Polycentrism as a Sustainable Development Strategy:

Empirical Analysis from the State of Maryland

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Abstract

We present in this paper an analysis of economic centers and their role in shaping employment development patterns and travel behavior in the state of Maryland. We begin by identifying 23 economic centers in the Baltimore-Washington region. We then examine these centers first with respect to their economic performance then with respect to their performance as nodes in the state transportation system. Finally, we identify the commute sheds of each center, for multiple modes of travel and travel times, and examine jobs-housing balance within these various commute sheds. We find that Maryland's economic centers not only promote agglomerative economies and thus facilitate economic growth; they also promote transit ridership and reduce vehicle miles traveled. These results provide empirical support for policies that promote polycentric urban development, and especially policies that promote polycentric *employment* development. Based on these findings we recommend that regional sustainable communities plans should encourage the concentration of employment within economic centers and encourage housing development within the transit commute sheds of those centers.

I. **Introduction.**

In what has become the signature urban policy of the Obama administration during its first term, the Sustainable Communities Initiative was launched on June 16, 2009, with the signing of a Memorandum of Understanding (MOU) between the US Department of Housing and Urban Development, the US Department of Transportation, and the Environmental Protection Agency. Under the MOU the three agencies agreed to support six livability principles and to coordinate their efforts to "to help communities nationwide improve access to affordable housing, increase transportation options, and lower transportation costs while protecting the environment." [1] Since 2009, the Partnership has provided over $3.5 billion in assistance to more than 700 communities in all 50 states, the District of Columbia, and Puerto Rico.

Perhaps most prominent among the many Sustainable Communities programs is the Sustainable Communities Regional Planning grant program. The Sustainable Communities Regional Planning grant program supports metropolitan and multijurisdictional planning efforts that integrate housing, land use, economic and workforce development, transportation, and infrastructure investments. The intent is to further: (1) economic competitiveness and revitalization; (2) social equity, inclusion, and access to opportunity; (3) energy conservation; (4) climate change mitigation; (5) improved public health and (5) environmental preservation. Recipients of these grants are to prepare Regional

Sustainable Communities plans, typically for large metropolitan areas or other large geographic regions.[2] Although the recipients of these grants often include large consortia of public, private, and not-for-profit organizations, most of these efforts are led by Metropolitan Planning Organizations (MPOs), organizations with considerable experience in transportation planning but less experience in promoting economic development or environmental sustainability.

To offer new information on how to promote sustainable development at the regional scale we present in this paper an analysis of economic centers and their role in shaping economic development and sustainable travel behavior in the state of Maryland. More specifically, we briefly review the literature on polycentric development as a regional development strategy. We then define economic *centers* and describe how we identify 23 such centers in the Baltimore-Washington region. We next examine these 23 centers first with respect to their economic performance—including measures of comparative employment density, wage levels, industrial composition, and employment growth—followed by an examination of their performance as nodes in the state transportation system—including measures of trip origins and destinations, mode share, and trip length. Finally, we identify the commute sheds of each center, for multiple modes of travel and travel times, and examine jobs-housing balance within these various commute sheds.

We find that Maryland's economic centers provide important economic and transportation benefits to the region. Specifically, our analysis suggests that Maryland's economic centers not only promote agglomerative economies and thus facilitate economic growth; they also

promote transit ridership and reduce vehicle miles traveled. These results provide empirical support for policies that promote polycentric development, and especially policies that promote polycentric *employment* development. In addition, we find that most of Maryland's economic centers contain many more jobs than households within their transit commute sheds but that the jobs-housing ratios are more balanced in automobile commute sheds. Based on these findings we recommend that regional sustainable communities plans should include policies that encourage concentration of employment within economic centers. In addition, to maintain jobs-housing balance and to encourage transit ridership, such plans should also encourage housing development within the transit commute sheds of those centers.

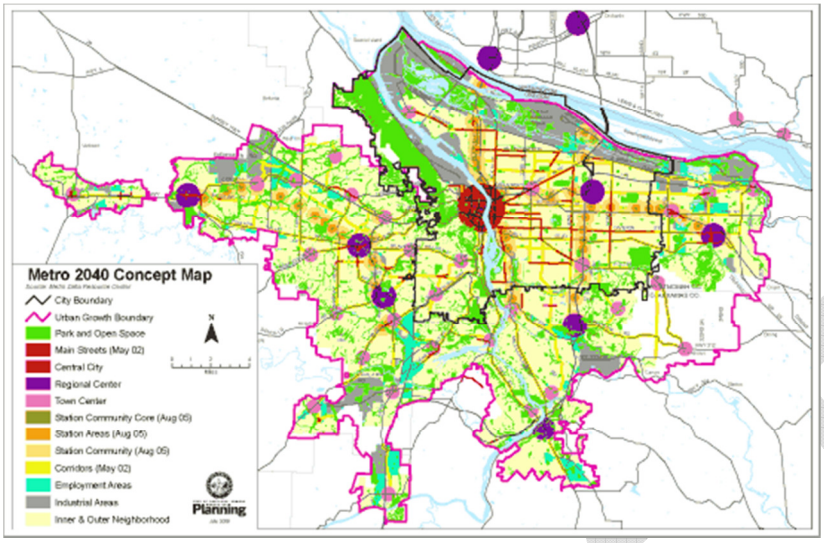
II. Polycentricity as a regional economic development strategy

The concept of polycentric regional development has been around for a long time both as a normative objective and as the subject of empirical research. Polycentric urban regions have not only been identified as the emergent spatial form of global cities (Hall and Pain, 2006) but also have been proposed as a planning solution for achieving efficiency and sustainability goals (Davoudi, 2003). According to Talen (2008, p. 22) , the notion of a planned polycentric city has experienced a number of iterations, "starting with Ebenezer Howard's "Social City," through Patrick Geddes' notion of regional settlement, to Clarence Stein's brand of "communitarian regionalism," which emphasized the role of communities as the building blocks of a region." Further, claims Talen, polycentricity is implicitly prescribed in the Charter for New Urbanism, under the heading "The Region: Metropolis,

City, and Town." According to Talen, " regions are economic "units" as well as environmentally determined "finite places" that can contain "multiple centers" within a metropolis. Edges should be clear and development patterns should be contiguous or else organized into towns, villages, and neighborhoods." In a more abstract treatment, Salingaros et al. (undated, p. 22), drawing on the seminal work of Alexander (1965) prescribe a polycentric region as a "multiply-centered-hierarchy" (sic) as a remedy for suburban sprawl.

