 2012 employment patterns by EDR Group, based on data from Moody's Analytics.

TABLE 1 Major Metro Areas with the Highest Concentrations of Selected Industry Sectors

Metro Areas with Highest Concentration of Professional/Scientific/Tech Services	Metro Areas with Highest Concentration of Information Technology Services
Washington, DC 15.8% San Jose, CA 12.0% San Francisco, CA 11.8% Boston, MA 9.7% San Diego, CA 9.2% Detroit, MI 9.2% Denver, CO 8.6% New York, NY 8.0% Atlanta, GA 7.8%	San Jose, CA 5.5% Seattle, WA 5.2% Los Angeles, CA 4.1% Atlanta, GA 3.5% Denver, CO 3.4% San Francisco, CA 3.4% New York, NY 3.2% Boston, MA 3.0%

Source: analysis of 2012 employment patterns by EDR Group, based on data from Moody's Analytics; only for metro areas with over 120,000 workers in professional/scientific/tech services or 40,000 in information services

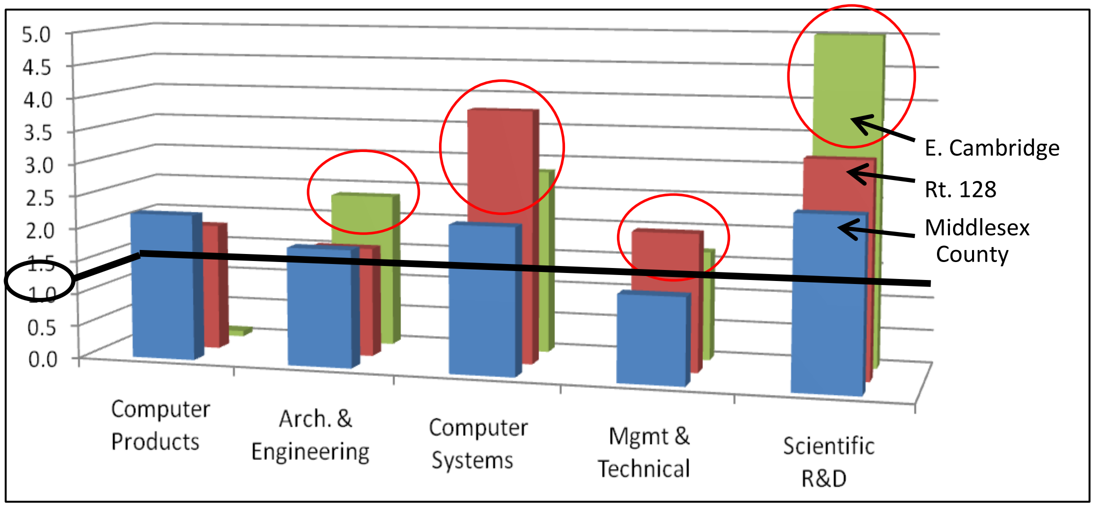
.

TABLE 2 Major Technology R&D Clusters in Urban Districts

Biotech Office Clusters (source 10)	**Computer/Tech Clusters** *(source 11)*
Boston Area	***Austin, TX***
East Cambridge (Kendall Square)	***Boston Area***
Longwood Medical Area	East Cambridge (Kendall Square)
Seaport District	Seaport District
Route 128/Rt. 3 Corridor	Route 128/Rt. 3 Corridor
Philadelphia Area	***Denver Area***
University City	Tech Center/US-87 Corridor
Route 202 Corridor	Northwest - Boulder
Raleigh Durham Area	***New York City***
Research Triangle	Midtown South
San Diego Area	Downtown
Torrey Pines	Penn Station/Garment District
UC/Eastgate	***Portland, OR***
Sorrento Mesa, Sorrento Valley	Sunset Corridor
San Francisco Bay Area	***San Diego Area***
Mid-Peninsula – South SF	Sorrento Mesa
Mission Bay	UC / Eastgate
Oakland- East Bay	***San Francisco Bay Area***
Seattle Area	South of Market / Mission Bay
South Lake Union	Mid Market
Bothell	Redwood City
Washington, DC / Maryland	San Mateo
I-270 Corridor / Frederick	Silicon Valley
Also…	***Seattle Area***
New York City/New Jersey area	South Lake Union
Los Angeles/Orange County area	Bellevue CBD
Minneapolis-St. Paul area	

Note A: The table shows seven metro areas with "established" biotech clusters. Eleven other "emerging" clusters are identified in the source report.
Note B) The table shows eight metro areas with "established" computer technology clusters. Ten other "emerging" clusters are identified in the source report.)

FIGURE 2 Relative Concentration of Technology Industry Sectors in Massachusetts.



Source: Massachusetts Office of Labor and Workforce Development, 2011 data

Note: Values represent Location Quotients; a value of 1.0 means that the study area has the statewide average concentration of the given industry, 2.0 means the area has double the state average concentration and 0.5 means it has half of the state average concentration of the given industry.

