The Chesapeake Megaregion Market Analysis

Report to the Federal Highway Administration
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EXECUTIVE SUMMARY

Across the world megaregions, large agglomerations of metropolitan areas, form an emerging development pattern, and within the United States they are becoming the typical urbanization pattern. To function effectively and to allocate scarce resources to infrastructure investments, megaregions must understand their relationships with other megaregions, intra-megaregion economies, and the interrelationships between economic flows and the transportation system. To support emerging megaregions the FHWA sponsored the report, “A Framework for Megaregion Analysis: Development and Proof of Concept”. The framework consists of a market analysis with three components; identification of megaregion issues, boundary definition and megaregion characterization. An economic and transportation model framework supports the market analysis.

This study demonstrates the applicability of the framework by applying it to the Chesapeake Megaregion, stretching from Wilmington Delaware to the Norfolk Virginia Beach area.
The Chesapeake Megaregion faces multiple issues including, the environment, the health of the Chesapeake Bay, continuing urban sprawl, and the economy and growing traffic congestion. While all of these issues are critical, this report focuses on the economy of the megaregion. The economy is a major issue in most parts of the U.S., designing efficient infrastructure systems supports economic development.

Defining the boundary of a megaregion must be done on a case-by-case basis and depends on existing political boundaries, the infrastructure of the megaregion, and the issues to be addressed. Unlike states and MPOs, megaregions do not follow strict boundary definitions. In the case of the Chesapeake Megaregion, the initial boundaries were based on a report by Dr. Catherine Ross from Georgia Tech, which covered most of Maryland, Delaware, and portions of eastern Virginia. To fully understand the economic interactions, the boundaries defined by Ross were expanded to cover all of Maryland, southern Pennsylvania, and all of eastern Virginia. To capture freight movements, New Castle County, Delaware, and the Port of Wilmington, are also included.

An extensive characterization of the Chesapeake Megaregion was conducted, including infrastructure, commuter sheds, economic flows, supply chain analysis and a projection of trends to 2030. The Chesapeake Megaregion contains three major airports; Baltimore-Washington International, Ronald Regan and Dulles International. It also contains the ports of Wilmington, Baltimore and Norfolk. Major Interstates, I-95, I-64, I-81 and I-70 along with the Chessie System, Norfolk Southern and Amtrak tie the region together. In 2010 the Chesapeake Megaregion had a population of 15 million, contained in 5 million households and employment of 9 million. Government, military, health, manufacturing and recreation are major employment sectors with government playing a significant role throughout most of the Chesapeake Megaregion. Analyses of FAF data showed that one third to one half of goods consumed within the Chesapeake Megaregion were produced in the Chesapeake Megaregion and that most freight shipments entering of leaving the Chesapeake Megaregion did so by truck. Shipments entering the ports complement each other with Wilmington providing primarily for oil imports, Baltimore serving shorter distance freight travel, usually truck trips less than 400 miles, and Norfolk serving a larger community with nearly 50% of traffic to and from the port moving by rail.
The region contains three commuter sheds, Baltimore - Washington, Richmond, and Norfolk - Virginia Beach. An analysis of county-to-county freight flows, showed that freight movements

within the Chesapeake Megaregion, tie the megaregion together. This is exemplified by both the dollar value of freight flows as well as the tonnage. A large portion of this freight movement is in the north south direction along the I-95 corridor. The characterization also looked at freight flows in and out of Baltimore, Washington, and Richmond to the rest of the megaregion. The analysis showed that these cities are interconnected by both import and export freight flows. The location of the origin and destination of these flows showed the movements occur along the I-95/I-64 corridors.

A supply chain analysis was also conducted, looking at key shipments into and out of Richmond and Baltimore. This analysis showed that each of these cities imported goods from other areas, processed them, and then sent them to other locations. Richmond processed a large share of paper products and Baltimore materials for soft drinks and ice manufacturing. These shipments, particularly shipments from Richmond to Baltimore, demonstrated how closely freight movements tie the megaregion together and north-south movements dominate freight flows. An additional sensitivity analysis was conducted on the effects of a 1% increase in the Baltimore and Richmond economies. This analysis showed that an increase of this type would influence surrounding counties and provide ripple effects throughout the entire megaregion.

The transportation model, which included economic and land use projections along with internal and external passenger and freight flows, estimated future passenger and truck travel and the effect of changes in travel patterns on the highway network. Truck trips greater than 50 miles were shown to have a major impact on VMT but accounted for a small number of total truck trips. Using the transportation model to look ahead to 2030, large increases in congestion were observed along the I-95 corridor, particularly in the Washington DC area. An analysis of future freight flows showed that this congestion, combined with the growth in freight traffic, would increase the cost of freight travel, particularly in the North-South direction.

The market characterization leads to conclusions about the Chesapeake Megaregion and megaregions in general. The Chesapeake Megaregion is linked together by the I-95/I-64 corridor. The location of population and employment along the corridor and freight movements within the Chesapeake Megaregion illustrate this. Economic flows between urban areas within the megaregion further support the megaregion linkages. Future growth in traffic congestion has the potential to threaten these economic linkages.

The analysis also shows that understanding the economy and economic interrelationships requires a larger view than the commuter sheds typically defining MPOs. Also, issue identification is critical to megaregion understanding and is tightly coupled with boundary definition. In this case study, the economy was analyzed and boundaries were defined accordingly. Had the issue been water quality in the Chesapeake Bay, much of the boundaries would have been different with more of a focus on the Bay watershed.

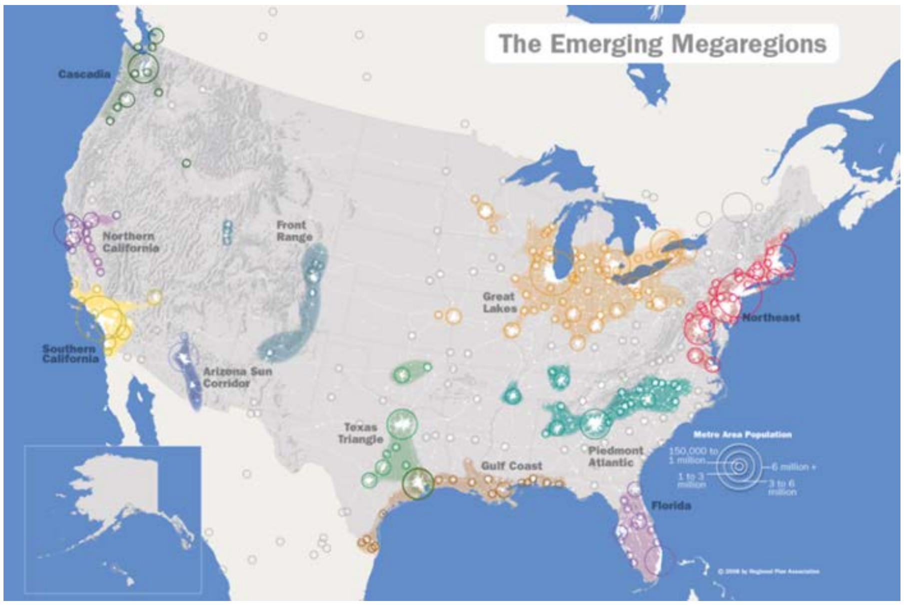
Finally, there is a need for a general analytic framework for megaregion analysis. The case study also demonstrates that a model, usable for megaregion-wide analysis, can be constructed from available resources.

1. MEGAREGION EMERGENCE

In many parts of the world, megaregions, large agglomerations of metropolitan areas and their supporting hinterlands, represent an emerging development pattern. Megaregions offer distinct agglomerative benefits that make such areas more competitive in the global marketplace. For example, they have a sufficiently diverse economic and land supply base that the entire value chain of a given multi-national firm would be able to locate its different functions within the megaregion rather than off-shoring activities for different functions. [1]

In the US, with large-scale agglomeration economies and the increased mobility of highly educated workers, megaregions are also becoming the typical urbanization pattern. As Figure 1shows, the emerging megaregion examples include the Northeast corridor covering Boston, MA to Richmond, VA, and the industrial areas surrounding the Great Lakes.[2] By 2050, megaregions will contain two-thirds of the nation's projected 430 million residents.[3] They are likely to be the "nation's operative regions when competing in the future global economy" according to the Federal Highway Administration's Strategic Plan.[4]

Figure 1 The Location of Emerging Megaregions Defined by the Regional Planning Association



Source: Regional Plan Association. The Emerging Megaregions [map]. "America 2050 Megaregions." 2008. http://www.america2050.org/maps/ (accessed February 5th, 2013).

Megaregions now compete with each other for economic development opportunities as well as complement and connect each other. As stated in the FHWA Strategic Plan, "a challenge is to determine how to foster greater efficiencies in these megaregions by creating a stronger infrastructure and technology backbone in the Nation's surface transportation system"[4]. To function effectively, and to allocate scarce resources to infrastructure investment, megaregions must not only understand their relationships with other megaregions, but must also understand their own intra-megaregion's economic flow and the interactions between these flows and the transportation system.

2. MEGAREGION ANALYSIS FRAMEWORK

2.1 Need for Framework

Many planning decisions are more appropriately made at the megaregional level than at the traditional Metropolitan Planning Organization (MPO) or state level. The larger scale is relevant in cases of spillovers, economies of scale, demand heterogeneity, and administrative cost efficiencies. Through a comprehensive literature review, as well as experience working on specific projects, issues and models, three issues have been identified that ought to be addressed at the megaregional level.

- Issues involving large spillovers which extend beyond existing local, regional, and possibly state governance arrangements but not to the scale of the entire nation. An example of this is congestion along major transportation links within the megaregion.

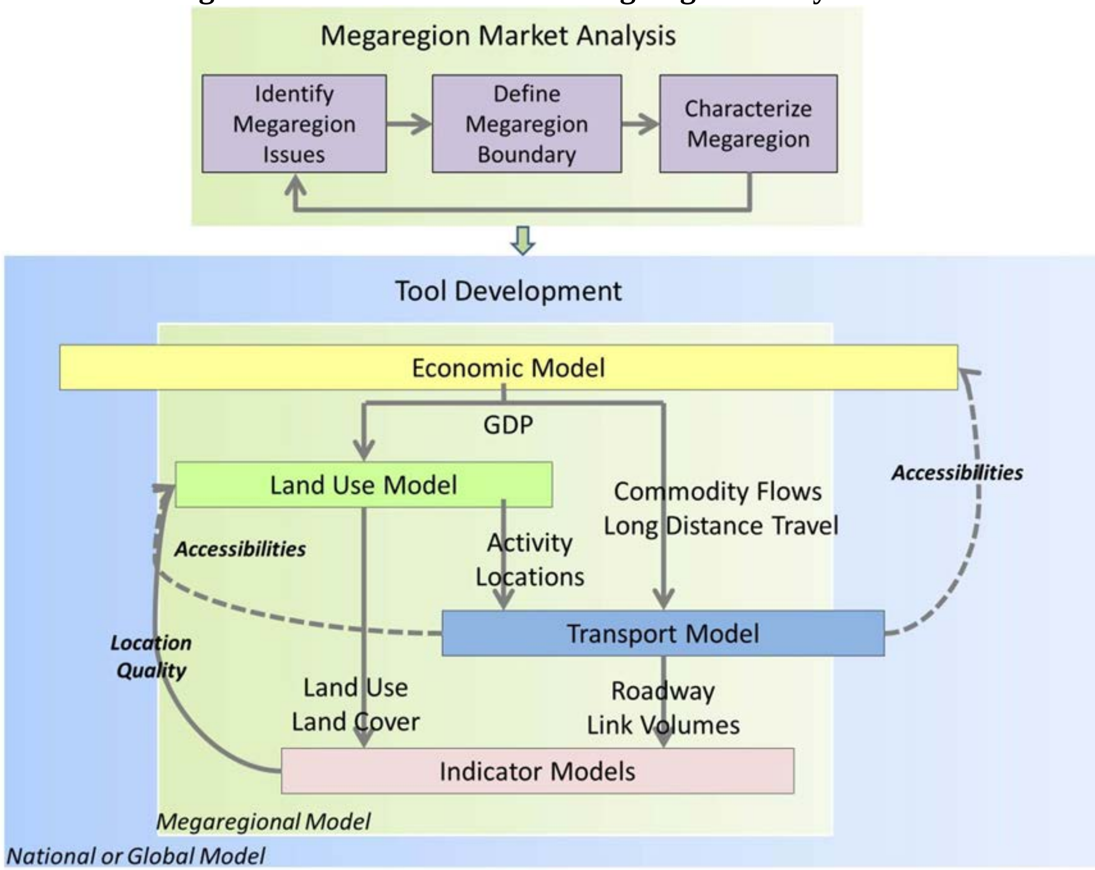
- Issues which involve a redistribution of resources across megaregion areas or states both which benefit from local (megaregional) knowledge regarding the nature of the redistribution.

- Issues that can be addressed with low administrative costs at the megaregional scale. If there are economies of scale in administration, then megaregional action would be preferred to local independent actions. The E Z Pass tolling system in the Northeastern U.S. is an example of this.

Megaregion analysis requires a comprehensive framework to respond to the issues identified above. Since megaregions encompass a larger area than typically covered by MPOs or state DOTs, a larger analytic view is required. This requires the inclusion of economic motivations for travel and a focus on longer distance intramegaregion freight and passenger travel. However, some local detail must remain to enable sensitivity to policies where changes in local conditions may collectively affect the entire megaregion.

A framework example is shown in Figure 2. Typically, a megaregion analysis framework should include two parts: market analysis and tool development. The market analysis defines issues and boundaries, and characterizes the economy and transportation flow within the megaregion. Based on the market analysis, the tool development process then tailors the analytic tools to the megaregion issues and conditions.

Figure 2 Flow Diagram of the Modules in the Megaregion Analysis Framework



2.2 Need for Market Analysis

The market analysis consists of three components: identifying the core issues, identifying the megaregion boundary, and characterizing the megaregion. These steps are interrelated. Depending on the circumstances, the market analysis may start with any of the three steps.

2.2.1 Identify Issues

Each megaregion is unique in terms of core issues that tie the megaregion together. The issue could be environmental, cultural, political, or economic. For many megaregions, economic competitiveness is paramount, with transportation, land use, and the environment supporting a vibrant economy. Thus, megaregion models should be driven by a national economic model, as well as an analysis of key industry sectors and goods movement flows within the megaregional economy and linkages to the transportation system. The transportation needs of these economic flows provide a key input to decisions regarding new infrastructure investment at the megaregional level.

2.2.2 Identify Boundary

A megaregion's boundary may vary. It may be defined by environmental concerns, economy, cultural similarities, or other considerations. For example, if the health of the Chesapeake Bay is of concern, the boundary could be defined by the Chesapeake Bay watershed. If the economy of the area surrounding the Bay is the issue, there would be a different boundary with attention to industrial chains. In some instances, a megaregion may be defined by political boundaries, with the megaregion addressing a number of issues.

2.2.3 Characterize Megaregion

The third step in the market analysis is to characterize the megaregion focusing on its most dominant issues. A two-tiered analysis is appropriate for megaregion characterization: first understanding the megaregion as an entity, identifying the relationship to other megaregions and the national/global economy, and then analyzing intramegaregion flows. The overall megaregional situation lays a foundation for detailed analysis. For example, as the backbone for megaregional economy, infrastructure reflects the spatial structure of a megaregion. In illustrating intramegaregion linkages, flow analysis works as an appropriate approach. By tracking various types of flows, such as people's flows, commodity flows, capital flows, and information flows, as well as their origins and destination, one can better understand the industrial chain and economic hierarchy within a megaregion. Combined with the flow analysis, an analysis of infrastructure can help to understand whether the current capacity can adequately support projected changes in flows. When issues warrant and data exists, a forecast of future conditions can be added to the current analysis through a forecasting model or other tools.

2.3 Tool Development

Tools may be developed depending on data availability, existing analytic methods, and the nature of the megaregion issues. They may be derived from existing procedures or developed based on the particular issue to be addressed. The nature of the tools and the overall emphasis will be determined by the particular issues to be addressed.

The megaregion analysis tool should include short- and long-distance freight flows as well as passenger movements. As such, it is more appropriate to employ integrated models where travel is driven by economic and land use decisions, and employ a multi-level model where activities are assessed at an appropriate national, megaregional, or local context reflecting the scale at which the phenomenon occurs. Such a suite of models would aspire to address:

- Economic, Transportation, Land Use and Environmental Impacts.
- Multi-Modal Transportation Systems.
- Short- and Long-Distance Travel.
- Multi-Scale Projects.
- Diversified Megaregion Context.

A multi-tiered approach with three layers – global, megaregion, and MPO/DOT layers - represents the context for travel decisions by the market segments important to megaregions.

This approach enables a tailoring of the spatial scale to various data and decision-makers represented in the model components. It also facilitates the integration with existing local MPO/DOT models. Probably most important is to tailor this framework to the policy questions of the particular megaregion.

The tool development box within Figure 2 shows the model components and structure for megaregion analysis. The megaregion analytical framework is built on the economy. The economy defines the megaregion geographically and serves as a driver for activity locations and associated travel demands. A land use model allows the analysis of coordinated policies that can work towards efficiencies rather than competitions indicator models are important measures of performance. The data flows and feedbacks between them that reveal the complex interplay of forces.

Megaregion models must consider both short and long - distance trips. The explicit distinction between short and long-distance travel has behavioral and technical implications for the framework. In terms of travel behavior, long-distance trips differ significantly from short-distance trips due to differences in travelers' income, mode and destination choice, as well as trip purpose. Limited information available to long distance travelers also affects time of day, mode selection and route selection; while longer trip lengths may reduce sensitivity to congestion and costs of travel.

The level of detail, at which each element of the framework operates, greatly depends on the policy questions that are likely to be asked. The following describes each of the framework components.

- **Economic Models.** Changes in the national economy will have effects on the megaregion, both with respect to growth in population and employment and trade with other megaregions. Important economic interactions occur at different geographies. A global scale captures interactions with other megaregions and drivers of national freight flows, while at congestion has a local economic impact.

- **Land-Use Models.** The land use model forecasts the likely location of future population and employment.

- **Transport Models.** Transport models forecast the number of trips made, origins and destinations, and mode. They do this for short and long distance passenger trips and short and long distance freight trips. They also place trips on the highway network and estimate congestion levels.

- **Indicator Models.** Indicator models are post-processor models, which are used to address specific issues of a megaregion. The development and use of indicator models is determined by the particular issues to be addressed. Some examples are air quality, water quality, and local economic impacts. Other types of indicators may be included as conditions warrant.

3. CHESAPEAKE MEGAREGION MARKET ANALYSIS

In the report "*Megaregions: Delineating Existing and Emerging Megaregions*", Ross provides a comprehensive methodology for defining and delineating megaregions.[5] Using available data from multiple sources including the Highway Performance Monitoring System (HPMS), the Freight Analysis Framework (FAF), Census, Woods and Poole, and private data sources, she first identified megaregion core areas, areas of influence, and clusters of metropolitan regions. Through applying analytic techniques including, Graph Theory, Markov chains, and factor analysis, 12 megaregions in the United States were identified.

One of the megaregions described by Ross is the Washington D.C – Virginia megaregion. Ross finds that interactions within the Buffalo-Boston-New York-Philadelphia megaregion and the Washington DC-Virginia megaregion are stronger than between these two megaregions. This smaller geography also makes policy implementation more feasible, given that collaborative policy solutions require cooperation among a smaller number of states and local governments. As described in section 3.2 Boundary, this area was expanded and redefined as the Chesapeake Megaregion.

In the following sections, the megaregion analysis framework developed above is applied. The economy and transportation are shown to be key issues within this megaregion in Chapter 3. Chapter 3.2 defines the boundary expanded beyond that provided by Ross to include additional critical areas as well as to apply available data analysis tools. A detailed characterization is developed in Chapter 3.4.