These normative principles of polycentric regional development are clearly expressed in Portland's pioneering 2040 plan, which feature urban design "building blocks" that include central city, regional centers, town centers, main streets, corridors, and station communities. As shown in Figure 1, these building blocks prescribe a polycentric hierarchy that serves as the foundation for spatially explicit land use, transportation, and functional plans. Similar polycentric regional development strategies are apparent in the Envision Utah plan for the Wasatch Valley, the Sacramento Area Council of Governments (SACOG) plan for Sacramento, the Chicago Metropolitan Agency for Planning (CMAP) plan for metropolitan Chicago, and the Washington Metropolitan Council of Government (MWCOG) Region Forward plan for metropolitan Washington, DC. In their review of recent metropolitan planning efforts, Knaap and Lewis (2012) argue that polycentric metropolitan plans have not only become the dominant form of plans for metropolitan areas, but are all but required under HUD's sustainable communities grant program.

Figure 1 - Portland 2040 Map



From a less normative perspective, economists, geographers and planners have documented the emergence of polycentric urban forms in post-industrial societies in the United States (Bogart 1999, Giuliano 1991), the European Union (Cismas 2010), and Japan (Nishimura 2011), as well as in developing economies like China (Chou 2011, He 2011). From a positive perspective, demographic shifts, economic growth, and technological advances have all contributed to the evolution of a new spatial order that is clearly distinct from classic mono-centric models of urban structure and function. As firms leave the CBD, in response to these fundamental changes, they tend to co-locate in well defined geographic areas forming new centers of dense employment that are distinct and isolated from the CBD. These centers tend to be characterized by some degree of industry specialization, and are, therefore, sometimes referred to as industry clusters (Anderson 2001). When these centers reach sufficient size, they are often recognized as regional employment clusters. Thus, a major focus in this field of research has concerned the formation and explanation of industry clusters, while another, not entirely distinct branch, has concentrated largely on

the identification of regional employment clusters, and their social and economic impacts in a broader context.[3]

According to Michael Porter's (2000, p. 15) original conception of economic clusters, "Clusters are geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g., universities, standards agencies, trade associations) in a particular field that compete but also cooperate". Thus clusters can be conceived as collections of firms, having a proximate relationship, whose common spatial location provides the basis for at least one shared interest. Long standing economic theory suggests that firms have a natural incentive to form these spatial relationships, because they benefit from positive externalities and economies of scale, commonly known as agglomeration effects. Sources of agglomeration effects include labor pooling, input sharing, human capital spillovers, shared infrastructure, and consumption effects, among others (Rosenthal 2004, Glaeser 2009, Kantor 2009). By convention, the benefits of agglomeration realized via location near firms in the *same* industry are referred to as localization economies, while benefits that accrue as a result of locating near firms in *other* industries are called urbanization economies.

A number of studies provide theoretical foundations and empirical support for both localization and urbanization effects that promote cluster growth. Giuliano (2011), for example, finds that labor force accessibility is significantly related to cluster growth. Rosenfeld (2003) argues that geographic proximity among firms remains necessary to foster beneficial social networks, (localization effects) even in the digital age. Elsewhere,

scholars have provided consistent empirical evidence that agglomeration stimulates urban growth. Bodenhorn and Cuberes (2010), for example, find that a strong financial industry presence mitigates constraints on entrepreneurial enterprises, fostering urbanization economies and facilitating urban growth.

Another area of research focuses on the identification of industrial clusters as regional employment centers.[4] This type of study is conducted by selecting a geographic unit of analysis, usually Census Tracts or Transportation Analysis Zones (TAZ), and identifying all TAZs that meet minimum density and total employment criteria. Adjacent TAZs meeting the selection criteria are aggregated and considered as a single employment center. Using this approach Giuliano (1991) identified 32 employment centers in the Los Angeles metropolitan area. Subsequently, Bogart et al, (1999, 2001) identified employment centers in Cleveland, Indianapolis, Portland and St. Louis using similar procedures. While Giuliano et al examine employment center proximity to airports and LA's highway system, there have been no attempts to analyze centers in the context of a region-wide transportation system. Thus while the literature has provided a sound analytical framework for understanding economic centers and clusters, there have been no attempts to integrate analyses of economic clusters with a regional transportation context in a way that informs regional economic, housing, and transportation planning.