TABLE 3 CHARACTERISTICS OF THE EIGHT CLUSTERS STUDIED

		Boston: Kendall Square	Boston: 128 Corridor	San Francisco: Silicon Valley	San Francisco: Midtown/SOM	Atlanta: Medline	Chicago: Deerfield	Denver Technology Center	Seattle: South Lake Union
(1) Overview of the Eight Clusters Studied									
Key Industries		biotech; IT; internet; social media	software; hardware, pharmaceuticals	software; internet; IT, social media	social media/gaming; internet; biotech	health; biotech	Pharma-ceuticals; headquarter s	IT; telecom.; software	health; biotech; internet
Region		Eastern	Eastern	Pacific	Pacific	Southern	Central	Mountain	Pacific NW
Setting		Urban	Suburban	Suburban	Urban	Suburban	Suburban	Suburban	Urban
(2) Roadway Accessibility Challenges for Major U.S. Clusters									
Number of Commuting Trips Occurring at Peak	**2010**	50,000	24,000	39,000	102,000	64,000	27,000	9,000	14,000
	2040	69,000	26,000	56,000	116,000	97,000	41,000	10,000	18,000
Peak V/C* Ratio on Routes Accessing Cluster	**2010**	At capacity	At capacity	At capacity	At capacity	At capacity	At capacity	At capacity	At capacity
	2040	1.4	1.3	1.4	1.5	1.2	1.5	1.5	1.5
% Increase in Auto Commuting Delay Expected 2010-2040		27%	39%	45%	20%	22%	39%	**	53%
(3) Roadway Capacity on Primary Access Routes to Selected Clusters									
Access Routes	Major Highways at Site	2	2	2	1	2	2	2	2
	Lanes Available today	8	12	14	10	18	12	16	16
Lanes Needed for Free Flow (both ways)	Additional Lanes Needed today	8	4	2	4	6	2	0	4
	Total Lanes Needed by 2040	10	6	4	6	10	6	8	10
	Widening Feasible?	No	Partially	Partially	No	No	Partially	No	No
(4) Transit and Residential Investments in the Cluster Areas Studied									
Transit Expansion Planned	**Bus Service**	Yes					Yes		
	Fixed Guideway	Yes		Yes	Yes	Yes		Yes	Yes
Private Shuttles in Existence		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Housing for Millennials Planned		Yes	Yes	Yes	Yes	Yes	Yes		Yes

Source: Derived from Travel Models from Metropolitan Planning Organizations

**V/C ratio is the volume/capacity ratio at peak period, based on the highest congestion level on a major route accessing the cluster.*

*** no congestion delay in 2010, so the percent increase in delay cannot be calculated.*

REFERENCES

1 Graham, D. J. Agglomeration, Productivity and Transport Investment. *Journal of Transport Economics and Policy,* Vol. 41, 2007, pp. 317-343

2 Venables, A. J. Evaluating Urban Transport Improvements: Cost-Benefit Analysis in the Presence of Agglomeration and Income Taxation. *Journal of Transport Economics and Policy,* Vol. 41, 2007, pp. 173-188

3 Melo, P. et al. Agglomeration, Accessibility, and Productivity: Evidence for Urbanized Areas in the US, *Transportation Research Board Annual Meeting*, 2013.

4 Song, Y., K. Lee, W. P. Anderson and T. R. Lakshmanan. Industrial Agglomeration and Transport Accessibility in Metropolitan Seoul. *Journal of Geographical Systems*, Vol. 14, No. 3, 2012, pp. 299-318.

5 Chatman, Daniel G., Noland, Robert B. Transit service, physical agglomeration, and productivity in US metropolitan areas. *TRB Annual Conference*, 2013.

6 Malizia, E.E. and E.J.Feser, *Understanding Local Economic Development,* CUPR Press, Rutgers University, 1999.

7 Harpel, E.D., Professional and Business Services in Regional Economies, *EDJ: The IEDC Economic Development Journal*, v.5, n.4, Fall 2006, pp.50-57.

8 Joint Economic Committee, Congress of the United States, *Location of High Technology Firms and Regional Economic Development,* GPO, 1982.

9 U.S. Bureau of Labor Statistics, Industry Employment and Output Projections to 2020, *Monthly Labor Review,* 2012. www.bls.gov/opub/mlr/2012/01/art4full.pdf

10 Economic Development Research Group, *The Role of Transit in Support of High Growth Business Clusters in the U.S.*, American Public Transportation Association, 2013

11 Jones Lang Lasalle, *Life Sciences Cluster Report Global*, 2012. www.us.am.joneslanglasalle.com/ResearchLevel1/Life%20Sciences%20Cluster%20Report_Global_2012.pdf.

12 Jones Lang Lasalle, *High-technology Office Outlook*, United States, 2012. www.us.am.joneslanglasalle.com/ResearchLevel1/US%20High-Technology%20Outlook_2012.pdf.

13 Rosenfeld, S.A. et al, *Clusters in Rural Areas: Auto Supply Chains in Tennessee and Houseboat Manufacturers in Kentucky*, TVA Rural Studies, 2000. http://rtsinc.org/publications/pdf/auto_supply.pdf

14 Ó hUallacháin, B. and T. F. Leslie (2013) Spatial Pattern and Order in Sunbelt Retailing: Shopping in Phoenix in the Twenty-First Century, *The Professional Geographer,* 65:3, 396-420.

15 Carlino,GA,. Increasing Returns to Scale in Metropolitan Manufacturing, *Journal of Regional Science,* 19, 363-373.

16 Rosenthal, S.S. and W.C. Strange, The Determinants of Agglomeration*, Journal of Urban Economics*, v.50, n.191, 2001

17 Audretsch, D.B. and M.P. Feldman, Geography of Production, *American Economic Review*, v.86, n.3, June 1996.

18 Melo, P., et al, A meta-analysis of estimates of urban agglomeration economies, *Regional Science and Urban Economics,* 39 (2009) 332–342

19 Ellison, G., E. Glaeser and W. Kerr, What causes industry agglomeration? Evidence from Coagglomeratin Patterns, *American Economic Review*, 100, 1195-1213.

20 Ciccone, A. and R. E. Hall, *Productivity and the Density of Economic activity,* Working Paper No. 4313, National Bureau of Economic Research, May 1996. http://www.nber.org/papers/w4313.