3.1 Issues

The Chesapeake Megaregion forms around its primary environmental resource- the Chesapeake Bay. It is comprised of an advanced system of rail, ports, and highways that facilitate commodity flows and link labor markets that depend heavily on the transportation and government sectors. The Chesapeake Megaregion is projected to grow the fastest among all other megaregions within the Northeast Corridor, giving rise to a range of growth-related policy challenges including traffic congestion and environmental pollution.[6] The widening of the Panama Canal may redirect a portion of international freight flows to the megaregion's major ports of Norfolk and Baltimore. Existing political linkages also support the concept of Chesapeake Megaregion. Examples of these linkages include the I-95 Corridor Coalition that tackles freight movement and the Chesapeake Bay Commission which addresses stewardship of the Bay, the unifying economic and environmental heart of the megaregion.[7&8]

Common issues in the megaregion include congestion and various discussions on congestion pricing solutions, growth in port traffic, land use planning to balance urban and agricultural interests, and environmental concerns about Bay water quality and sea level rise due to global climate change. In addition, like most areas in the United States, the economy is a major issue and actions to promote or support economic development are a major concern.

While there are multiple issues facing the Chesapeake megaregion, in this study the focus is economic and transportation concerns. These concerns determine the boundaries of the

Chesapeake megaregion and the types of analyses conducted. Other areas using the market analysis framework may address different issues, resulting in different ways of defining the megaregion and different analytic techniques.

3.2 Boundary

While Ross has provides an initial definition of the Washington D.C. – Virginia megaregion borders, to fully understand what is occurring in this area requires an expansion of the boundary to capture the interactions with surrounding areas and the development of necessary tools to analyze flows within the megaregion. This expanded area is referred to as the Chesapeake Megaregion. The northern borders were expanded to encompass southern Pennsylvania and the eastern borders extended to encompass Northern Delaware and Wilmington, both areas which interact with the Washington DC – Virginia economy.

In defining the boundary, the availability of analytic tool was considered. Previously the study team had developed the Maryland Statewide Transportation Model (MSTM) for the Maryland State Highway Administration. This model covered most of the area identified in the Ross report plus the Southern Pennsylvania and Wilmington, Delaware areas. As said above, these are key areas to understanding the economic and transportation issues and should be included. The MSTM coverage area had significant overlap with the Ross definition so the two areas were combined. Combining these two delineations provided for an increased analytic capability and an improved understanding of the megaregion.

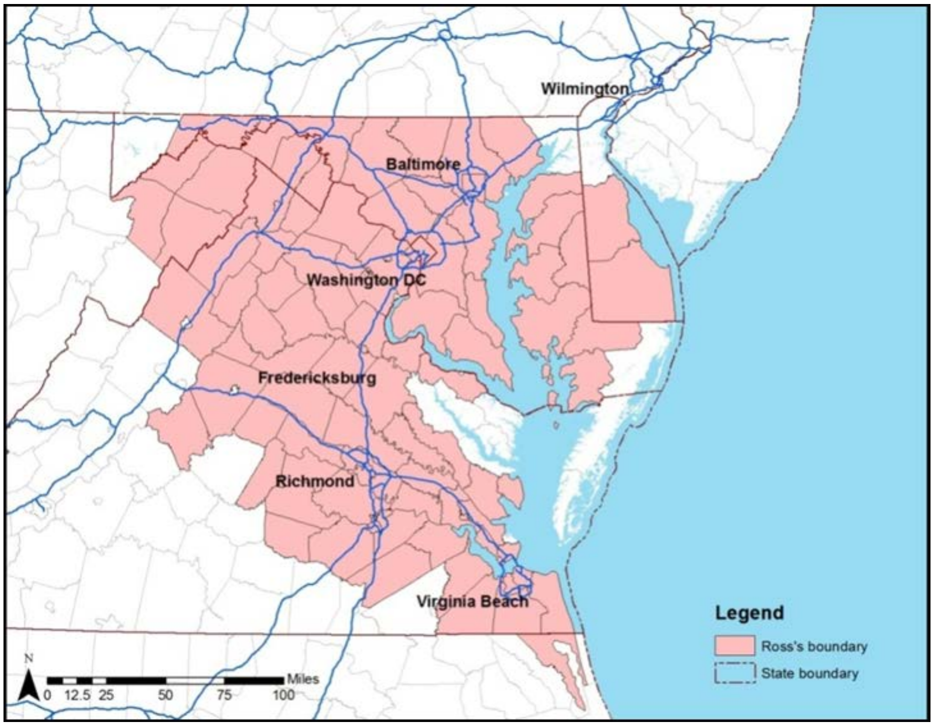
Figure 3, Figure 4, and Figure 5 illustrate the steps in the development of the Chesapeake Megaregion area.

- Figure 3 illustrates the Washington DC – Virginia megaregion as defined by Ross. The area includes most of Maryland, the eastern portion of Virginia, and a portion of the Delmarva Peninsula (The area between the Chesapeake Bay and Atlantic Ocean containing portions of Delaware, Maryland and Virginia).

- Figure 4 shows the coverage area of the MSTM, including Southern Pennsylvania, Northern Delaware. It also includes western Maryland and Northeast West Virginia. These areas are needed to fully understand Chesapeake Megaregion boundary conditions.

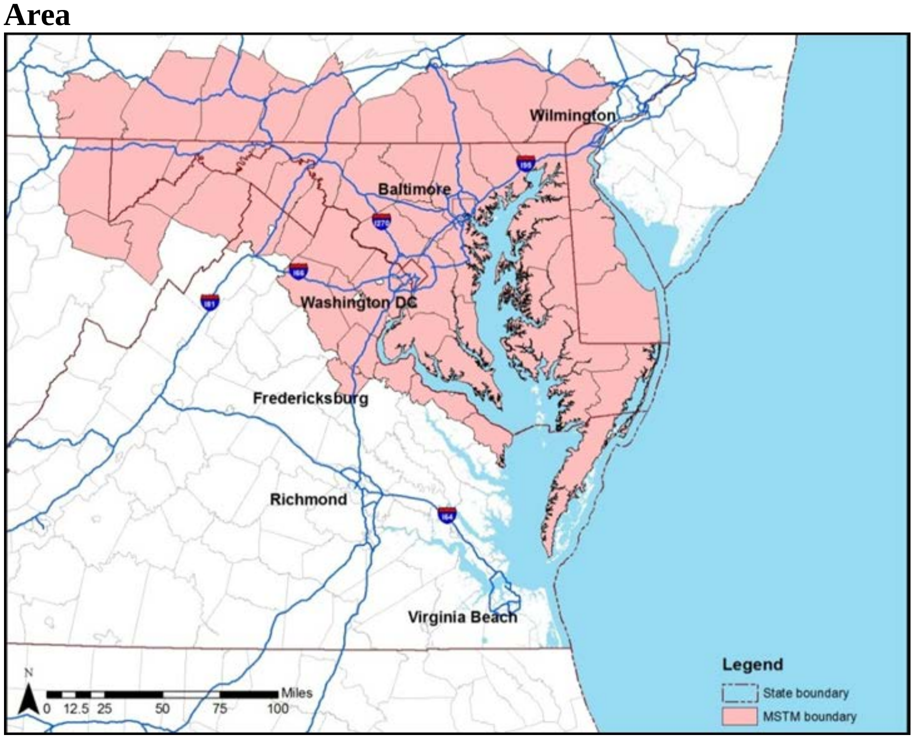
- Figure 5 combines the addition of the MSTM area to the Ross areas and adds rural areas necessary to smooth the boundary for model development. In Figure 5 the Ross definition is shown in the maroon area, the portions added by the MSTM in red and the orange areas were added in to ensure boundary conditions were properly represented for modeling purposes.

Figure 3 County Boundaries in the Washington DC-Virginia Megaregion as Defined by Ross



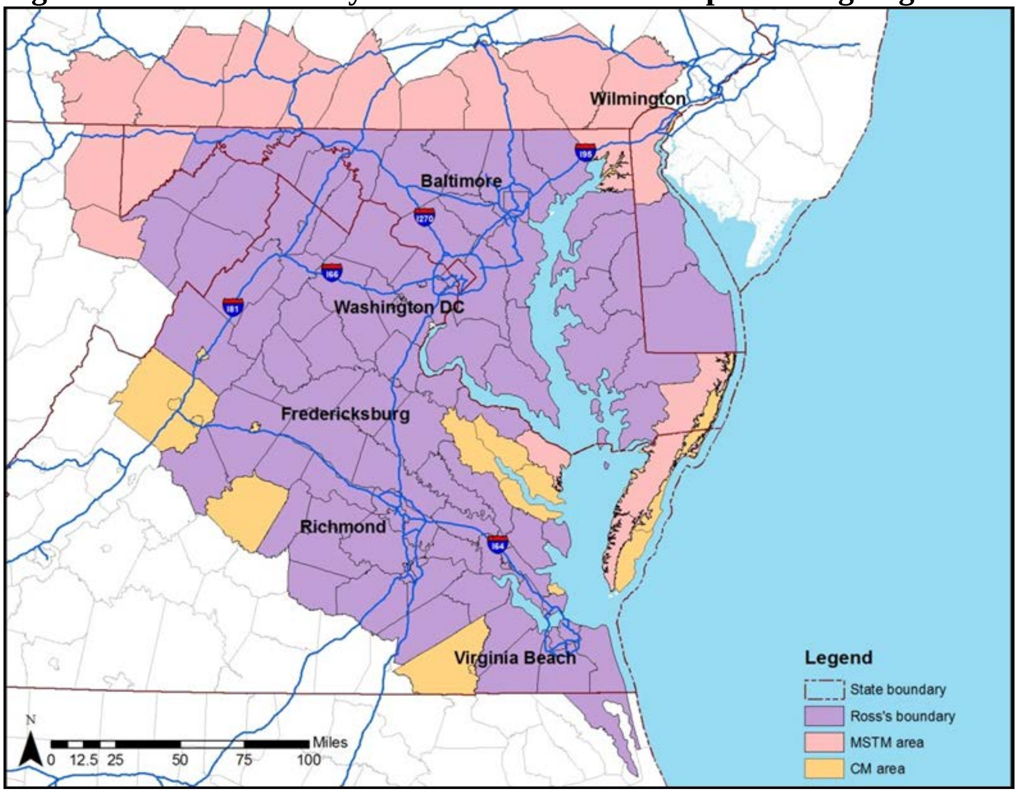
Source: Ross, Catherine. DC-Virginia Megaregion [facsimile]. "Literature Review of Organizational Structures and Finance of Multi-jurisdictional Initiatives and the Implications for Megaregion Transportation Planning in the U.S." 2011. <http://www.fhwa.dot.gov/planning/publications/megaregions_report_2012/megaregions2012.pdf>. Reproduced.

Figure 4 County Boundaries in the Maryland Statewide Transportation Model Coverage Area



Source: Center for Smart Growth Research and Education. Maryland State Transportation Model Coverage Area.

Figure 5 State and County Boundaries in the Chesapeake Megaregion Modeling Area



The Chesapeake Megaregion contains 142 counties or county equivalents. Within the megaregion there are 12 MPOs including; the Metropolitan Washington Council of Governments, the Baltimore Metropolitan Council, the Cumberland Area MPO, the Hagerstown Area MPO, the Salisbury Maryland/Delaware MPO, The St. Charles Maryland MPO, the Charlottesville-Albemarle MPO, the Fredericksburg Area MPO, the Hampton Roads Planning Organization, the Richmond Area MPO, the Winchester Frederick MPO, and the Wilmington Area Planning Council. The megaregion also contains areas not part of an MPO. For illustration purposes the counties have been aggregated into 17 subregions, as shown in Figure 6.

Figure 6 Subregion Boundaries in the Chesapeake Megaregion

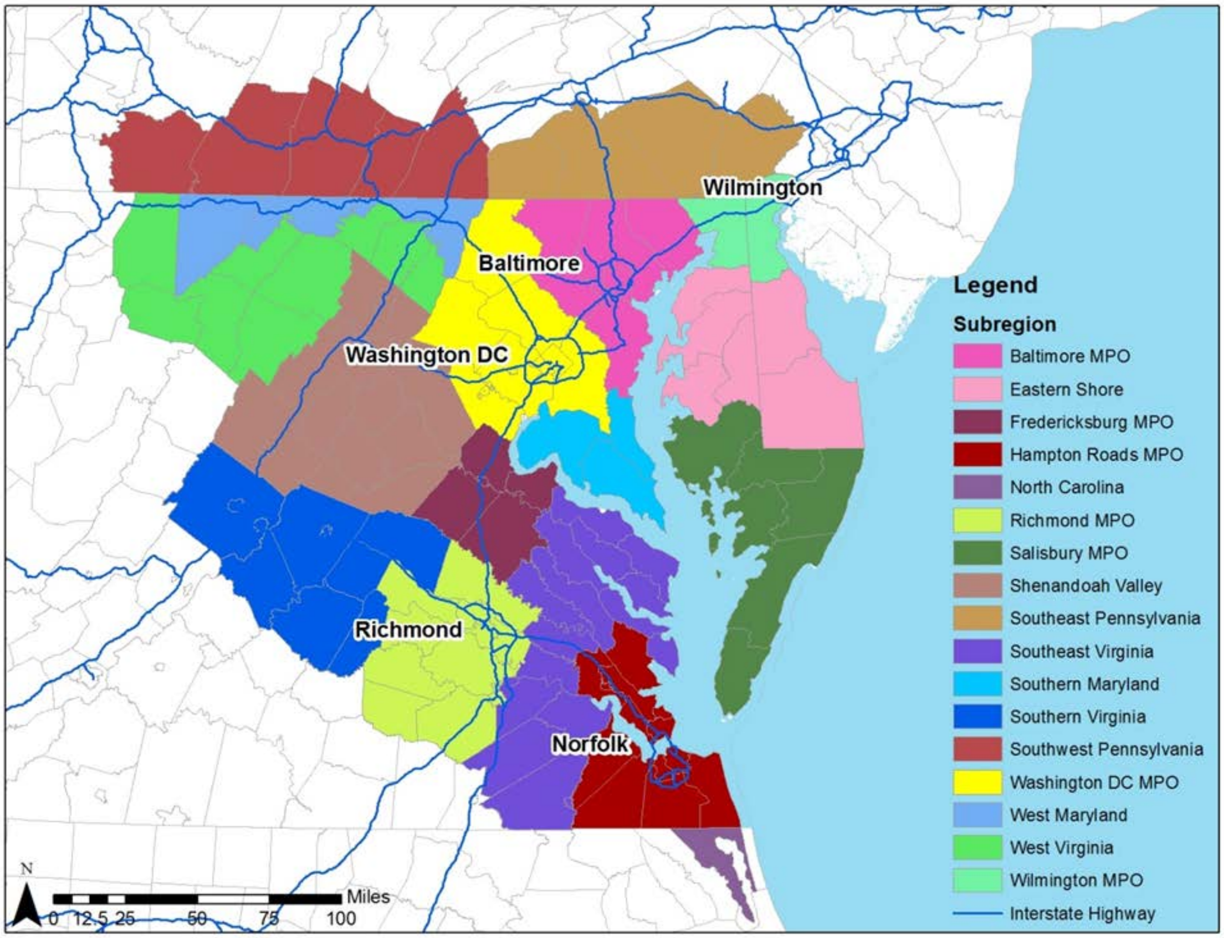
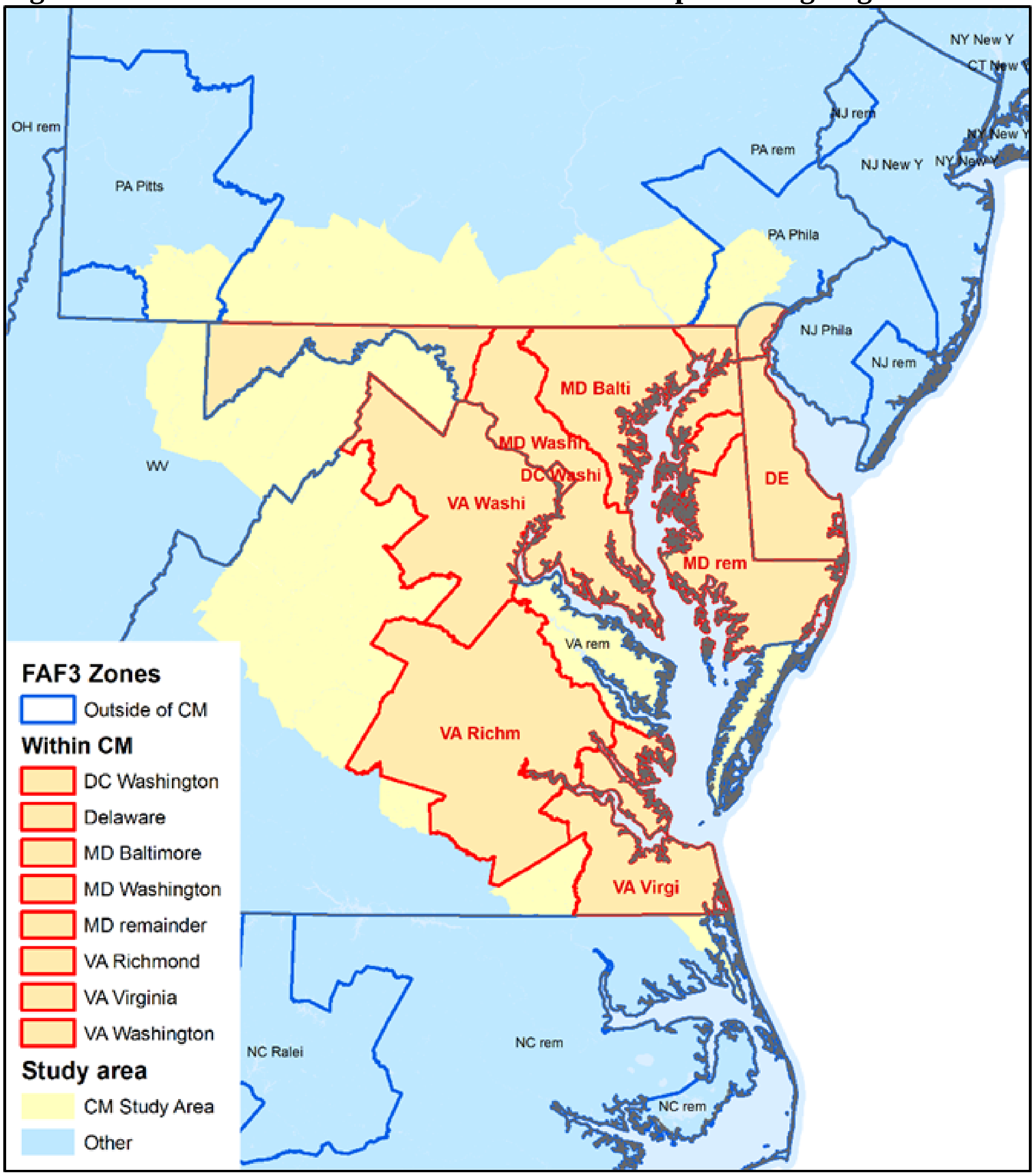


Figure 7 illustrates the FAF zones in the CBM. The zones in tan are contained entirely within the Chesapeake Megaregion; the zones in yellow partially within the Chesapeake Megaregion, and zones in blue are external. The following are definitions of the zones: (1) MD Balt – Maryland, Baltimore area, (2) MD Washi – Maryland, area around Washington, (3) MD Rem – Remainder of Maryland, (4) VA Washi – Virginia, Washington area, (5) VA Richm – Virginia, Richmond area, (6) VA Virgi – Virginia, Norfolk and Virginia Beach, (7) DC Washi – Washington, DC, and (8) DE – Delaware.

Figure 7 Boundaries of FAF Zones within the Chesapeake Megaregion



Source: Federal Highway Administration; Freight Analysis Framework 3; <http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/faf3/userguide/index.htm>; (7 January 2012).

3.3 Data Sources

The primary data sources used to characterize the Chesapeake Megaregion include; (1) Freight Analysis Framework 3.3, (2) American Community Survey 2006-2008 three-year estimate, and (3) 2009 IMPLAN data.

Freight Analysis Framework (FAF)

FAF data illustrates the freight flows between the Chesapeake Megaregion and other major metropolitan areas and states by all modes of transportation. The third generation of the FAF data, called FAF3, was released in summer 2010 and contains flows between 123 domestic FAF zones and 8 international FAF regions. FAF3 data provide commodity flows in tons and dollars by:

- FAF zones (123 domestic + 8 international zones)
- Modes (7 types: Truck, Rail, Water, Air, Multiple modes & mail, Pipeline, Other & unknown)
- Standard Classification of Transported Goods (SCTG) commodity (43 types)
- Port of entry/exit for international flows (i.e. border crossing, marine port or airport)

The base year is 2007, freight flow forecasts are provided for the years 2015 to 2040 in five-year increments. At the time of the implementation of this model, the most recent version of FAF3 was 3.3. It should be noted, that FAF was built on non-classified freight data. While private-sector shipments are included, military shipments tend to be classified. According to the FAF support team at FHWA, military-to-military shipments are not included in the FAF data, but shipments from a private sector establishment to the military are represented. This possible under-accounting is particularly relevant for the Port of Norfolk/Virginia Beach, which handles a large number of military shipments.