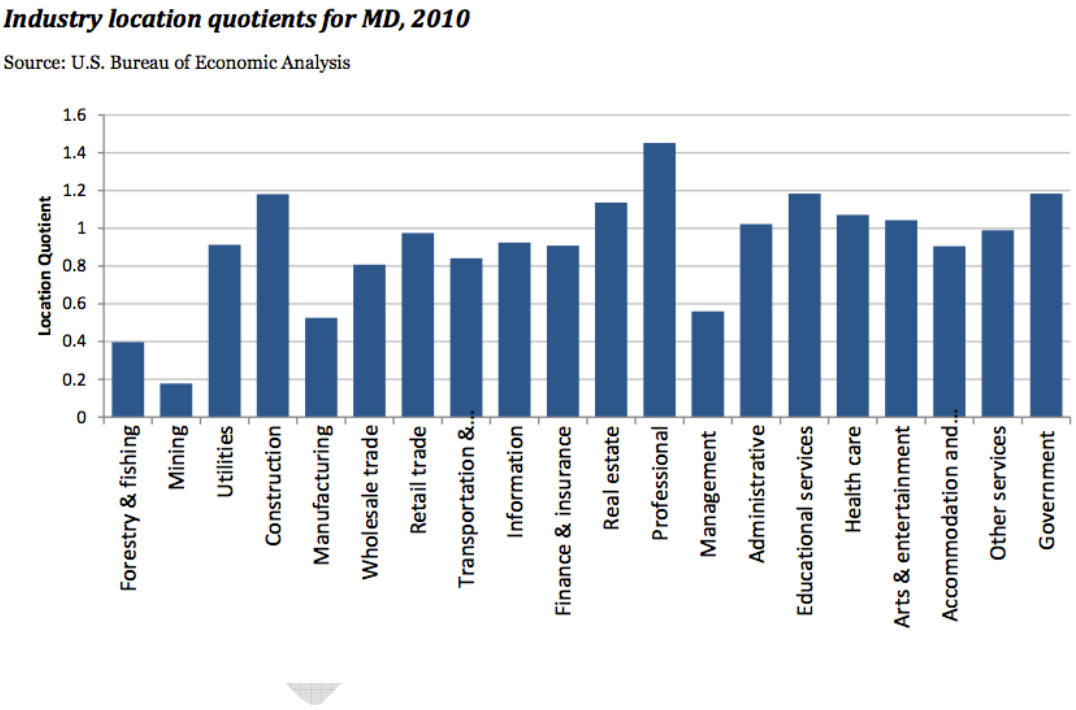
III. Employment Centers in Maryland

To gain a richer understanding of the benefits of polycentric development, we conduct an analysis of employment, transportation, and housing patterns in the State of Maryland. Located in the middle of the Eastern seaboard, the state of Maryland is lies just north of Washington, DC, and contains the Baltimore metropolitan area. Although it extends from the Appalachian Mountains to the Atlantic coast most of its population and economic activity is located in the Baltimore-Washington corridor. Baltimore is an old industrial city that continues to lose population. Washington, DC, located just 40 miles south of Baltimore, gained population in the most recent decade, but most of its growth is also occurring in the suburbs. In general, Maryland is relatively prosperous, predominantly suburban, and closely linked to the economy of Washington, DC.

Because of its proximity to Washington, and the deindustrialization of Baltimore, Maryland's largest industrial sectors include Education, Construction, Professional Services, and, of course, Government. See Figure 2. The growth and performance of these sectors contributes to Maryland's relative insulation from the recent national economic recession. Also because of its location on the Eastern Seaboard and its proximity to Washington, DC, Maryland has an extensive multi-modal transportation system. The system includes 28,000 miles of highways, freeways, and roads, 861 miles of intra metropolitan fixed guide way rails, 187 miles of commuter rail, a large but declining seaport, and one of the three airports in the Baltimore-Washington region. Interstate 95 and the Baltimore and Washington beltways are heavily traveled by passenger car and by short- and long-haul trucks. In many respects the highway system is built out. There is little space or political appetite for new roads or highways and the Maryland Department of

Transportation is expressly more focused on highway maintenance than highway construction. The transit system, however, is continues to expand. An extension of the Washington Metro transit system from the District to Dulles Airport is now underway in neighboring Virginia. New light rail lines are in preliminary engineering for suburban Washington and Baltimore. For these reasons, the planning challenge for the region is how to better utilize the existing system of roads and highways and how best to capitalize on limited new investments in transit.

Figure 2 - MD Industry Location Quotients



Identifying Economic Centers

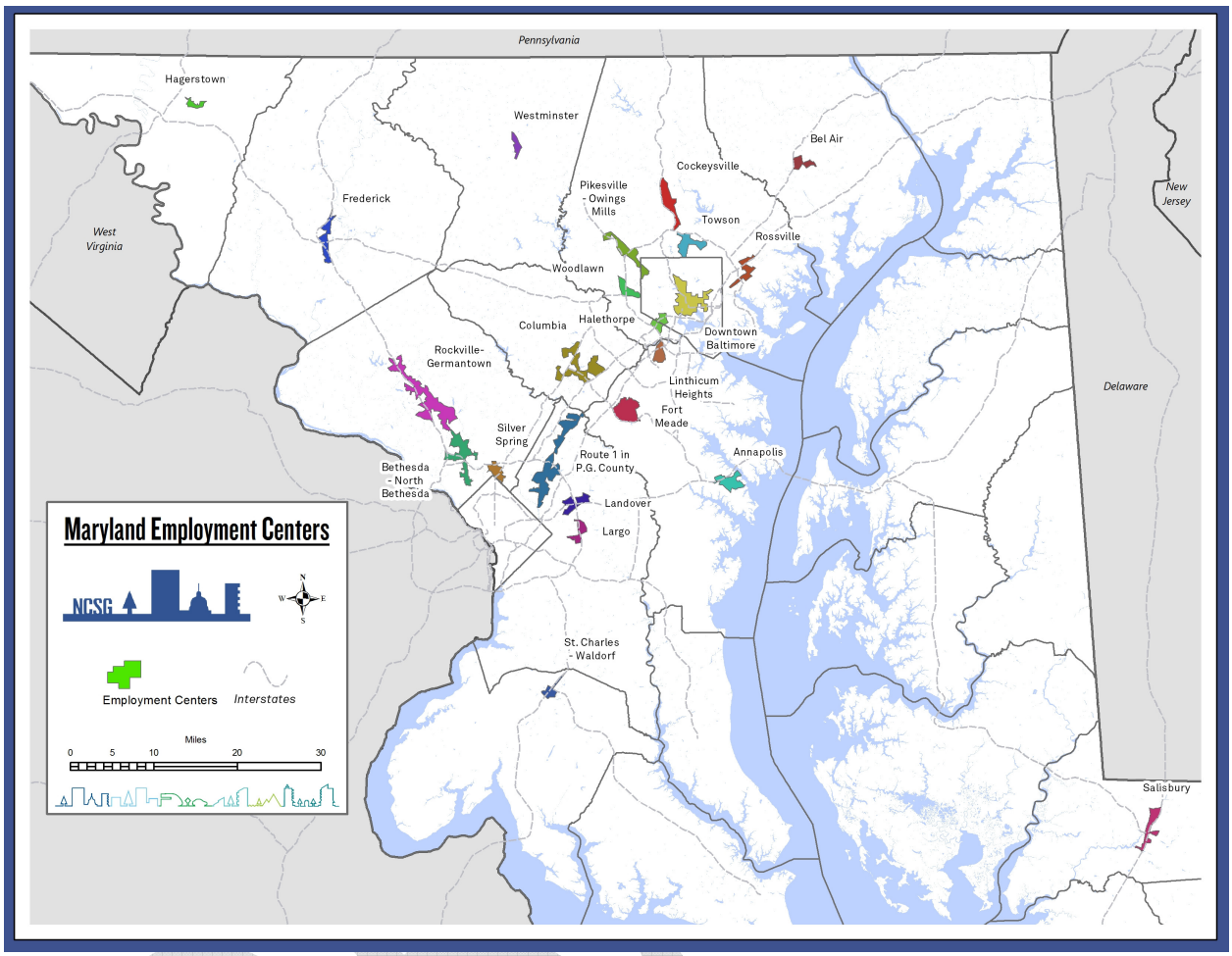
We begin our analysis by drawing on the conceptual framework outlined by Giuliano et al, (1991), using the 2007 Maryland Quarterly Census of Employment and Wages (QCEW), and

by exercising the Maryland Statewide Transportation Model.[5] The QCEW data contain highly detailed information for each employer in the state of Maryland, including total employment, wages paid, and NAICS industry classification. We use data from 2007 to avoid the influence of the recession that began in 2008.. [6]

Following Giuliano (1991) and Bogart (1999), we define employment centers in terms of contiguous TAZs with at least eight workers per acre and at least 10,000 total employees. We choose a slightly lower density threshold than that used by Giuliano to reflect overall differences between Maryland and Los Angeles. We then aggregate QCEW data to TAZs, maintaining information on the number of firms, wages, employment, and industrial composition. Using this framework, we identify 23 employment centers with a diverse set of characteristics.

The location of the centers identified using the above methods is presented in in Figure 3. As shown, most of the centers are located in central Baltimore and the suburbs that surround Baltimore and Washington. Most also are located along major transportation corridors.[7]

Figure 3 - MD Employment Center Map



Economic Characteristics of Maryland's Centers

The characteristics and economic significance of these centers are illustrated in Table I. Although they represent approximately 1.2% of the state's land area, yet they represent a quarter of the firms, nearly 40 percent of employment, 46.1 percent of total wages, and 17.04 percent of all households. As a result, compared to the rest of the state, the centers have relatively high employment densities, high wages, and high jobs-housing ratios.

Table I - Economic Characteristics of Centers

Economic Characteristics Inside vs. Outside Centers						
	Inside Centers		Outside Centers		State of Maryland	
	total	%	total	%	total	%
Land Area (Acres)	75,639	1.18%	6,320,979	98.82%	6,396,618	100%
Employment Firms	35,182	26.0%	100,093	74.0%	135,275	100%
Jobs	1,096,482	39.50%	1,679,753	60.50%	2,776,235	100%
Households	362,524	17.0%	1,765,488	83.0%	2,128,012	100%
Total Wages Paid (Billions)	$ 11.93	46.1%	$ 13.94	53.9%	$ 25.86	100%
Average Annual Wage	$ 43,521	-	$ 33,195	-	$ 37,259	-
Jobs per Firm	31	-	17	-	21	-
Jobs per Acre	14.50	-	0.27	-	0.43	-
Households per Acre	4.79	-	0.28	-	0.33	-
Jobs per Houshold	3.02	-	0.95	-	1.30	-

Although the centers share many characteristics they differ in many dimensions as well. As shown in **Error! Reference source not found.** the largest center, measured in jobs, is Downtown Baltimore with over 196,000 jobs, although the two centers in the I-270 corridor--Bethesda and Rockville—have a combined total of 299,964 jobs. Route 1 is the only other center with more than 100,000 jobs. After Route 1, the number of jobs per center falls rapidly; only five additional centers have more than 50,000 jobs. The distribution of jobs among these centers follows a typical central place hierarchy.

By construction, every center has a job density greater than eight jobs per acres. Two centers, however—Downtown Baltimore and Bethesda—have job densities greater than 35 jobs per acre, while Towson and Silver Spring have job densities greater than 25 jobs per acre. The rest have job densities between nine and 25 jobs per acres. Most centers have industrial compositions that are highly diverse. Fifteen centers have Herfindal diversity indexes greater than nine. Only Linthicum (the location of a large Northrup-

Grumman facility) and Woodlawn (the location of a large office of the Social Security Administration) have Herfindal indexes less than five. The largest center in area is Route 1 in College Park with over 8,700 acres; the smallest is Hagerstown, with just over 850 acres. Annual wages range from a high of $84,500 in Linthicum Heights to a low of $28,600 in St. Charles.