American Community Survey (ACS)

The American Community Survey is an ongoing sample survey by the Census Bureau to collect the information for planning investments and services. The ACS is conducted annually and data is released at three and five year intervals. The ACS data used in this market analysis is the 2006-2008 3-year estimate.[9]

IMPLAN

IMPLAN contains information on dollar flows between counties by 440 IMPLAN classifications. These flows are between each classification pair, thus between two counties there are 440x440 flows or 193,600 flows. There are 108 counties within the Chesapeake megaregion, making for 193,600x108 flows to be analyzed. Due to budget limitations, IMPLAN data was purchased for Delaware, Maryland, Virginia, and the Washington DC but not for adjacent states. The IMPLAN data thus represents dollar flows within the megaregion but does not represent flows to or from external counties.

For the economic flows analysis, only highway freight flows were considered. In order to develop the intercounty highway freight flows HaulChoice, a proprietary model developed by ECONorthwest, was used. HaulChoice is a freight mode-choice model that predicts surface transportation mode choice by commodity class. It provides these forecasts by a subset of IMPLAN sectors.

HaulChoice uses proprietary mathematical and statistical procedures, as well as its own crosswalks between NAICS and IMPLAN commodity categories. The model uses characteristics of zonal endpoints, the haul distance and cost, and certain megaregional controls to parameterize the mode choice model. The model first identifies which financial flows include physical movement of goods, then converts those movements by dollar value into tonnage. The result of the HaulChoice model is truck tonnage by county pair and the dollar value of truck tonnage by county pair. Due to budgetary limitations, IMPLAN data could only be obtained for Washington, DC, Delaware, Maryland, and Virginia.[10]

3.4 Characteristics

3.4.1 Transportation Networks

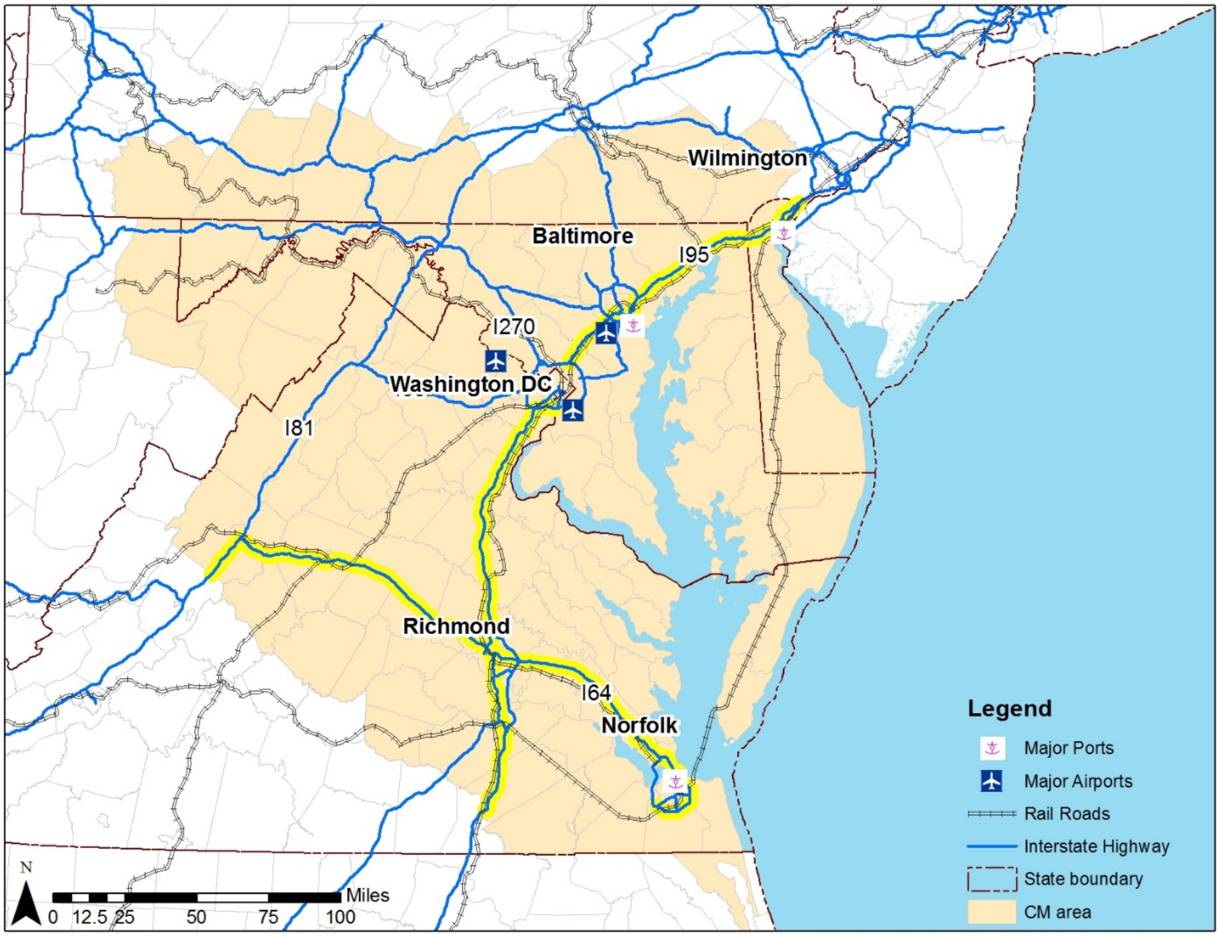
The Chesapeake Megaregion contains major air, maritime, rail, and highway facilities, which provide external linkages to the rest of the nation and the world and support internal flows of freight and people, as shown in Figure 8.

Three major airports serve the Chesapeake Megaregion, Baltimore Washington International (BWI), Dulles, and Ronald Reagan. Collectively, they account for more than 31 million enplanements annually. Dulles and BWI are major international hubs, as well as serving as transfer points for domestic air travel.[11]Washington Reagan Airport links to most of the east coast.

Major port facilities include Baltimore and the Hampton Roads, accounting for a large volume of ocean going trade. Baltimore handles 40 million tons of trade per year. Hampton Roads, handling 62 million tons per year, ranks eighth nationally and is second only to the New York area in moving tonnage on the east coast. Baltimore handles 40 million tons per year and ranks 16th nationally in terms of tons handled. With the widening of the Panama Canal, the potential for more deep draft ships landing at east coast ports, will affect the Chesapeake Megaregion seaborne traffic. While Hampton Roads can handle more traffic, Baltimore has landside access problems and must expand the landside transportation facilities, which provide access to the port.[12]

The surface transportation linkages include, 13,000 lane miles of Interstate highways, with significant north -south routes of I-95 and I-81 and east - west routes I-270. These linkages also include major north - south and east - west rail routes provided by the Norfolk Southern, the Chessie System and AMTRAK. The I-95/I-64 corridor, stretching from Wilmington to Norfolk, is a key route binding the entire megaregion together.

Figure 8 Major Transportation Routes and Facility Locations within the Chesapeake Megaregion

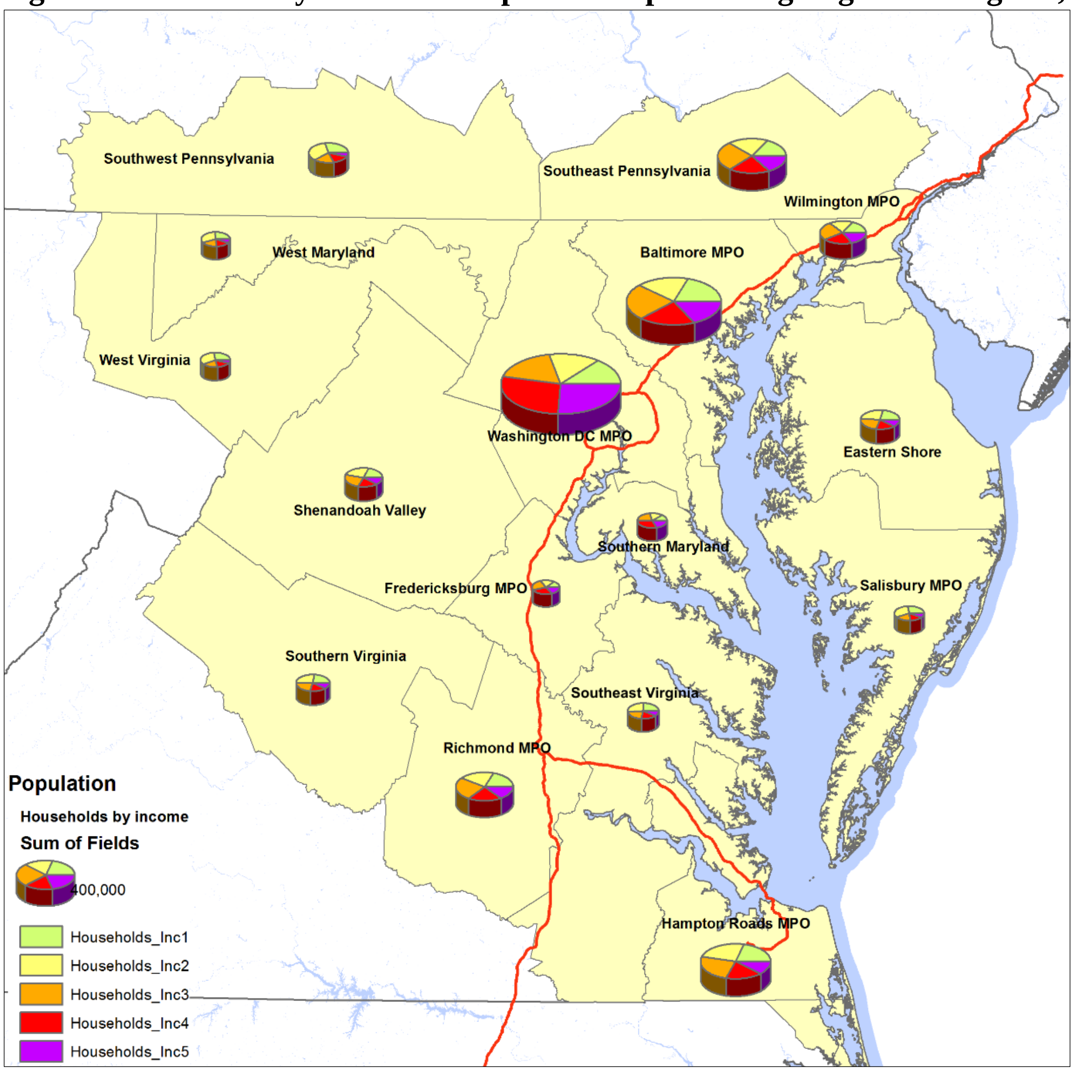


Source: American National Atlas. Railroad, 2004. <http://nationalatlas.gov/mld/railrdl.html> (November, 2012).

3.4.2 Population and Employment

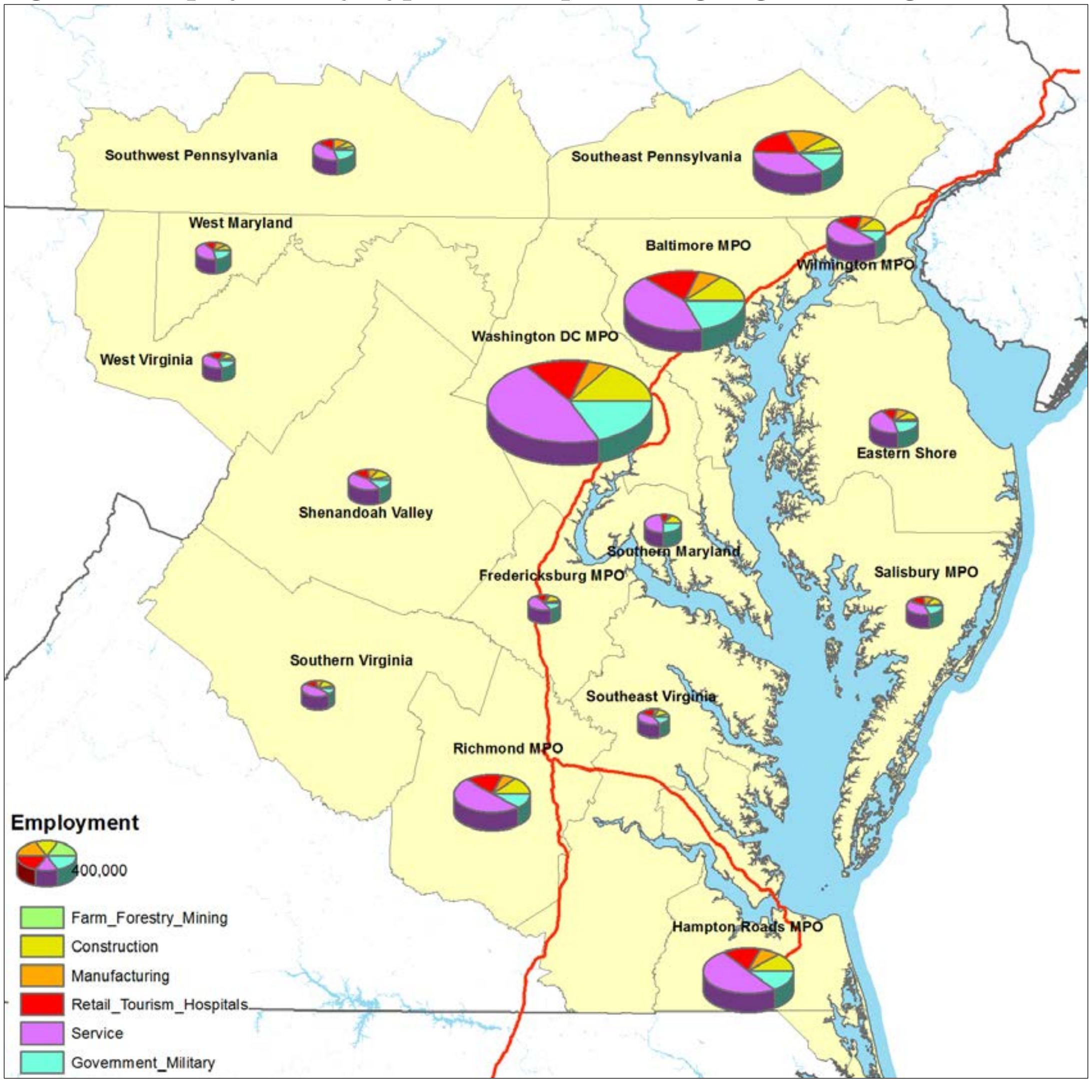
In 2010, the Chesapeake Megaregion had a population of 15 million[13] and employment of 9 million.[14] Population is organized by 5 million households. Figure 9 and Figure 10 illustrates the location of population and employment. The largest population and employment centers are located along I-95 and I-64, with the Washington DC area having the most high-income households. Similarly, as Figure 10shows, most jobs are located along the I-95 and I-64 arc. In terms of industry, service and government/military employment dominate. GDP for the Chesapeake Megaregion was $880 billion in 2010, or 6 percent of the nation's GDP.[15] The Chesapeake Megaregion is projected to grow faster than other areas of the northeast corridor and by 2030 will contain more than 7 million households with employment above 12 million.

Figure 9 Household by Income Group in Chesapeake Megaregion Subregions, 2007



Source: Chesapeake Megaregion Model Outputs: 2007 Base year

Figure 10 Employment by Type in Chesapeake Megaregion Subregions, 2007



Source: Chesapeake Megaregion Model Outputs: 2007 Base year

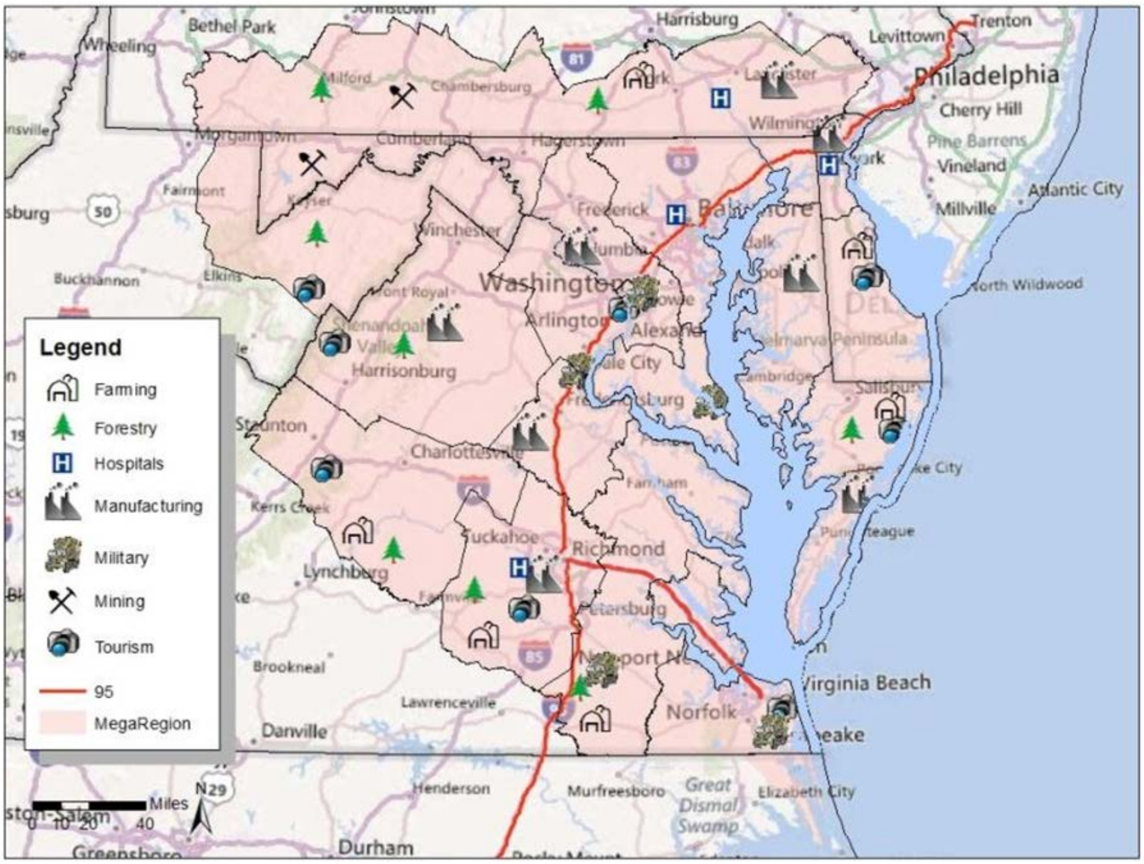
3.4.3 Industry Mix and Commodity Mix

The megaregion houses a complex mix of industries including, government, military, health, manufacturing, and recreation. Basic industrial employment constitutes about one -third of the Chesapeake Megaregion's employment, dropping to less than 20 percent in 2030. The USDA ERS[16] uses an economic dependence metric, to show where a county's economy is very reliant on key sectors. Approximating this metric in our Chesapeake Megaregion, finds that overall the Chesapeake Megaregion is economically dependent upon government employment (16 percent of the Chesapeake Megaregion employment in 2007, 19 percent in 2030). With the forecast shift from industrial to service jobs by 2030, the government dependency is more pronounced. The Manufacturing share of Chesapeake Megaregion employment (a portion of industrial) is only 5 percent, but the two Pennsylvania subregions are more dependent, having over 15 percent share in 2007. In 2030, there is dependency on government employment for Baltimore, Washington

DC, Fredericksburg MPOs, Hagerstown, and Salisbury MPOs, as well as Eastern Shore, Southern Maryland, SE Virginia, and Shenandoah.

The mix of industries is further shown geographically in Figure 11. This illustrates the composition and inter-dependencies in the megaregion. There is a dominant MPO core running north - south along the I-95 corridor from Wilmington, DE to Hampton Roads, VA, which houses the urban services of hospitals, military bases, and manufacturing. The manufacturing spills east and west into areas with natural resources (farming, forestry, mining), and recreation services.