Table II - Economic Characteristics by Center

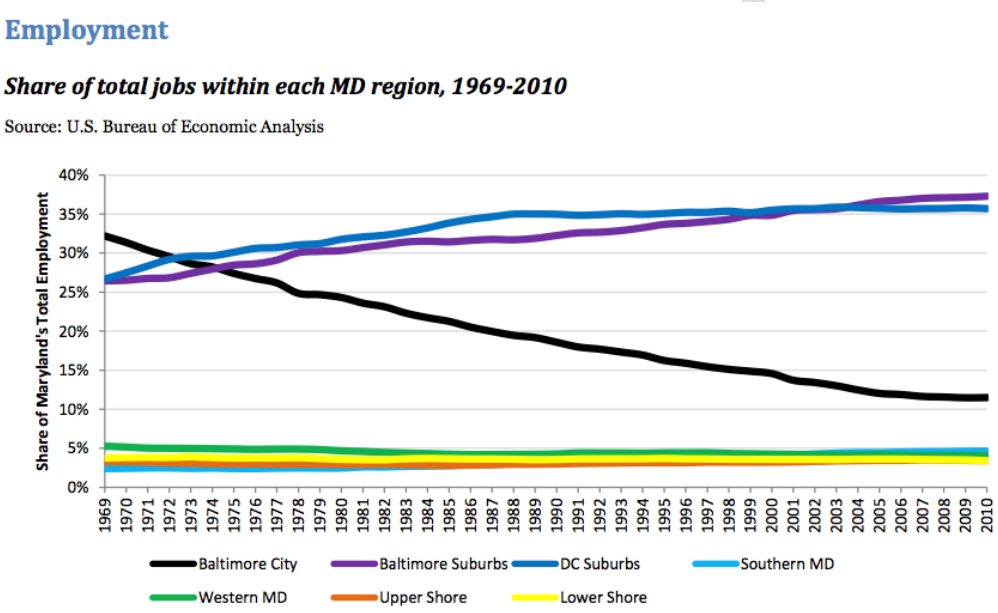
Economic Characteristics by Center

Employment Center	County	Acres	Employment Firms	Jobs	Households	Jobs per Firm	Average Annual Wage	Jobs per Acre	Diversity Index
Annapolis	Anne Arundel	2720.93	1,590	52,917	10,180	20	$ 37,593	11.94	8.30
Bel Air	Harford	1474.51	665	10,532	3,555	15	$ 29,076	6.78	9.06
Bethesda - North Bethesda (along M-355)	Montgomery	4994.33	4,909	124,840	37,727	30	$ 56,522	29.21	10.37
Cockeysville (along I-83 and M-45)	Baltimore	3316.66	1,270	45,776	1,507	31	$ 46,046	12.01	9.95
Columbia	Howard	6133.47	1,872	64,033	15,494	32	$ 49,711	9.75	9.31
Downtown Baltimore	Baltimore City	6599.60	5,461	196,167	66,817	39	$ 44,554	32.39	9.52
Fort Meade	Anne Arundel	4362.71	45	44,842	2,470	977	$ 2,492	10.08	-
Frederick	Frederick	2718.20	1,307	47,937	17,660	23	$ 37,839	11.30	10.80
Hagerstown	Washington	857.38	471	19,614	11,433	26	$ 29,038	14.51	6.80
Halethorpe	Baltimore	1663.67	482	17,084	4,152	31	$ 44,749	8.91	9.72
Landover	Prince George's	2346.61	665	21,851	6,240	30	$ 75,310	8.43	9.64
Largo	Prince George's	1611.61	540	18,416	5,177	29	$ 35,742	9.85	9.90
Linthicum Heights	Anne Arundel	1581.38	192	5,622	1,320	73	$ 88,687	8.81	4.71
Pikesville - Owings Mills (along I-795 and M-140)	Baltimore	3593.62	1,526	37,625	8,214	25	$ 29,685	10.50	10.61
Rockville-Gaithersburg-Germantown (I-270 & M-355)	Montgomery	9614.07	4,667	175,124	63,934	32	$ 44,077	15.72	10.50
Rossville	Baltimore	2021.12	715	15,193	4,437	28	$ 48,562	10.04	9.33
Route 1 in Prince George's County	Prince George's	8704.31	2,486	82,860	28,665	30	$ 37,782	8.47	9.83
Salisbury (along M-13)	Wicomico	2696.71	930	30,765	11,899	26	$ 31,125	9.02	10.85
Silverspring	Montgomery	1685.23	1,690	42,174	15,383	23	$ 38,820	23.41	8.22
St. Charles - Waldorf (along M-301)	Charles	1256.26	572	21,990	22,337	20	$ 24,206	8.92	7.41
Towson	Baltimore	2830.77	2,270	45,254	12,644	20	$ 52,373	15.82	9.57
Westminster	Carroll	1072.30	376	21,346	7,272	23	$ 28,579	7.97	7.46
Woodlawn	Baltimore	1783.64	481	31,095	4,007	66	$ 41,532	17.91	5.30
All Centers	-	**75639.07**	**35,182**	**1,173,057**	**362,524**	**33**	**$ 43,521**	**14.5**	-

Because of significant changes in how the data are collected and geocoded over time, the Maryland QCEW are not suitable for time series analysis and thus can not be used to describe how much each center has grown in jobs over time. Figure 4 below, however, illustrates the growth of jobs by region. As shown, in 1969 Baltimore City contained over 30 percent of all jobs in the state, today it only contains slightly greater than ten percent. The Washington suburbs, in contrast, contained just over 25 percent of jobs in 1969, while today it contains nearly 35 percent of jobs. Thus, despite the lack of disaggregate time series data, there is clear evidence of job decentralization form places like downtown

Baltimore to its the suburban subcenters and from the Baltimore region to suburban Washington, DC.

Figure 4 - MD Regional Employment Shares



Transportation Characteristics of Maryland's Centers

Maryland's 23 employment centers also play important roles in the state's transportation system as demonstrated using output from the Maryland State Transportation Model for the base year 2010. As shown in Table III and Table IV - Transportation Characteristics by Center, the centers combined, during the peak hour of travel, produce 21.35 percent of trips in the state and attract 28.76 percent of trips. By mode, the centers comprised 20.75

percent of all automobile trips and 39.38 percent of all transit (bus and rail) trips. The transit share of trips to the centers is 8.0 percent compared to a transit share of 1.8 percent for the rest of the state.

Table III - Transportation Characteristics of Centers

Transportation Characterstics Inside vs. Outside			
	Inside Centers	Outside Centers	State of Maryland
Trips Produced	21.35%	78.65%	100%
Trips Attracted	28.76%	71.24%	100%
Auto Trips	20.75%	79.25%	100%
Transit Trips	39.38%	60.62%	100%

The number of trips to each center is closely related to the number of jobs at each center. More jobs, more trips. Downtown Baltimore attracts the greatest number of trips followed by Rockville and Bethesda. Bethesda, Cockeysville and Silver Spring attract the highest share of transit trips at nearly 16 percent. Hagerstown, Frederick, and Bel Air, which have very limited transit service, have the lowest transit share at less than two percent.

Table IV - Transportation Characteristics by Center

Transportation Characteristics by Center									
	Productions		Attractions		Auto Trips		Transit Trips		Mode Share
Employment Center	Total	Percent	Total	Percent	Total	Percent	Total	Percent	Transit Share
Annapolis	164,550	0.72%	271,951	1.24%	160,727	0.75%	3,760	0.38%	2.3%
Bel Air	40,504	0.18%	66,406	0.30%	40,096	0.19%	264	0.03%	0.7%
Bethesda - North Bethesda (along M-355)	504,203	2.22%	666,285	3.03%	418,930	1.95%	85,059	8.66%	16.9%
Cockeysville (along I-83 and M-45)	82,921	0.37%	167,459	0.76%	69,267	0.32%	13,409	1.37%	16.2%
Columbia	244,344	1.08%	322,319	1.47%	239,093	1.12%	5,056	0.51%	2.1%
Downtown Baltimore	816,717	3.60%	1,076,726	4.90%	716,876	3.35%	99,251	10.10%	12.2%
Fort Meade	141,864	0.62%	194,320	0.88%	140,073	0.65%	1,778	0.18%	1.3%
Frederick	216,202	0.95%	267,184	1.22%	214,925	1.00%	1,178	0.12%	0.5%
Hagerstown	117,908	0.52%	127,562	0.58%	117,747	0.55%	161	0.02%	0.1%
Halethorpe	61,178	0.27%	79,099	0.36%	56,095	0.26%	5,032	0.51%	8.2%
Landover	91,661	0.40%	124,203	0.57%	86,310	0.40%	5,285	0.54%	5.8%
Largo	80,403	0.35%	104,337	0.47%	75,830	0.35%	4,532	0.46%	5.6%
Linthicum Heights	21,118	0.09%	25,786	0.12%	19,321	0.09%	1,778	0.18%	8.4%
Pikesville - Owing Mills (along I-795 and M-140)	120,804	0.53%	186,776	0.85%	102,523	0.48%	18,078	1.84%	15.0%
Rockville - Gaithersburg - Germantown (I-270 & M-355	780,953	3.44%	935,996	4.26%	721,441	3.37%	59,278	6.03%	7.6%
Rossville	63,093	0.28%	89,942	0.41%	60,817	0.28%	2,209	0.22%	3.5%
Route 1 in Prince George's County	378,101	1.67%	476,031	2.17%	352,518	1.65%	25,263	2.57%	6.7%
Salisbury (along M-13)	149,270	0.66%	177,607	0.81%	149,269	0.70%	0	0.00%	0.0%
Silverspring	180,722	0.80%	224,499	1.02%	150,054	0.70%	30,582	3.11%	16.9%
St.Charles - Waldorf (along M-301)	225,664	0.99%	214,542	0.98%	217,461	1.01%	8,196	0.83%	3.6%
Towson	174,667	0.77%	254,716	1.16%	166,165	0.78%	8,297	0.84%	4.8%
Westminster	93,576	0.41%	133,212	0.61%	92,205	0.43%	0	0.00%	0.0%
Woodlawn	97,305	0.43%	133,875	0.61%	78,876	0.37%	8,361	0.85%	9.6%
All Centers	**4,847,728**	**21.35%**	**6,320,833**	**28.76%**	**4,446,619**	**20.75%**	**386,807**	**39.38%**	**8.0%**

Jobs-Housing Balance

To integrate our economic and transportation analyses, we explore jobs-housing balance within each center and within the automobile- and transit-commute sheds of each center. As shown in **Error! Reference source not found.** the existing jobs-housing ratio within centers ranges from a low of .98 for Charlestown to over 30 in Cockeysville. Because they were selected based on their high employment densities, the jobs-housing ratio for most centers is greater than 2.0. The existing jobs-housing ratio over all centers is 3.24.

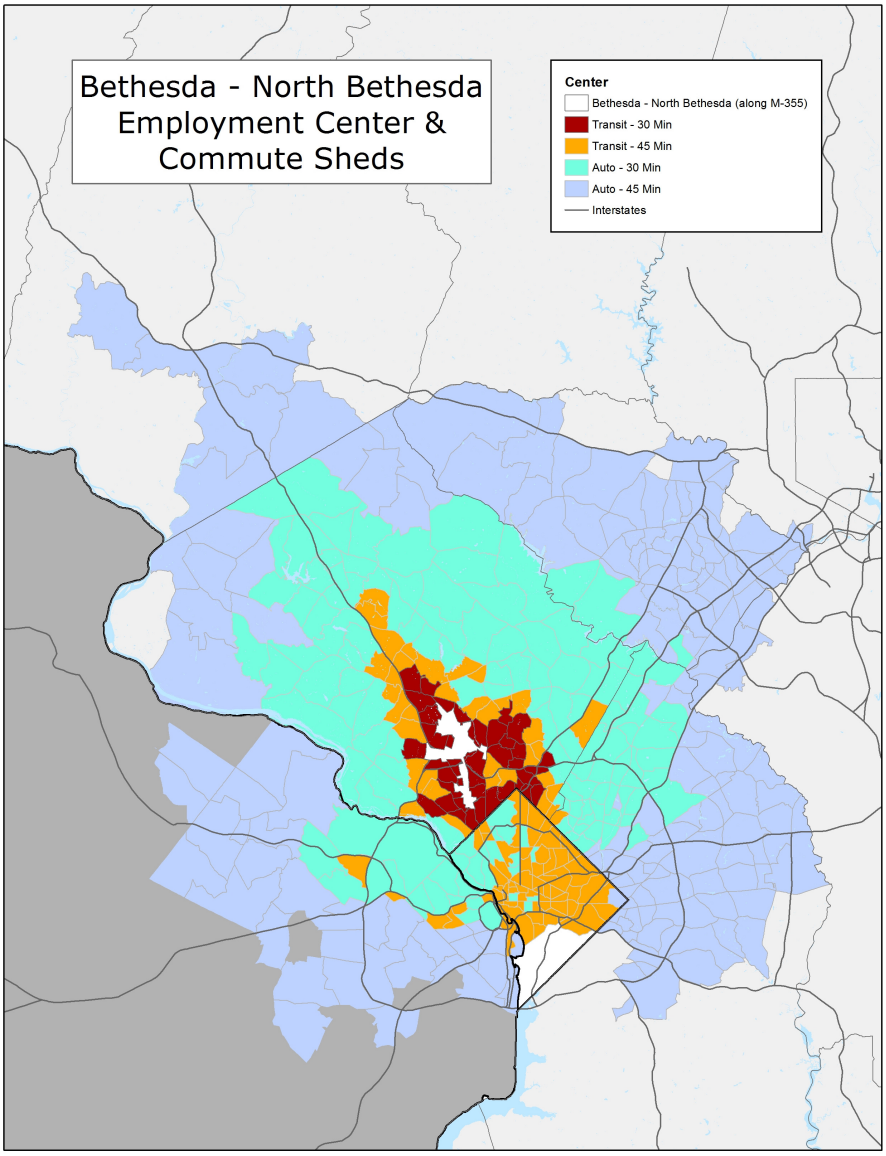
Table V - Jobs-Housing Balance by Center