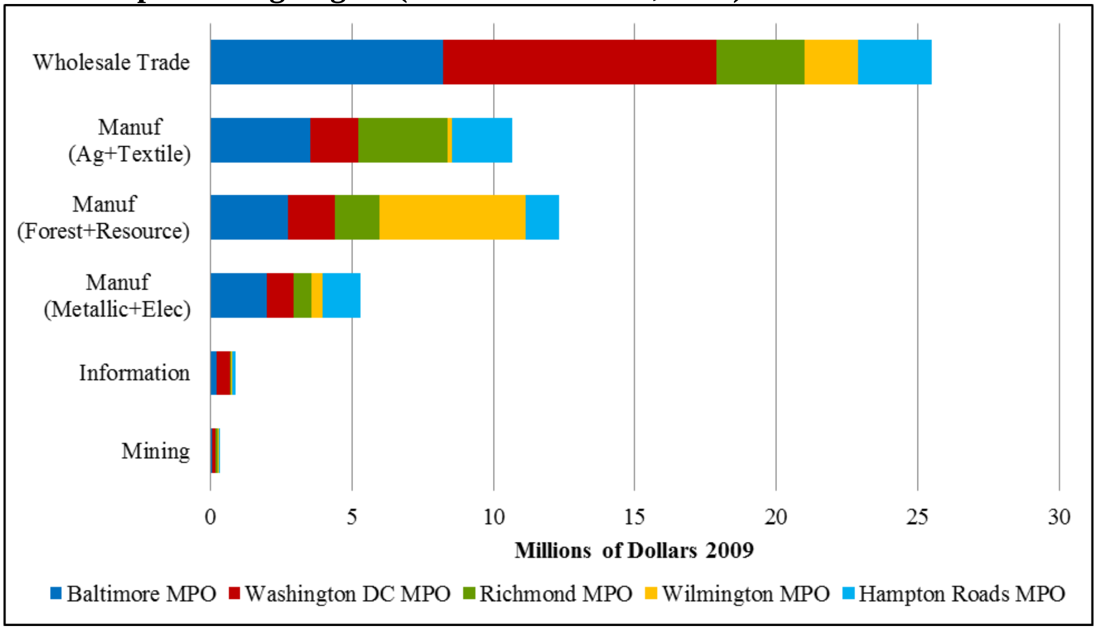
Figure 11 Location of Major Industries, by Type, in the Chesapeake Megaregion.



Source: MIG, Inc. IMPLAN System (2009 county-pair commodity data). <www.implan.com>.

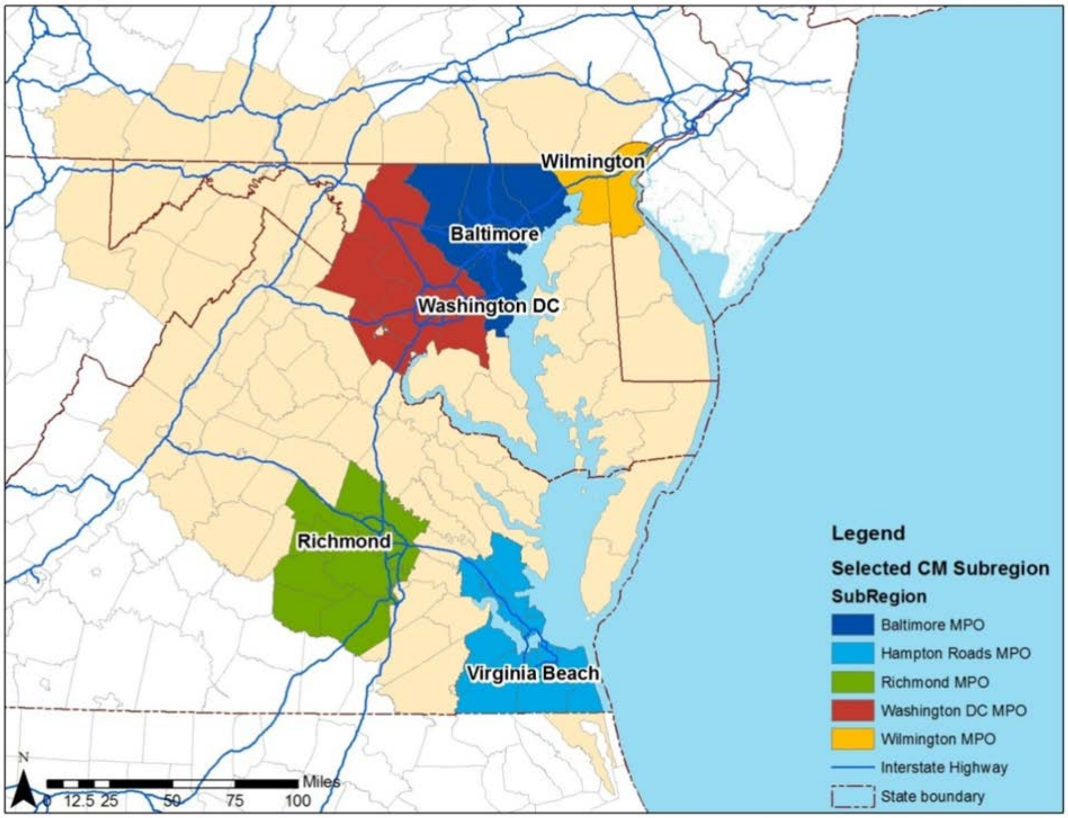
Figure 12 and Figure 13 provide additional information on the six selected employment types for major areas along the I-95 and I-64 arc, within the Chesapeake Megaregion in 2007. As can be seen, the Washington and Baltimore areas have large shares of wholesale trade while Wilmington has a large share of Chesapeake Megaregion manufacturing.

Figure 12 Truck Commodity Flow Production by MPO and Selected Industry Types within the Chesapeake Megaregion (millions of dollars, 2009)



Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>, EcoNorthwest Haul-Choice Model of truck-dependent industries.

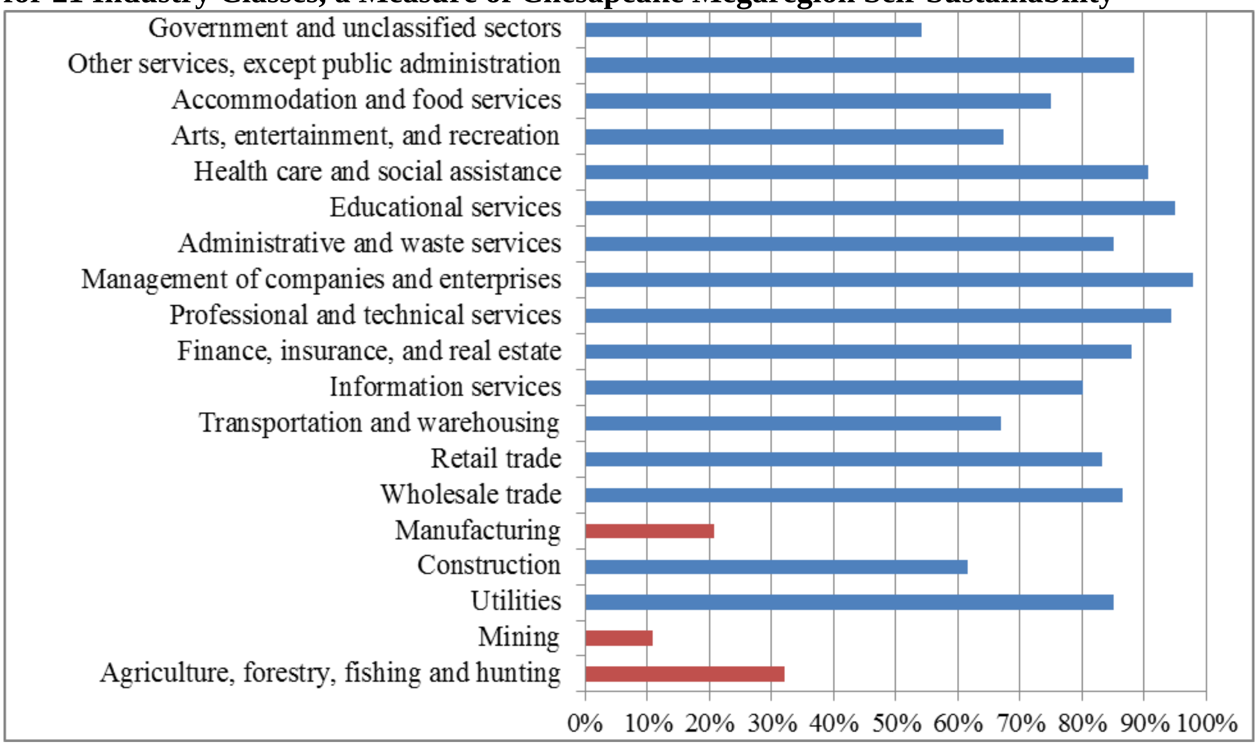
Figure 13 Location of Selected Chesapeake Megaregion MPOs used in Commodity Flow Analysis



3.4.4 Goods Production, Consumption and Mode Share

Figure 14 illustrates which portion of the megaregions share of each activity's production is purchased within the megaregion. For example, nearly 100 percent of management activities within the Chesapeake Megaregion are purchased within the Chesapeake Megaregion. The Chesapeake Megaregion internally produces more than 50 percent of the required products in most industries. The lower share (in red) indicates industries that need to import from an area outside the megaregion, which include manufacturing, mining, and agriculture. All of them are resource intensive industries, and material shipping into the megaregion heavily depends on the highway system. These highlight the importance of the transportation function of the megaregion along the eastern seaboard and inland, as well as connecting through seaports to global markets. The internal demand analysis demonstrates the economic connection between the megaregion, external areas, and the reliance on highway system for freight shipping. However, in terms of value, as Figure 14 shows, the "import" share for the majority of industries is not large.

Figure 14 Percentage of Goods and Services Purchased within the Chesapeake Megaregion for 21 Industry Classes, a Measure of Chesapeake Megaregion Self-Sustainability

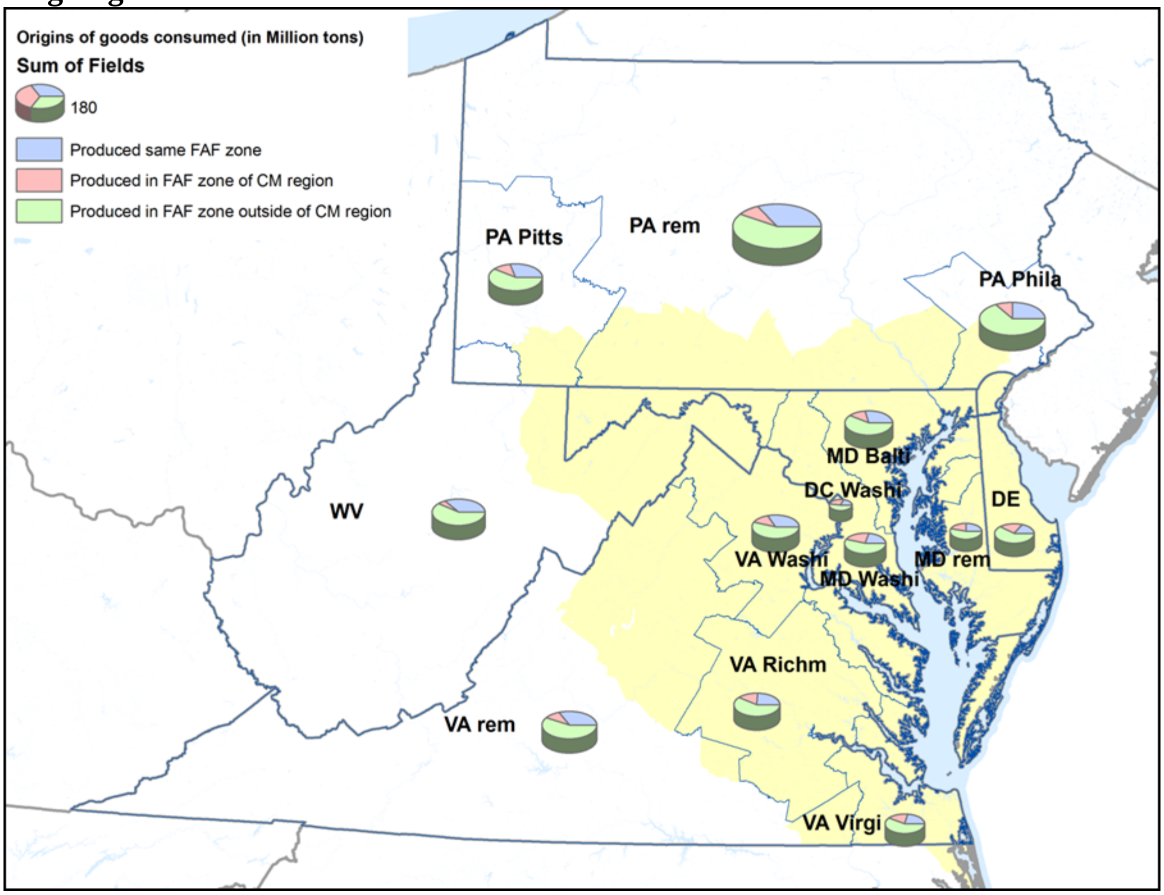


Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>, EcoNorthwest Haul-Model of truck-dependent industries.

Figure 15 shows the origin of goods consumed in a given FAF zone covering the Chesapeake Megaregion study area. Again, the size of the pie chart stands for the total amount of goods consumed in a FAF zone. The largest segment shown in green, ranges from 52 percent to 64 percent, and shows flows of goods that originate in zones outside of the Chesapeake Megaregion study area. The blue segment shows goods generated in the same FAF zone and the red segment represents goods generated in any other FAF zone covering the Chesapeake Megaregion study area. Such local flows represented by the sum of blue and red segments range from 36 percent to

48 percent. In other words, every FAF zone within the Chesapeake Megaregion study area receives at least one third but less than half of its goods from FAF zones in the Chesapeake Megaregion study area.

Figure 15 Location of Origin of Goods, by FAF Zone, Consumed in the Chesapeake Megaregion



Source: Federal Highway Administration; Freight Analysis Framework 3.2 (all commodity groups), <http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/faf3/userguide/index.htm>; (7 January 2012).

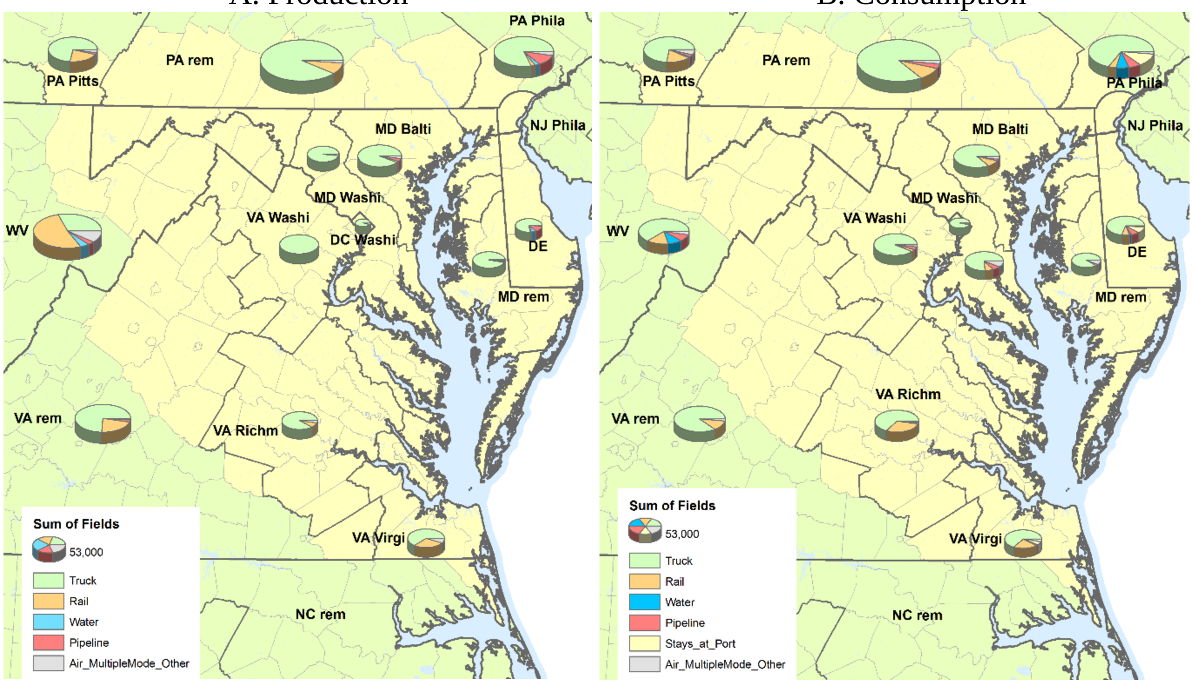
Figure 16 A summarizes the modal share of goods that are generated in FAF zones that cover the Chesapeake Megaregion study area. The analysis is based on FAF data for 2007 using commodity flows in tons. The pie chart size reflects the total volume, and the segments show the modal share. Note that FAF zones and the Chesapeake Megaregion study area do not nest within each other; hence, pie charts at the border of the study area do not represent production in the Chesapeake Megaregion area alone.

With the exception of West Virginia, truck is the dominant mode across all FAF regions in the Chesapeake Megaregion for goods that are produced here. On the average, 76 percent of all goods produced in the area, are transported by truck. The 52 percent rail flows in West Virginia are largely due to coal production. Virginia Remainder, Norfolk/Virginia Beach, Pittsburgh, and Pennsylvania Remainder are the other zones with a substantial share of rail flows between 23 percent and 32 percent. Delaware and Philadelphia send 12 percent and 10 percent of their goods produced by pipeline, which for most part, are refinery products. All other non-truck shares are with less than 8 percent relatively small.

Figure 16 B shows the same graphic for the other direction, i.e. flows that are consumed in the respective FAF zones. Again, truck is the dominant mode with an average of 77 percent of all goods produced in the area. Richmond receives 33 percent of all goods consumed by rail and Norfolk/Virginia Beach receives 26 percent by rail. Somewhat surprisingly, West Virginia has with 11 percent, the highest share of goods delivered by water, followed by Philadelphia with 9 percent. Elsewhere, flows delivered by water have a share of less than 2 percent. Both for goods produced and goods consumed in this area, the share of air is below 0.1 percent. This is common when analyzing flows by weight, as air tends to be used for less heavy but more valuable goods.

Figure 16 Mode Share, by FAF Zone, of Goods Produced and Consumed in the Chesapeake Megaregion, 2007

A. Production | B. Consumption



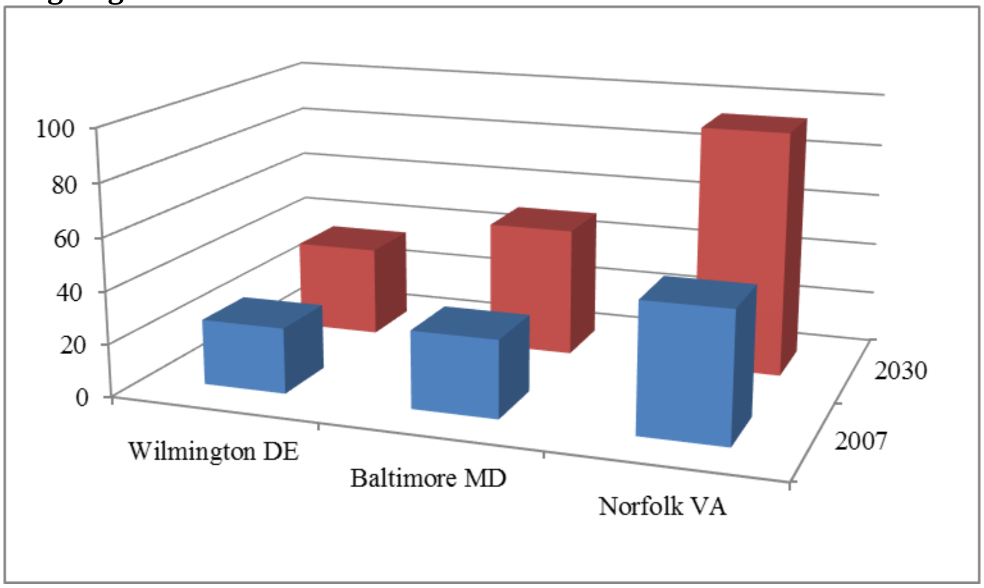
Source: Federal Highway Administration; Freight Analysis Framework 3.2, <http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/faf3/userguide/index.htm>; (7 January 2012).