Jobs/Housing Balance by Employment Center

Employment Center	Jobs per Household				
	Inside Centers	Transit Commute		Auto Commute	
		30 Min	45 Min	30 Min	45 Min
Annapolis	5.20	5.20	5.20	1.08	1.25
Bel Air	2.96	2.96	1.20	0.86	0.96
Bethesda - North Bethesda (along M-355)	3.31	2.43	2.89	2.18	1.93
Cockeysville (along I-83 and M-45)	30.38	21.33	2.82	1.41	1.31
Columbia	4.13	4.13	2.40	1.62	1.40
Downtown Baltimore	2.94	2.15	1.47	1.45	1.35
Fort Meade	18.15	18.15	4.93	1.79	1.54
Frederick	2.71	2.71	2.71	1.30	1.34
Hagerstown	1.72	1.72	1.72	1.31	1.17
Halethorpe	4.11	3.36	1.72	1.39	1.36
Landover	3.50	1.74	2.42	1.28	1.84
Largo	3.56	1.31	2.88	1.18	1.87
Linthicum Heights	4.26	5.10	2.45	1.49	1.34
Pikesville - Owings Mills (along I-795 and M-140)	4.58	4.93	1.87	1.38	1.37
Rockville-Gaithersburg-Germantown (I-270 & M-355)	2.74	3.09	2.02	1.47	1.73
Rossville	3.42	1.66	2.12	1.37	1.36
Route 1 in Prince George's County	2.89	2.26	2.25	1.97	1.78
Salisbury (along M-13)	2.59	2.59	2.59	1.28	1.21
Silverspring	2.74	1.89	2.44	2.23	1.94
St. Charles - Waldorf (along M-301)	0.98	0.98	0.98	0.77	1.06
Towson	3.58	2.23	2.25	1.35	1.33
Westminster	2.94	2.94	2.94	0.98	1.03
Woodlawn	7.76	3.01	2.12	1.51	1.37
All Centers	**3.24**	**2.47**	**2.05**	**1.60**	**1.57**
State of Maryland	**1.30**				

Again, because they were chosen for their high employment densities, the jobs-housing ratios within the centers are greater than the metropolitan average of 1.30. This is not surprising. Job-rich centers draw workers from their surrounding commute sheds. To explore how jobs-housing ratios vary by commute shed we construct commute sheds for travel by automobile and by transit for 30 minute and 45 minute commutes. The results are shown in **Error! Reference source not found.** for the Bethesda employment center.

Figure 5 - Bethesda Commute Shed



As shown in Figure 5 - Bethesda Commute Shed the 30-minute transit commute shed extends little beyond the boundaries of the Center. This is because the 30-minute transit commute includes the time it takes to get to the station, the time spent waiting for the train or bus, and the time spent in travel. When all this time is included, it is not possible to travel very far by transit within 30 minutes. As shown, it is not even possible to enter the

District of Columbia within a 30-minute transit commute. The 45 minute commute shed is considerably larger; this is because once aboard a transit vehicle, an additional 15 minutes enables the commuter to travel considerably further. As also shown, the 30-minute automobile commute shed is considerably larger than the 45-minute transit commute. This is because commuting by automobile doesn't require travel to a station or waiting for a bus or train. For obvious reasons, the 45-minute auto commute shed is even larger than the 30-minute commute shed and includes most of the Baltimore-Washington region.

For the reasons described above, the jobs-housing ratio over all the centers is 3.24, but falls to 2.47 within a 30-minute transit commute, and to 2.05 for a 45-minute transit commute. Similarly, because the automobile commute shed is larger than the transit commute shed, the jobs-housing ratio over all the centers falls to 1.60 for a 30 minute automobile commute, and to 1.57 for a 45-minute automobile commute.

It is not surprising to observe the jobs-housing ratio fall as the commute shed expands. As the commute shed expands to include areas with more housing and fewer jobs, the ratio of jobs to households declines. Although not every employee will work at the nearest center, it is interesting to observe that the number of jobs greatly exceeds the number of households within each center and within the commute shed of most centers, but that the jobs-housing ratio for the 30-minute automobile commute is very close to the ratio for the entire region. This suggests there may be equilibrating market forces that produces jobs-housing balance within the average commute time. We plan to explore this in future work.

IV. Summary and Policy Implications

In this paper we explored the spatial distribution of jobs and households within the state of Maryland and identified 23 economic centers with large numbers of jobs and high employment densities. Further examination revealed that these centers contained only a very small share of the state's land area but a large share of the states jobs. We also found these centers to feature a diverse industrial mix, firms that pay high wages, and an environment well suited for economic growth.[8] In an analysis of commuting patterns to and from the centers, we found the centers to create and attract a disproportionate share of trips. And that compared to trips to other locations, trips to the centers were shorter and more often taken by transit. These findings offer important insights for Maryland and regional sustainability planning more generally.

For Maryland, and the Baltimore and Washington metropolitan areas, the results strongly support the proposition that policies should be adopted to encourage job growth within the 23 economic centers in the state. Further, while there may be some value in targeting specific industries, it appears as though most of the existing centers are relatively diverse so that industry-specific targeting is not necessary. The results also strongly suggest that investments in transit should be strategically targeted to serve employment centers. Columbia and Fort Meade appear to be strong candidates for additional transit service. Finally, the results suggest that the state should pay particular attention to downtown Baltimore as a strategic employment center. While downtown Baltimore remains among

the largest, most dense, and most highly transit-served center in the state, the primacy of Baltimore appears to be fading in favor of the suburban centers in the I-270 corridor.

More generally, these findings provide strong empirical support for polycentric regional development strategies. Specifically they suggest that regional plans and policies should encourage job growth within select economic centers, especially in centers with high levels of transit service. Such concentration of economic activity would simultaneously further the goals of fostering economic growth, increasing transit ridership, reducing vehicle miles traveled, and mitigating automobile-related environmental impacts. To avoid further exacerbating jobs-housing imbalance, however, such economic development policies should be paired with housing policies that encourage housing development within the transit commute shed of these centers. Such policies would serve to balance jobs and housing within the transit commute sheds and similarly serve the goals of increasing transit ridership. Finally, the results offer strong empirical for the normative prescriptions advocated by New Urbanists and the HUD's sustainable communities initiatives.

References:

Alexander, C. (1965) A City Is Not A Tree, Architectural Forum, 122,1: 58-6, Reprinted In: John Thackara, Editor (1988) Design After Modernism (Thames And Hudson, London), Pp. 67-84.

Anderson, N. B., & Bogart, W. T. (2001). The structure of sprawl: Identifying and characterizing employment centers in polycentric metropolitan areas. American Journal of Economics and Sociology, 60(1), 147-169. Retrieved from Google Scholar.