3.4.5 Ports Traffic

The Chesapeake Megaregion contains three major ports, Wilmington, Baltimore, and Norfolk (In discussing Norfolk, Hampton Roads is also included). Figure 17 shows the current tonnage and projected growth in tonnage through each of these ports. Figure 18 illustrates the percentage of landside access by mode to each port.

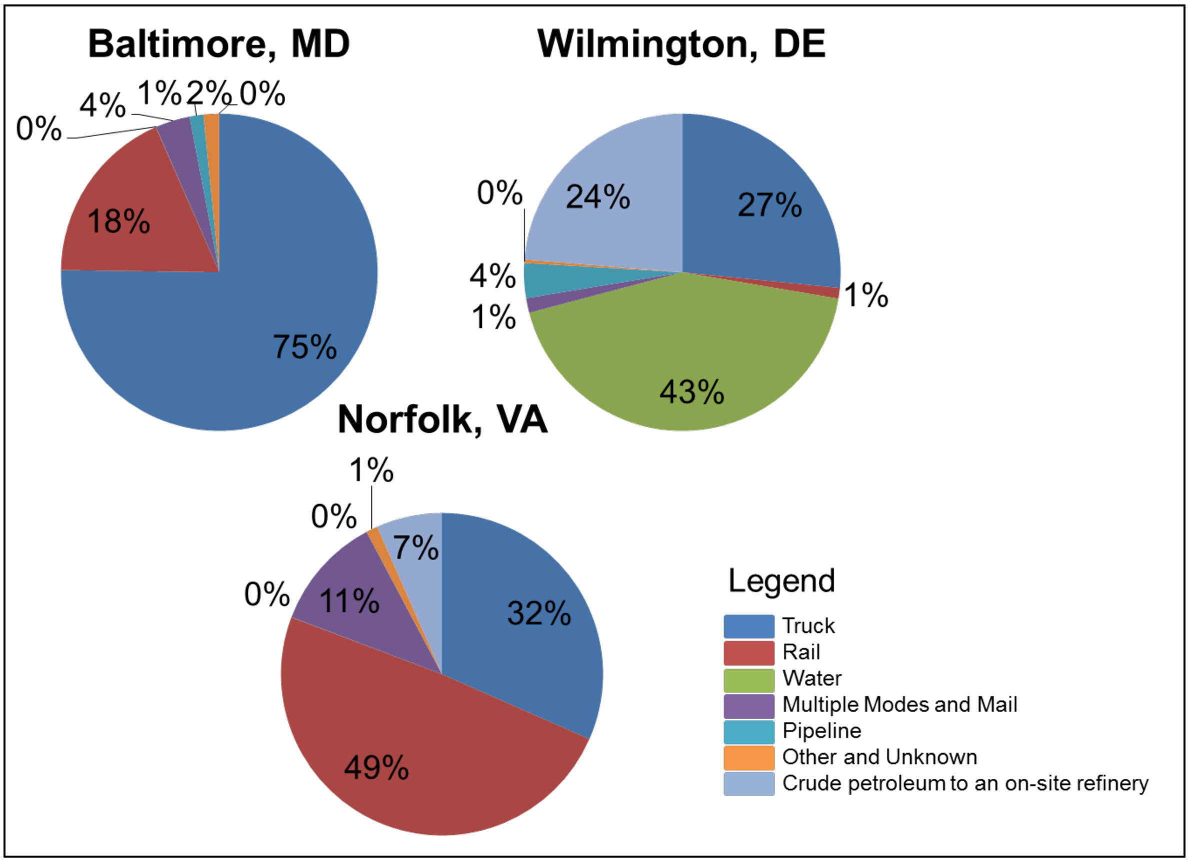
Truck access dominates traffic in Baltimore. Staff at the Port of Baltimore indicated during interviews, that the Port is regional, and generally provides shipments to or from locations less than 400 miles away. Staff indicated that for trips less than 400 miles, the dominant shipping mode was truck, except for shipments of low value bulk cargo. Norfolk on the other hand, serves a much larger area and is a major east coast port. With traffic moving long - distance, Norfolk has nearly 50 percent of its cargo shipped by rail. Wilmington is a major destination for oil tankers. These ships typically transfer much of their cargo to smaller ships for movement to refineries or pipelines, thus accounting for the high percent of access by water.

Figure 17 Comparison of 2007 and 2030 Tonnage (millions) in Major Chesapeake Megaregion Ports[17]



Source: Federal Highway Administration; Freight Analysis Framework 3.2, <http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/faf3/userguide/index.htm>; (7 January 2012).

Figure 18 Percentage, by Mode, of Total Goods Shipped to and from the Major Chesapeake Megaregion Ports



Source: Federal Highway Administration; Freight Analysis Framework 3.2, <http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/faf3/userguide/index.htm>; (7 January 2012).

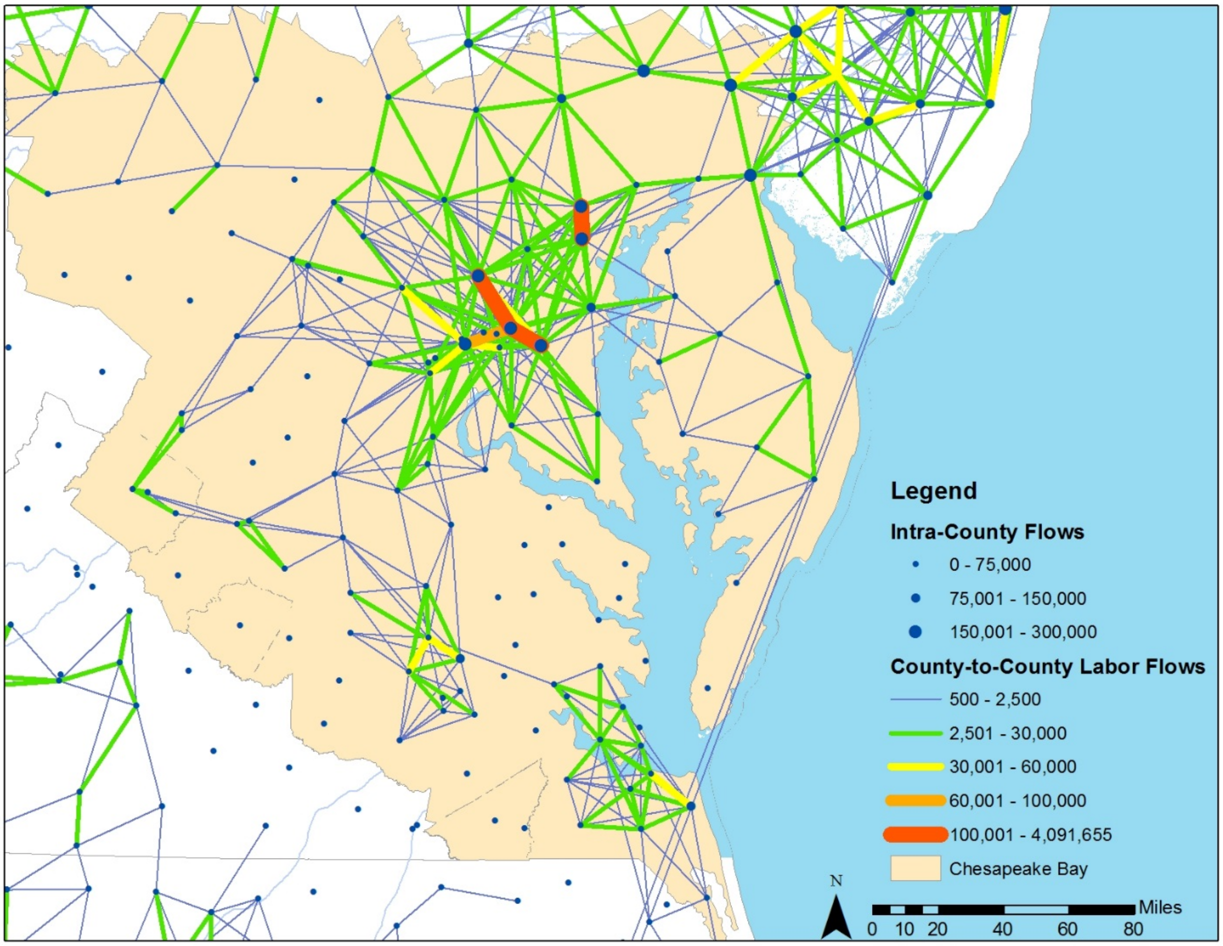
3.5 Intramegaregion Linkages

Intramegaregion linkages illustrate connections within the Chesapeake Megaregion. The connections presented include commuter flows, freight flows by values and tonnage, and a supply chain analysis that identifies the impact of economic changes in one area on economic changes in other areas within the megaregion. These flows, when compared, show linkages within the megaregion and the importance of these linkages on the megaregion economy.

3.5.1 Commuter Flows

Figure 19 illustrates the commuting flows between counties in the Chesapeake Megaregion. This figure shows a nearly continuous cluster of commuting from north of Baltimore down to Fredericksburg, as well as, clusters around the Richmond and Norfolk areas. This type of pattern, illustrates the Ross concept of megaregions containing clusters of metropolitan areas.

Figure 19 Map of County to County Commute Flows within the Chesapeake Megaregion



Source: U.S. Census Bureau; American Community Survey, 2006-2008 American Community Survey 3-Year Estimates, Table GCT0101; using American FactFinder; <http://factfinder2.census.gov>; (7 January 2012).

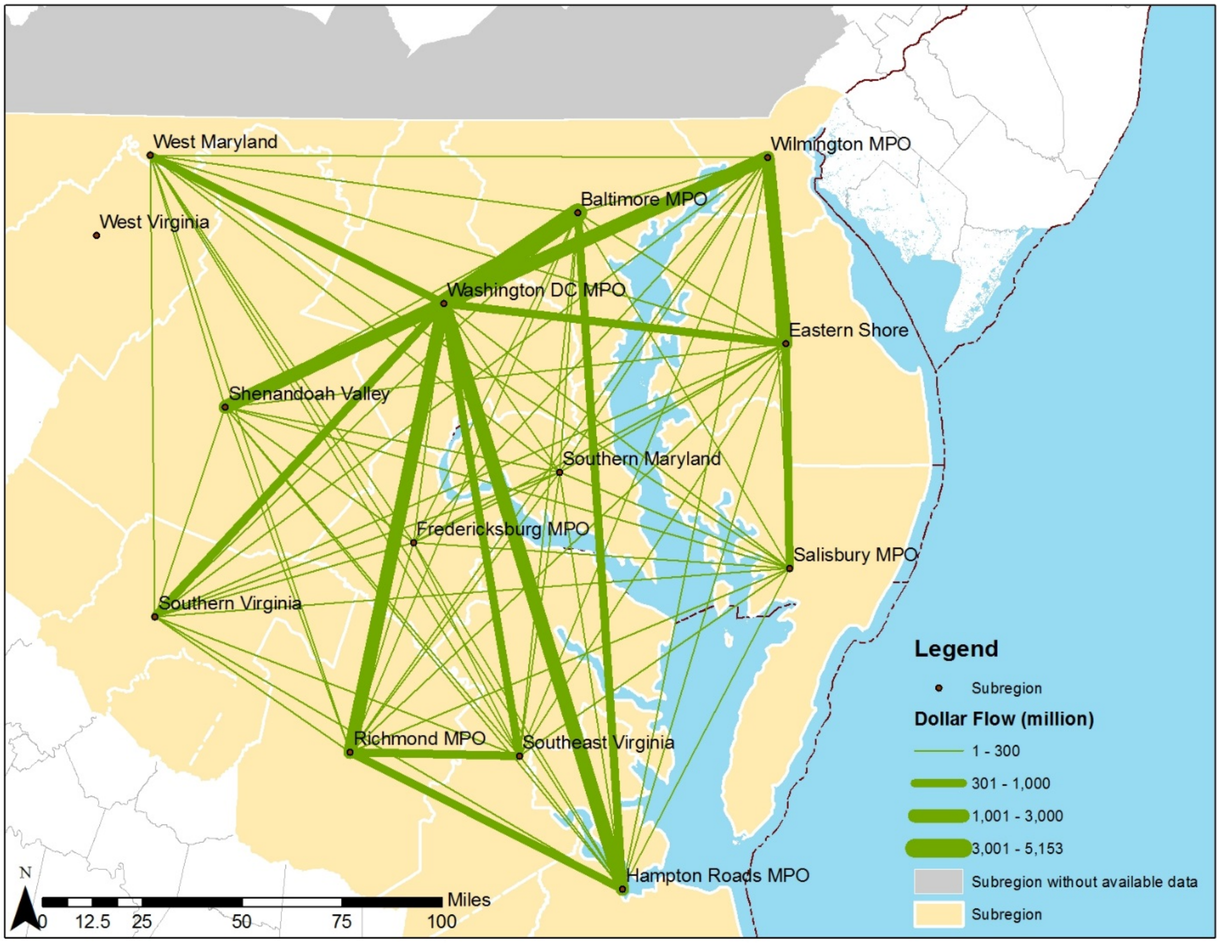
3.5.2 Freight Flows

Freight flows among subregions in terms of both, tonnage and value help to illustrate freight linkages within the Chesapeake Megaregion.

Figure 20 and Figure 21 illustrate the dollar value and tonnage of truck goods movement between the subregions (defined in Figure 6), based on the IMPLAN- dataset.[18]

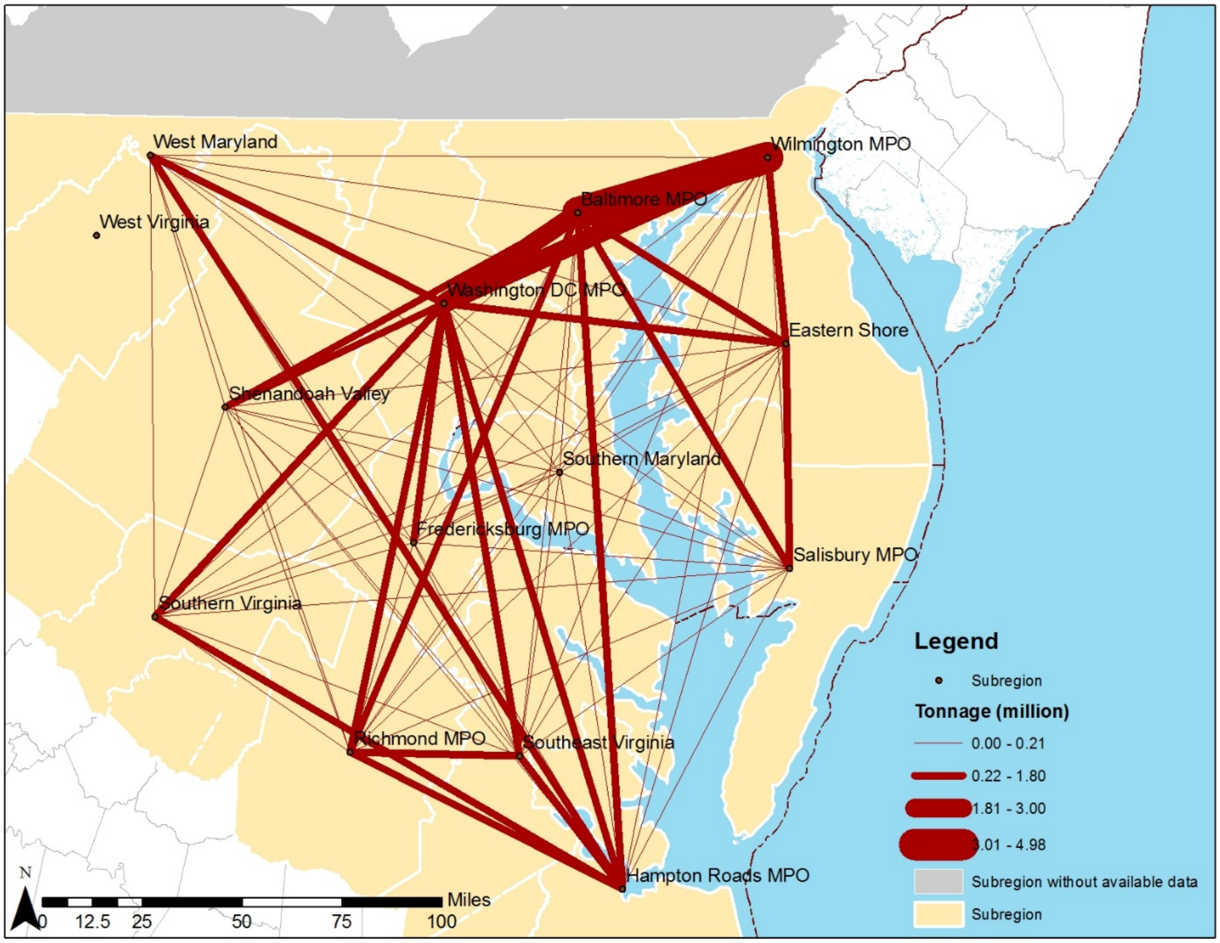
Figure 20 demonstrates the overall strong connection among several subregions in terms of the dollar value of truck goods. Figure 21, on the other hand, illustrates freight tonnage flows between subareas. Both of these figures illustrate that the linkages along I-95 and I-64, from Wilmington to Baltimore, Washington, Richmond, and Norfolk are critical to economic movements within the megaregion. These routes serve as the backbone of commerce within the Chesapeake Megaregion.

Figure 20 Dollar Value of Highway Freight Flows between Major Subareas in the Chesapeake Megaregion, 2009



Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>, EcoNorthwest Haul-Model of truck-dependent industries.

Figure 21 Tonnage of Highway Freight Flows between Major Subareas in the Chesapeake Megaregion, 2009



Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>, EcoNorthwest Haul-Model of truck-dependent industries.

This section analyzes the freight flows by dollar value and tonnage into and out of Baltimore, Washington, and Richmond, identifying the economic linkages with the megaregion.

Dollar Value of Highway Freight Flows from Baltimore, Washington DC, and Richmond

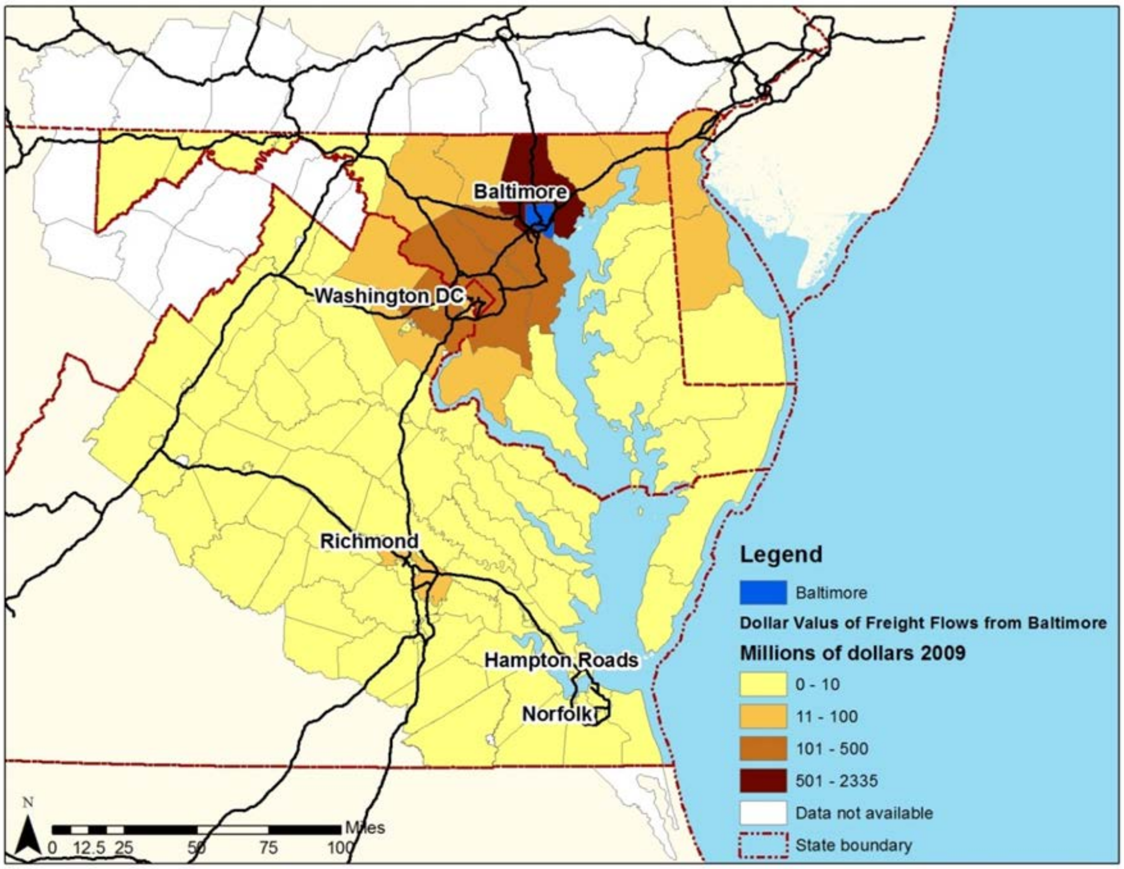
Figure 22, Figure 23, and Figure 24 represent the dollar value of freight flows from selected areas within the Chesapeake Megaregion, to counties within the Chesapeake Megaregion. These figures clearly show that major core areas, Baltimore, Washington DC, and Richmond have areas of influence surrounding them, which extend beyond their commuter sheds and MPO definitions. This is particularly true in the case of Richmond, with Richmond's influence extending to the northern border of the Chesapeake Megaregion and down to Hampton Roads-Norfolk. These maps also show that freight considerations cover a larger area than commuting considerations and point to the need to define a megaregion by its freight movements, as well as passenger movements. Several area specific conclusions can be drawn from this information:

- Baltimore, Figure 22 generates freight flows to an area, which encompasses Washington DC and extends east into northern Delaware and south to Richmond. This illustrates the Ross concept of influence area, which goes beyond the MPO areas.