Bodenhorn, H., & Cuberes, D. (2010). Financial development and city growth: Evidence from northeastern American cities, 1790-1870. Retrieved from Google Scholar.

Bogart, W. T., & Ferry, W. C. (1999). Employment centres in greater Cleveland: Evidence of evolution in a formerly monocentric city. Urban Studies, 36(12), 2099-2110. Retrieved from Google Scholar.

Chou, T. L., Ching, C. H., Fan, S., & Chang, J. Y. (2011). Global linkages, the chinese high-tech community and industrial cluster development. Urban Studies, 48(14), 3019-3042. Retrieved from Google Scholar.

Cruz, Sara C. S. and Aurora A. C. Teixeira 2010, The Evolution of the Cluster Literature: Shedding Light on the Regional Studies–Regional Science Debate, Regional Studies 44,9: 1263-1288

Davoudi, S.(2003) EUROPEAN BRIEFING: Polycentricity in European Spatial Planning: From An Analytical Tool to a Normative Agenda." *European Planning Studies* 11, 8

Giuliano, G., & Small, K. A. (1991). Subcenters in the Los Angeles region. Regional Science and Urban Economics, 21(2), 163-182. Retrieved from Google Scholar.

Giuliano, G., Redfearn, C., Agarwal, A., & He, S. (2011). Network accessibility and employment centers. Urban Studies. Retrieved from Google Scholar.

Glaeser, E. L., & Gottlieb, J. D. (2009). The wealth of cities: Agglomeration economies and spatial equilibrium in the united states. Retrieved from Google Scholar.

He, Z., Rayman-Bacchus, L., & Wu, Y. (2011). Self-organization of industrial clustering in a transition economy: A proposed framework and case study evidence from china. *Research Policy, 40: 1280-94.*

Kantor, S., & Whalley, A. (2009). Do universities generate agglomeration spillovers? Evidence from endowment value shocks. Retrieved from Google Scholar.

Knaap, Gerrit-Jan and Rebecca Lewis, 2012, Metropolitan Planning for Sustainability and the Hegemony of Metropolitan Regionalism. In E. Seltzer & A. Carbonell (Eds.) American Regional Planning: Practice and Prospect. Cambridge, MA: Lincoln Institute of Land Policy.

Mishra, S., Welch, T., Moeckel, R., Mahapatra, S., and Tadayon, M. (2013). Development of the Maryland Statewide Transportation Model and its Application in Scenario Planning, Compendium of Papers, 92nd Annual meeting of Transportation Research Board (TRB), National Academy of Science, Washington DC.

Nishimura, J., & Okamuro, H. (2011a). R&D productivity and the organization of cluster policy: An empirical evaluation of the industrial cluster project in japan. The Journal of Technology Transfer, 36(2), 117-144. Retrieved from Google Scholar.

Nishimura, J., & Okamuro, H. (2011b). Subsidy and networking: The effects of direct and indirect support programs of the cluster policy. Research Policy.

Porter, M. E. (1996). Competitive advantage, agglomeration economies, and regional policy. International Regional Science Review, 19(1-2), 85-90. Retrieved from Google Scholar.

Porter, M. E. (2000). Location, competition, and economic development: Local clusters in a global economy. Economic Development Quarterly, 14(1), 15-34. Retrieved from Google Scholar .

Rayman-Bacchus, L., & Wu, Y. (2011). Self-organization of industrial clustering in a transition economy: A proposed framework and case study evidence from china. Research Policy. Retrieved from Google Scholar.

Rosenfeld, S. (2005). Industry clusters: Business choice, policy outcome, or branding strategy? Journal of New Business Ideas and Trends, 3(2), 4-13. Retrieved from Google Scholar.

Rosenthal, S. S., & Strange, W. C. (2004). Evidence on the nature and sources of agglomeration economies. Handbook of Regional and Urban Economics, 4, 2119-2171. Retrieved from Google Scholar .

Salingaros, Nikos, Lucien Steil Michael W. Mehaffy, Undated, Growing Sustainable Suburbs: An Incremental Strategy For Reconstructing Sprawl, Downloaded From Http://Www.Academia.Edu/188207/Growing_Sustainable_Suburbs_An_Incremental_Strategy_For_Reconstructing_Sprawl, December 26, 2012

Spencer, Gregory M., Tara Vinodrai, Meric S. Gertler, and David A. Wolfe 2010, Do Clusters Make a Difference? Defining and Assessing their Economic Performance, Regional Studies 44,6: 697-715

Talen, E. (2008). Beyond the front porch: Regionalist ideals in the new urbanist movement. Journal of Planning History, 7(1), 20-47. Retrieved from Google Scholar.

[1] The six livability principles are: Provide more transportation choices; Promote equitable, affordable housing; enhance economic competitiveness; support existing communities. coordinate and leverage federal policies and investment; value communities and neighborhoods. (http://www.sustainablecommunities.gov)

[2] (http://portal.hud.gov/hudportal/documents/huddoc?id=2011scrpgfullappnofa.pdf)

[3] For a thorough analysis of the history and evolution of employment cluster studies, see Cruz and Teixeira (2010).

[4] The term "economic centers" is more commonly used in this line of research as the focus is less on interindustry relationships and more on relative employment density.

[5] For more on the Maryland State Transportation model, see Mishra et al. (2013).

[6] It is important to note that QCEW data is derived from unemployment insurance records filed by each employer. This introduces a set of known limitations including the omission of sole-proprietor firms, and incomplete military and government employment information. Since these three groups do not purchase unemployment insurance, they are not accurately represented in the population. However, through a number of adjustment procedures, we estimate

total military and government employment by comparing QCEW total employment in each industry with figures published by the Bureau of Economic Analysis (BEA) and other trusted sources. We then use proportional allocation to distribute adjusted employment among known firm locations until our estimates are consistent with other sources. This adjustment process could impact our analysis, however we believe it produces better results than if no adjustment had been made.

[7] Because of the large geographic size of the center in the 270 corridor, we define two centers in this corridor based on a natural break in the geography

[8] In another paper, (author suppressed) we conducted a statistical analysis of the job growth in the state and found the probability of new firm start ups to be significantly higher in the 23 employment centers than in other parts of the state.