- The Washington DC area, Figure 23 generates less freight flow to other counties than either Baltimore or Richmond. This is expected since Washington DC is heavily dependent on government employment.

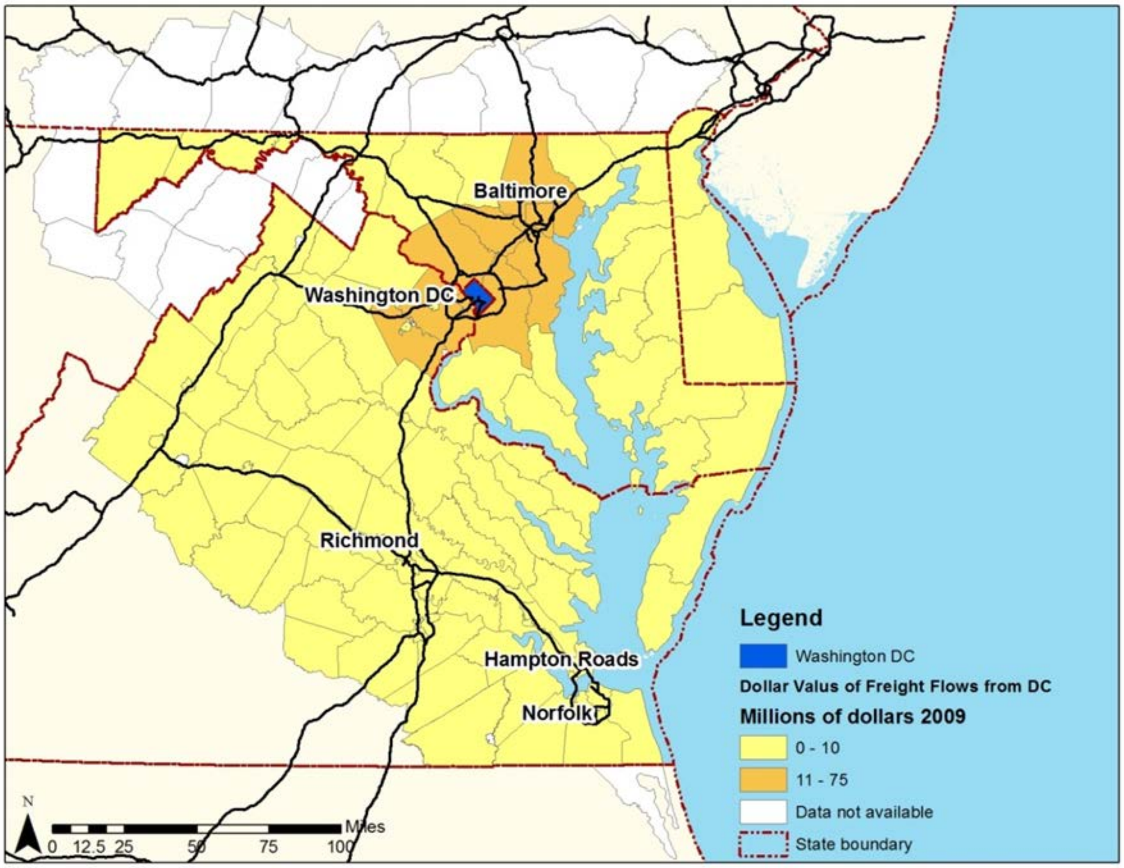
- Finally, as shown in Figure 24, movements from Richmond tie the entire Chesapeake Megaregion. Richmond exports extend to Baltimore and Delaware in the north and Hampton Roads and Norfolk in the southeast. With respect to freight movements, Richmond has an influence area much larger than the area covered by the Richmond MPO.

Figure 22 Freight Shipments by Dollar Value from the City of Baltimore to Chesapeake Megaregion Counties, 2009



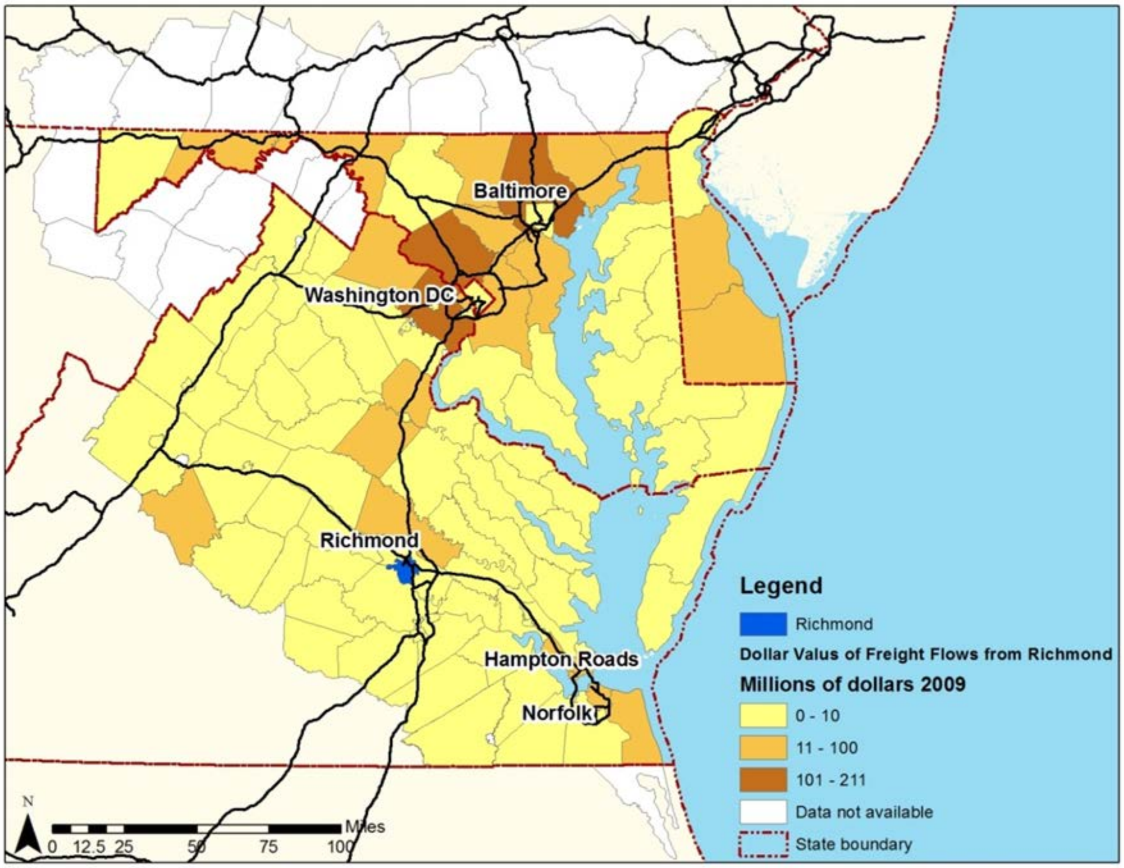
Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>, &HaulChoice

Figure 23 Freight Shipments by Dollar Value Dollar Value from Washington, D.C. to Chesapeake Megaregion Counties, 2009



Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>, &HaulChoice

Figure 24 Freight Shipments by Dollar Value from Richmond City to Chesapeake Megaregion Counties, 2009



Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>, &HaulChoice

Dollar Value of Highway Freight Flows into Baltimore, Washington DC and Richmond

Figure 25, Figure 26, and Figure 27 show the dollar value of highway freight flows coming into Baltimore, Washington DC, and Richmond. These figures show that freight moves across the entire Chesapeake Megaregion, and that freight links the Chesapeake Megaregion together.

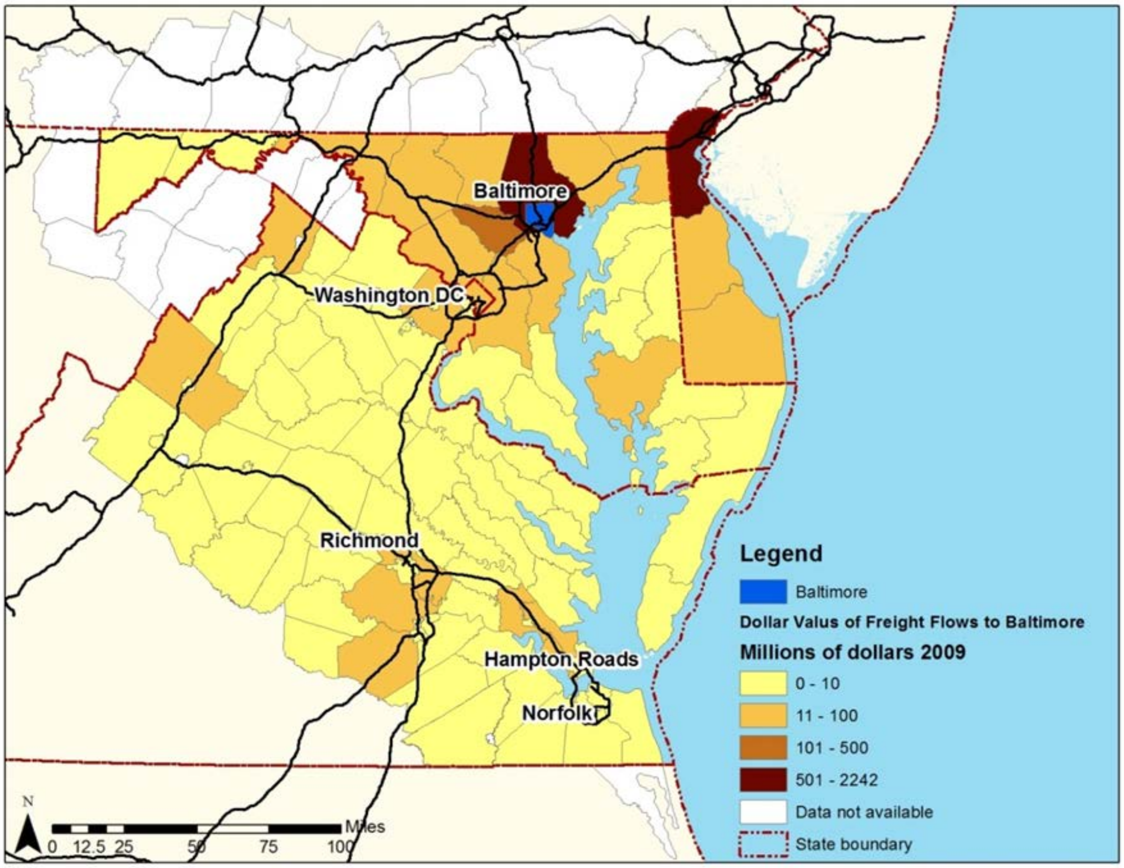
- Baltimore – Imports from across the Chesapeake Megaregion but particularly from Northern Delaware, likely due to shipments into the Port of Wilmington, as shown in Figure 25.

- Washington, DC –Figure 26takes in a large amount of freight from across the Chesapeake Megaregion. Comparing this to Washington's exports, Figure 6, it can be seen that Washington imports much more freight, by value, than it exports. His would be expected since as the center of government Washington's primary exports would be finance and services, which do not generate a significant volume of freight.

- Richmond – Figure 27 has low values of imports compared to other areas. However, comparing Richmond's imports to its exports, Figure 27, shows that by values

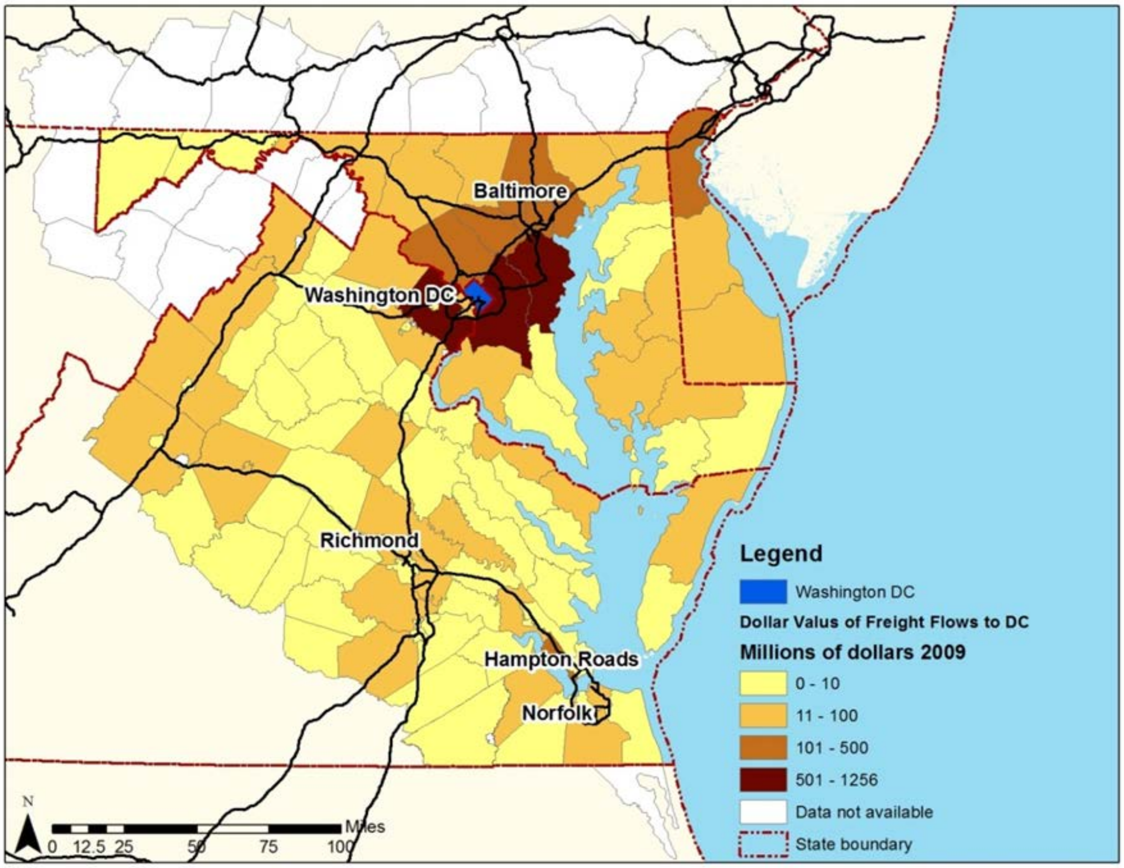
Richmond is a net exporter. When the imports and exports are taken together, it can be seen that there are significant trade flows within the Chesapeake Megaregion and that the economy of the Chesapeake Megaregion ties the Chesapeake Megaregion together.

Figure 25 Dollar Value of Highway Freight Flows to the City of Baltimore from Chesapeake Megaregion Counties, 2009



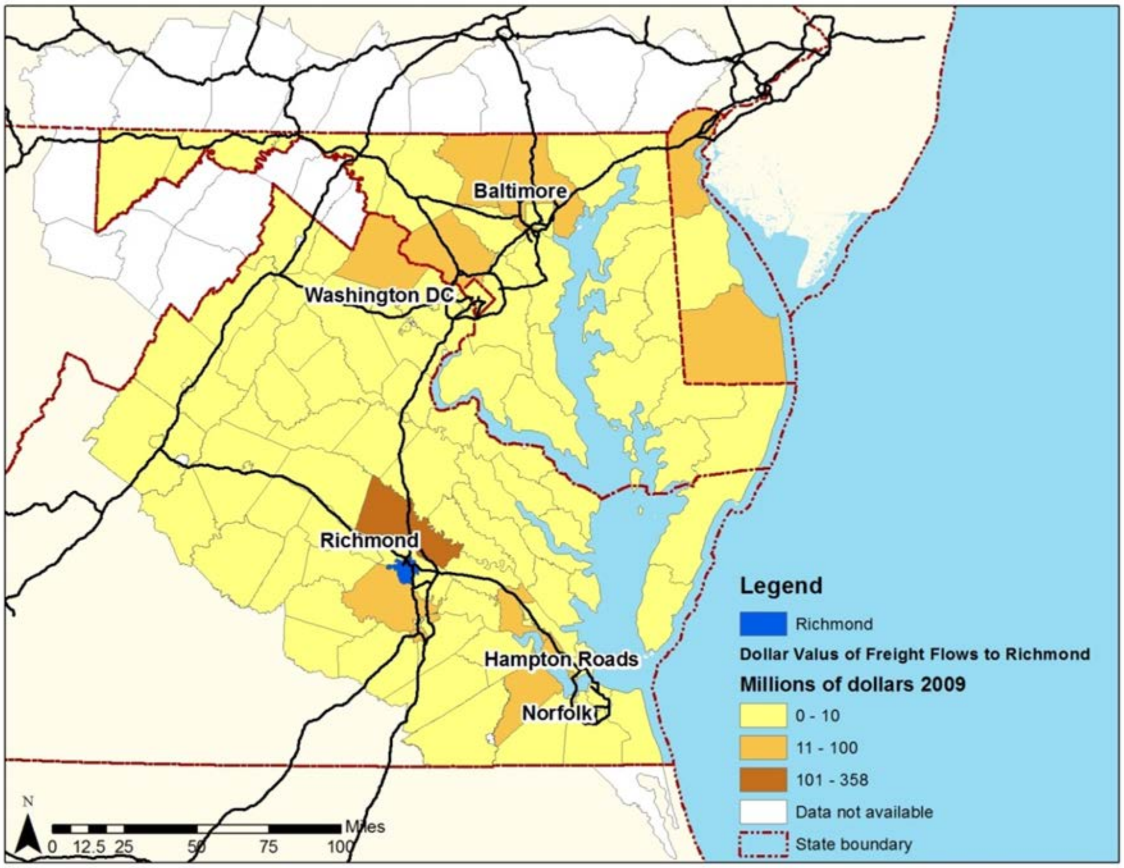
Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>, &HaulChoice

Figure 26 Dollar Value of Highway Freight Flows to Washington, D.C. from Chesapeake Megaregion Counties, 2009



Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>, &HaulChoice

Figure 27 Dollar Value of Highway Freight Flows to Richmond from Chesapeake Megaregion Counties, 2009



Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>, &HaulChoice

3.5.3 Supply Chain Analysis

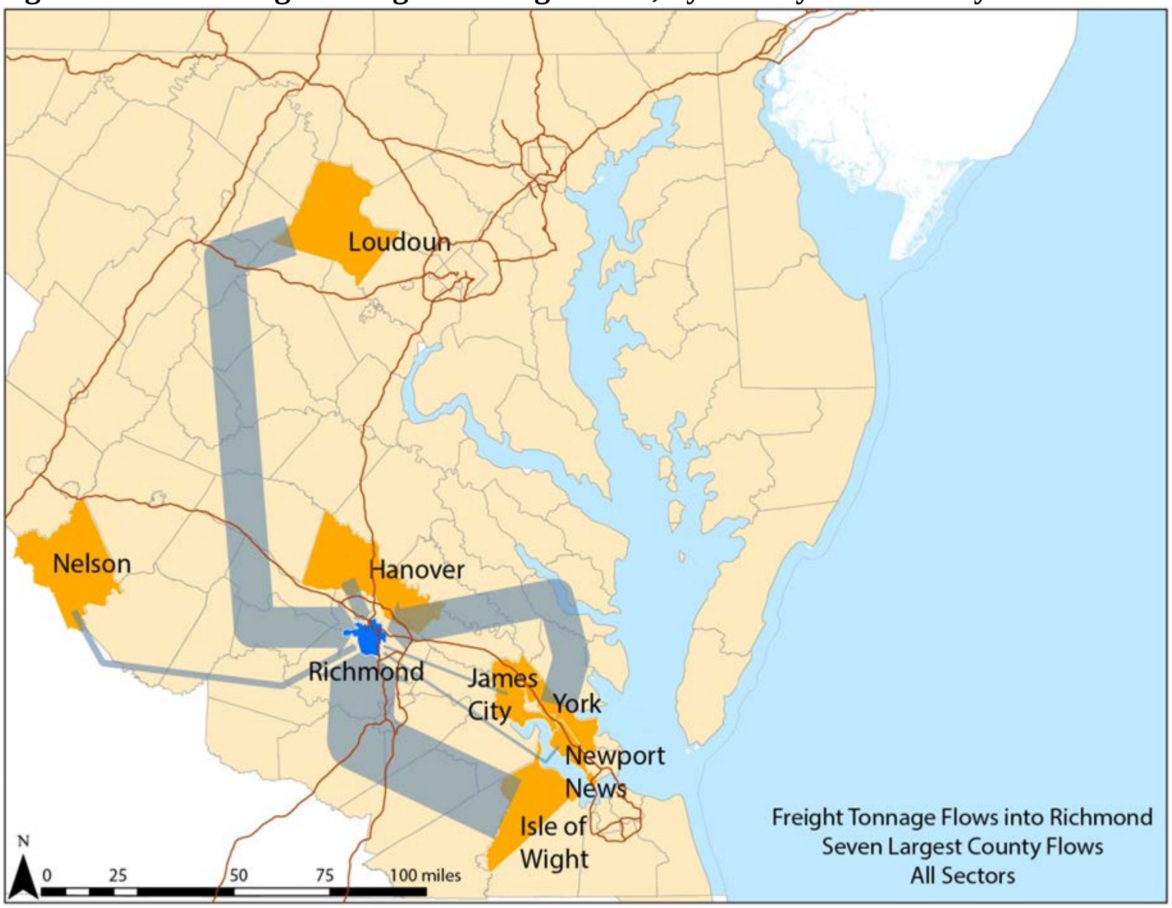
To illustrate the Chesapeake Megaregion interconnectivity, the highway flow of commodities into, between, and out of the City and County of Baltimore and the City of Richmond were analyzed.

Counties shipping to Richmond- Richmond to Baltimore - and Baltimore to other Counties

In the first analysis, the trade in tonnage between the City of Richmond, Virginia and Baltimore (city and county) is examined. In this flow pattern, the top seven freight flows into Richmond are mapped. Richmond imports a diverse range of commodities from the surrounding region. In some cases, commodities are shipped from counties near Baltimore, processed in Richmond and shipped up to Baltimore for further processes. This is an example of the specialization in production for individual counties that has been made possible by a reliable transportation network and a highly connected region. Figure 28shows the extensive range of counties providing incoming commodities to Richmond. The major suppliers are in Virginia and centered near the Hampton Roads port area. To the northwest, another major source of freight flows is from Loudon County, VA.

The specialization in production made possible by the interconnectivity of the Chesapeake Megaregion has allowed Richmond to become a major center for paper product recycling and production. This specialization means that Richmond imports from surrounding counties a significant amount of paper related commodities. Trade in this industry makes up nearly 10 percent of all freight entering Richmond from other counties in the megaregion. Another important set of commodities for Richmond are concrete and stone-related materials. The shipment of these commodities represents over 16 percent of all incoming freight, and in addition the shipments are bulky and expensive to transport. The megaregional trade in for these industries is facilitated by the low transport costs from the underlying highway network.

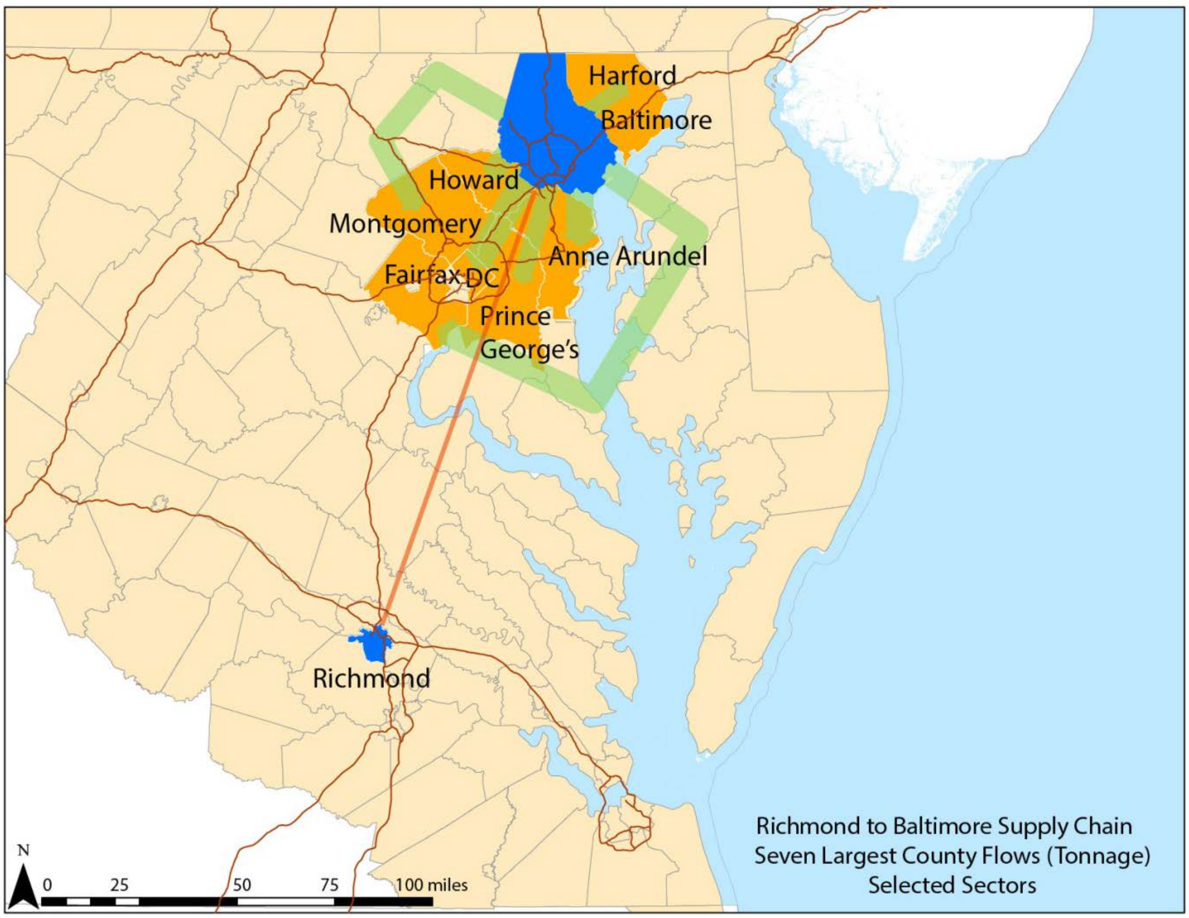
Figure 28 Seven Largest Freight Tonnage Flows, by County into the City of Richmond



Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). www.implan.com

Figure 29 shows the freight movement from Richmond to Baltimore, and the Baltimore exports to other counties directly related to the incoming flows from Richmond. Major commodities moving from Richmond to Baltimore, include paper-related commodities, aluminum products, pharmaceutical preparation manufacturing, and seasoning and dressing manufacturing. Outputs related to these commodities are then mapped as shipments to other counties. Major consumers of commodities dependent on trade between Richmond and Baltimore include the surrounding counties of Howard, Montgomery, Prince Georges County, Maryland, and Fairfax, Virginia. These related shipments include stationary products, cardboard and boxes, aluminum alloys, pesticide and fertilizer, and medicinal and botanical manufactured goods. Importantly, this map shows the commodity flow that is dependent on trade between Richmond and Baltimore and subsequently dependent on I-95, the major interstate connection between the two areas.

Figure 29 Richmond to Baltimore Supply Chain: Seven Largest Flows of Goods Shipped fr om Richmond to Baltimore, Processed in Baltimore, and Shipped to Other Counties



Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). www.implan.com

Table 1 provides a list of the major commodity flows from Richmond to Baltimore, their rank in terms of total trade between the two cities and the percent of total trade between the two locations (in tons) that the commodity makes up. The table shows that paper related commodities make up the bulk of shipments from Richmond to Baltimore. As mentioned previously, Richmond specializes in the paper industry and is a major supplier of related commodities, especially to Baltimore where many goods are manufactured using these products.

Table 1 Percentage of Total Commodity Shipments for the Top Ten Commodity Categories, Richmond to Baltimore

Rank	Percent (of total trade)	Commodity Description
1	37.66 %	Paper mills
2	9.86 %	Aluminum product manufacturing from purchased aluminum
3	7.79 %	Pharmaceutical preparation manufacturing
4	6.71 %	All other paper bag and coated and treated paper manufacturing
5	5.45 %	Paperboard Mills
6	3.01 %	All other food manufacturing
7	3.00 %	All other converted paper product manufacturing
8	2.58 %	Ornamental and architectural metal products manufacturing
9	2.22 %	Seasoning and dressing manufacturing
10	2.03 %	Urethane and other foam product (except polystyrene) manufacturing

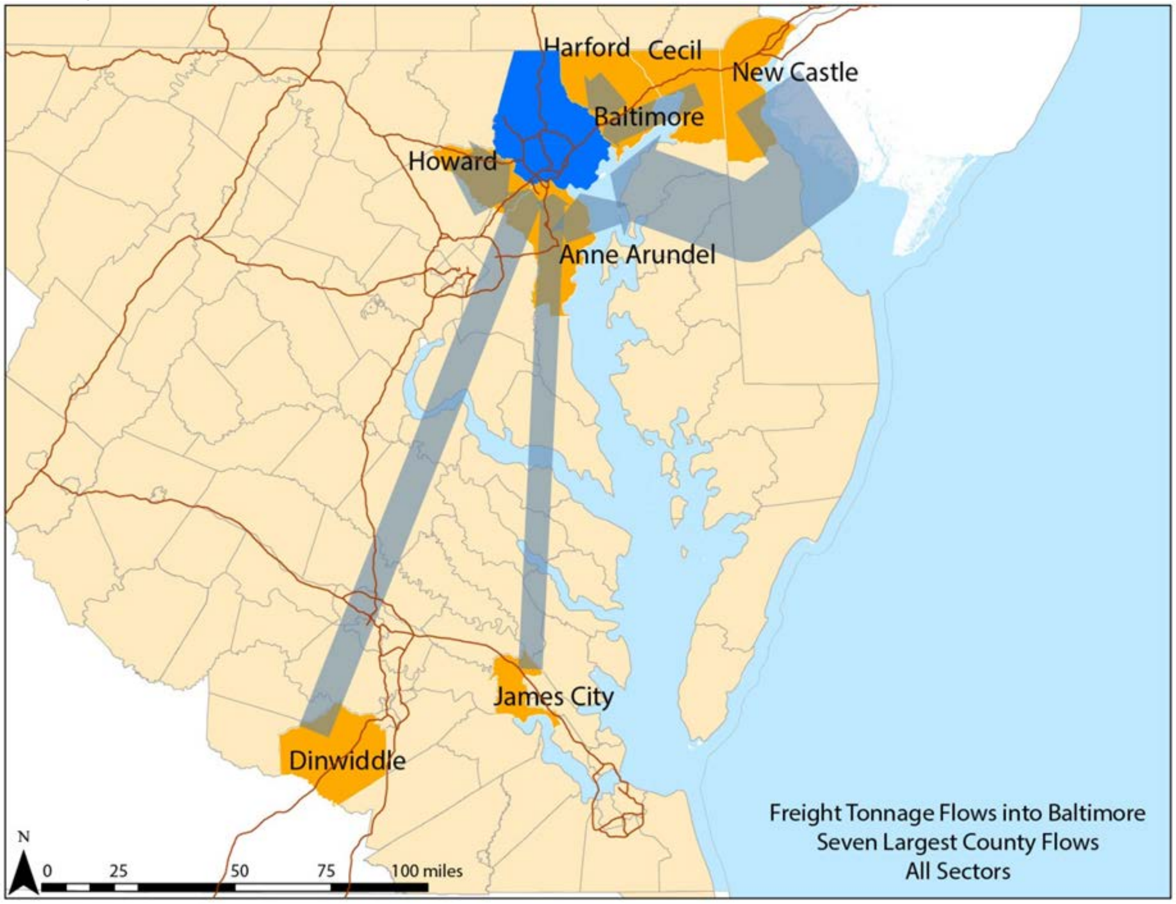
Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>.

Counties Shipping to Baltimore - Baltimore to Richmond - Richmond to Surrounding Counties

The next set of figures shows the freight flows from Baltimore to Richmond. Figure 30 shows the counties shipping to Baltimore. The graphic shows the greater spatial reach of suppliers. Much of the imported commodities come from along the corridor between Baltimore and the major port areas of New Castle County, Delaware. This trade is also heavily reliant on I-95. Other major commodity flows come from Virginia and also rely on I-95. Much like the shipments imported to Richmond (described above) some of the major flows of commodities into Baltimore come from counties closer to Richmond. This represents flows of goods, which Baltimore specializes in reprocessing.

Baltimore imports a large amount of food related products to support extensive industries in spice and other processed food manufacturing. Baltimore also operates as a manufacturing center for plastics, importing petroleum products and other related goods from surrounding counties.

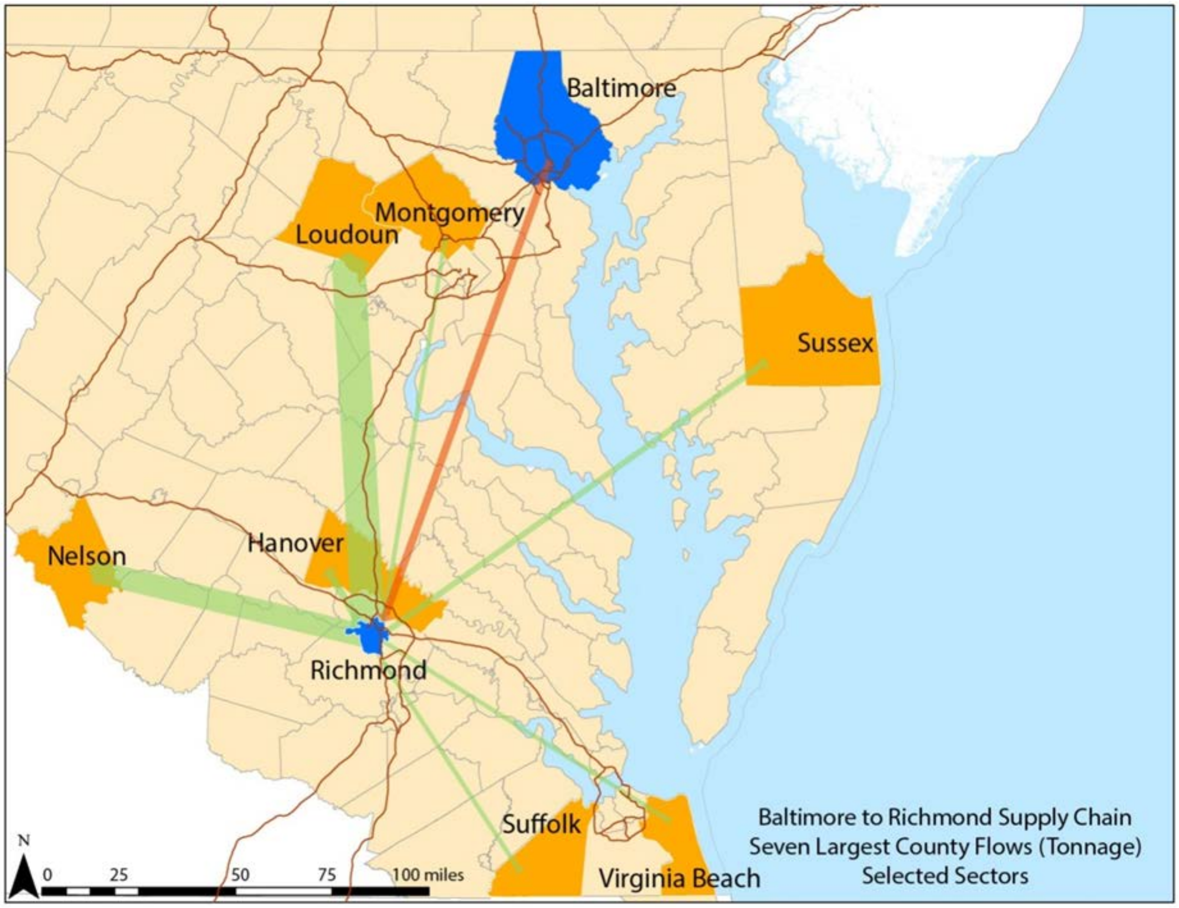
Figure 30 Seven Largest Freight Tonnage Flows, by County into Baltimore City and County



Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). www.implan.com

Figure 31 shows the flow from Baltimore to Richmond, and the commodities directly related to that trade which flow out of Richmond. The primary commodities shipped from Baltimore to Richmond include iron and steel, output from distilleries, paperboard containers, and many food related products. The figure also shows the expansive consumption of commodities first shipped from Baltimore, then exported out of Richmond. These products are directly related to those shipped from Baltimore and include finished food products, smelted alloys, and brewery products. These substantial flows go to nearly every corner of the megaregion; all of which directly depend on movement across the I-95 corridor.

Figure 31 Baltimore to Richmond Supply Chain: Seven Largest of Goods Shipped from Baltimore to Richmond, Processed in Richmond, and Shipped to other Counties



Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). www.implan.com

Table 2 provides a list of the major commodity flows from Baltimore to Richmond, their rank in terms of total trade between the two cities and the percent of total trade between the two locations (in tons) that the commodity makes up. The table shows that food related commodities make up the bulk of shipments from Richmond to Baltimore. As mentioned previously, Baltimore specializes in the food industry and is a major supplier of related commodities, especially to Richmond where many goods are consumed or reprocessed for export.

Table 2 Percentage of Total Commodity Shipments for the Ten Largest Categories, Baltimore to Richmond

Rank	Percent (of total trade)	Commodity Description
1	19.91 %	Soft drink and ice manufacturing
2	19.65 %	Iron and steel mills and ferroalloy manufacturing
3	18.79 %	Distilleries
4	12.51 %	Paperboard container manufacturing
5	9.93 %	Seasoning and dressing manufacturing
6	3.79 %	In-vitro diagnostic substance manufacturing
7	2.02 %	Petroleum lubricating oil and grease manufacturing
8	1.90 %	Cheese manufacturing
9	1.55 %	Bread and bakery product manufacturing
10	1.17 %	Printing

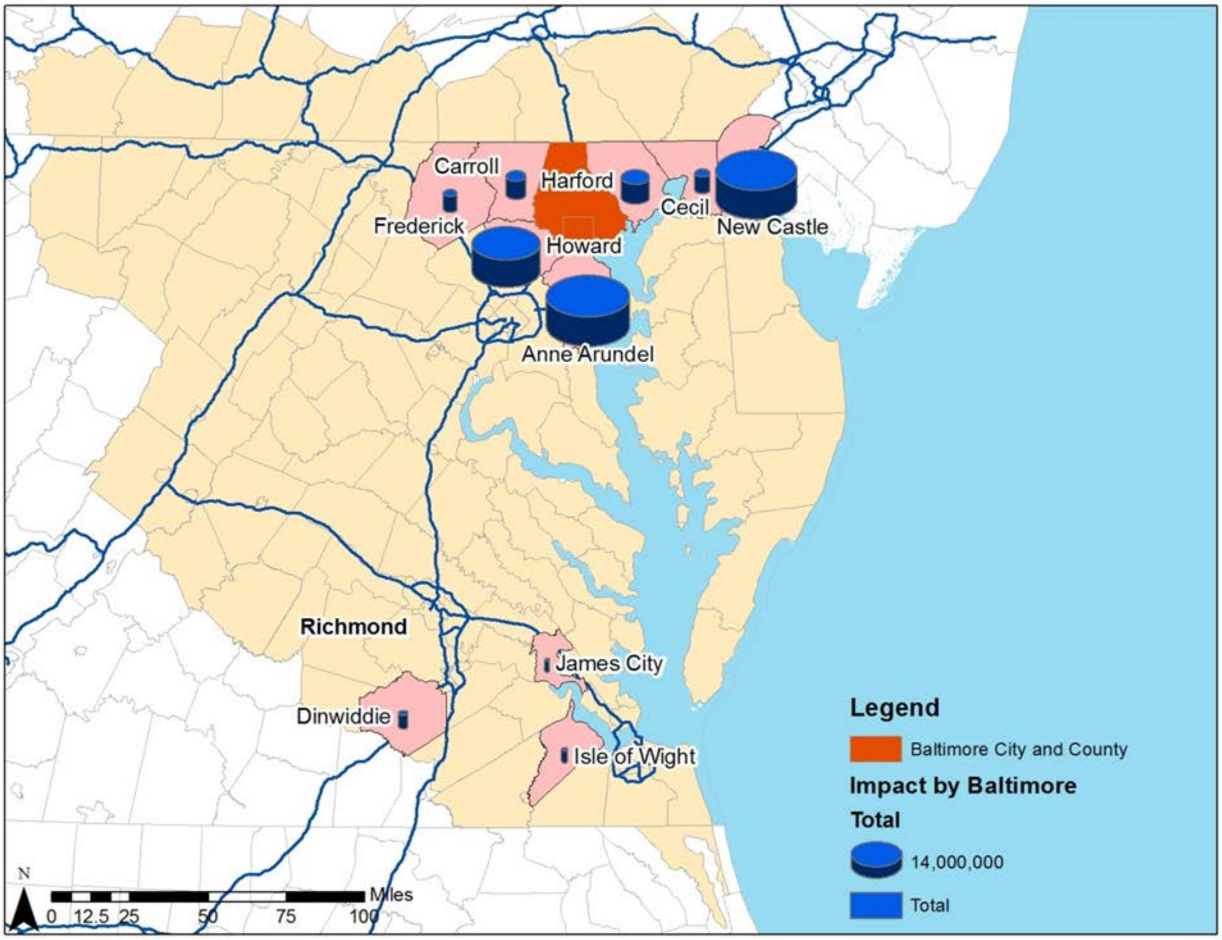
Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>.

3.5.4 Economic Impact Analysis[19]

Another way to view economic linkage is through analyzing the impact of an economic change in one county on other counties within the megaregion. Impacts on other counties are examined in both magnitude and industry mix. Only the top 10 counties with the largest dollar flows have been shown here (due to the programming limitation).

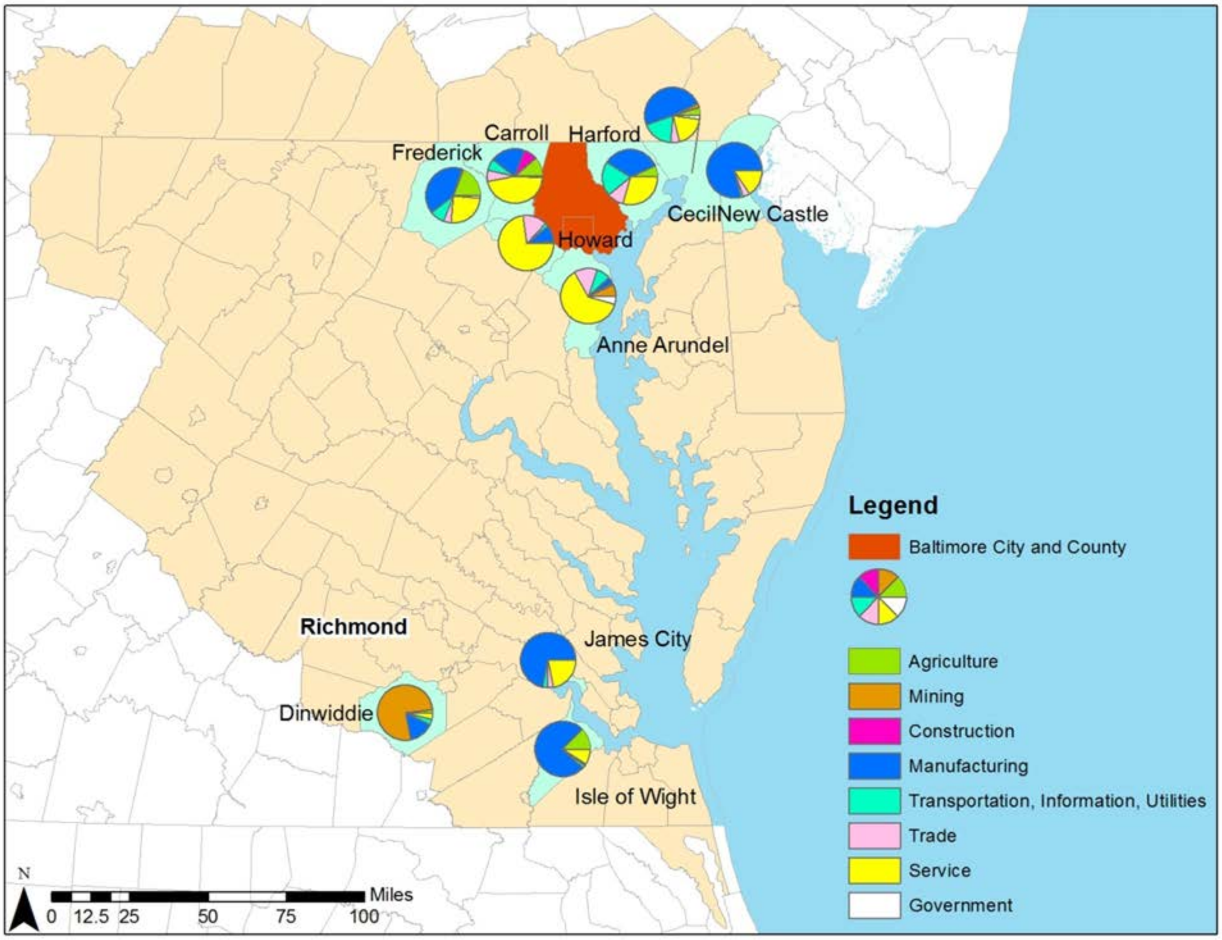
Figure 32 and Figure 33 illustrate the impact of a 1 percent increase in production in Baltimore on the 10 counties with the greatest economic interactions with Baltimore. As can be seen the impacts occur as far away as Southern Virginia and Wilmington, Delaware. However, the impacts are not uniform. In terms of magnitude, counties surrounding Baltimore, particularly New Castle, Anne Arundel, and Frederick have been impacted the most. In terms of industry mix, some areas, such as Anne Arundel County show the greatest impact on agriculture while others, such as Wilmington, James City, and the Isle of Wight in southern Virginia, show the greatest impact on manufacturing.

Figure 32 Impact of 1 Percent Increase in Baltimore City and County Economic Production on Selected Counties



Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>.

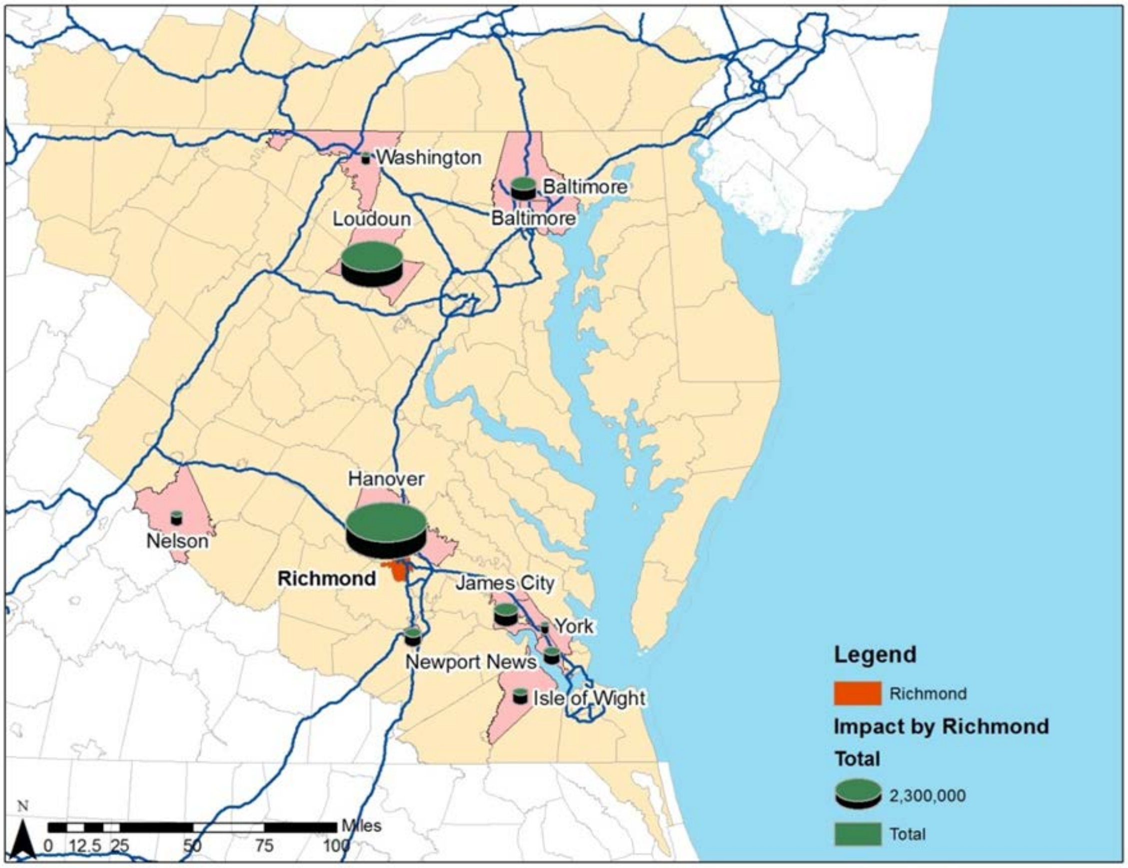
Figure 33 Impact of 1 Percent Increase in Baltimore City and County Production, by Industry Share, on Selected Counties



Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>.

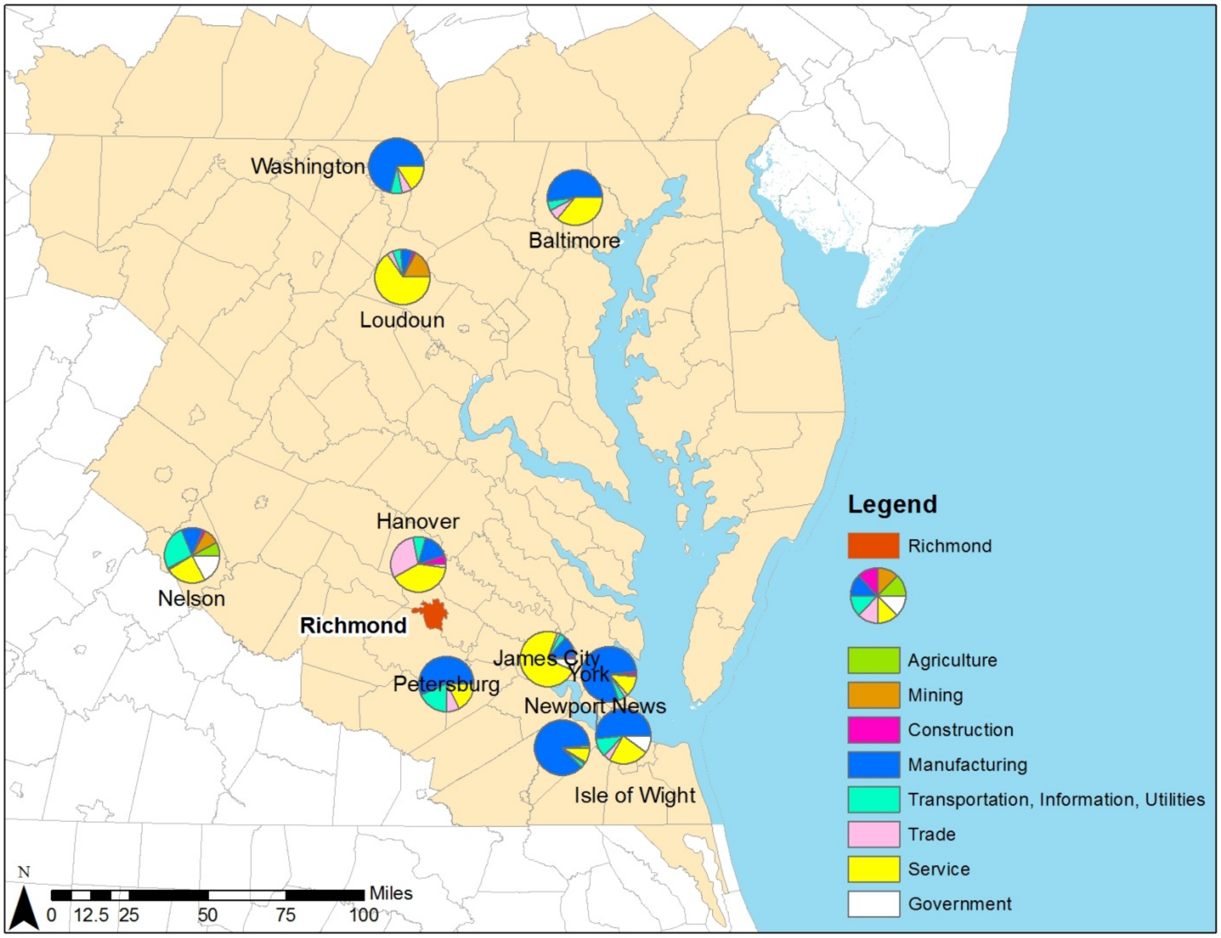
Figure 34 and Figure 35 show the impact of a 1 percent change in Richmond production on the counties with the greatest trade interaction with Richmond. As can be seen, Richmond production has a major impact across the Chesapeake Megaregion, with significant impacts up to Baltimore and down to areas near Newport News and Norfolk. In addition, the sector impacts are not uniform. In some areas such as Loudon County and James City the greatest impact is on services while in other areas like Washington County the greatest impact is on manufacturing.

Figure 34 Impact of 1 Percent Increase in Richmond Economic Production on Selected Counties



Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>.

Figure 35 Impact of 1 percent Increase in Richmond Production, by Industry Share, on Selected Counties



Source: MIG, Inc.. IMPLAN System (2009 county-pair commodity data). <www.implan.com>.

Both the Baltimore and Richmond analyses point out the key role I-95 and I-64 play in the economy of the Chesapeake Megaregion. The economic flows identified in these analyses are tied to the ability of the transportation system to move goods along this corridor.

3.6 The Trend to 2030

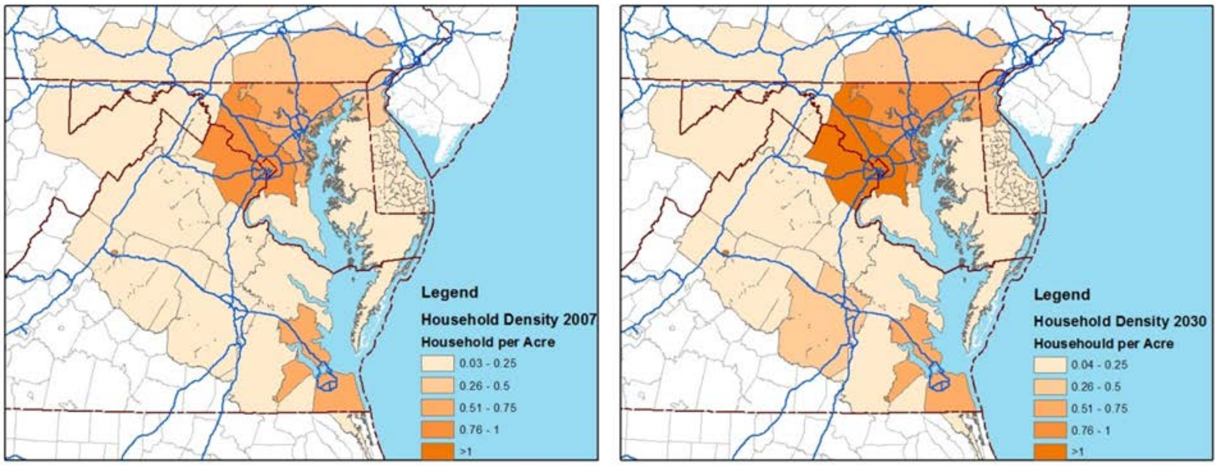
In order to estimate future conditions, a land use and transportation model was developed for the megaregion. The model is further described in section 2.3 and in "*A Framework for Megaregion Analysis: Development and Proof of Concept*".[20]

3.6.1 Household and Employment Change

The Chesapeake Megaregion consists of 5.7 million households in 2007 and 7.5 million by 2030; employment increases from 9.3 million to 12.3 million by 2030, both roughly 30 percent over 23 years, at an annual compound average growth rate of 1.2 percent.

The percent change in households between 2007 and 2030 is shown in Figure 36. While households increase across the entire area, growth in the Baltimore, Washington and Wilmington areas can be observed, with significant growth also observed in Richmond.

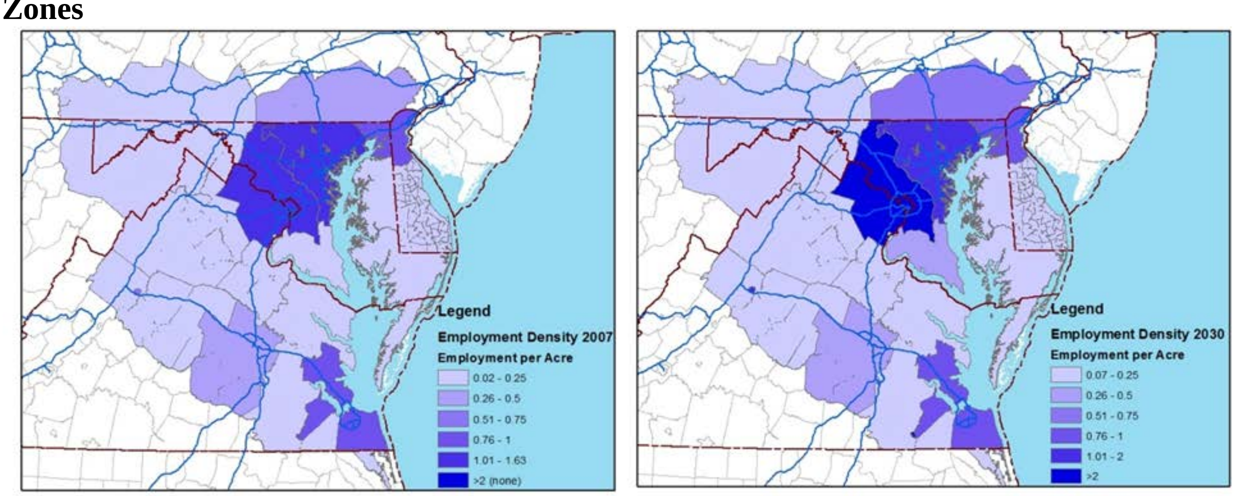
Figure 36 Household Density in 2007 and 2030 by Chesapeake Megaregion Modeling Zones



Source: Chesapeake Megaregion Model Outputs: 2007 Base and 2030 Reference scenarios.

The employment increases in these regions are shown in Figure 37. Again, as with households, employment growth occurs in all parts of the region regions but changes in employment density are greatest in the Northeastern part of the megaregion and the southeast tidewater area of Virginia.

Figure 37 Employment Density in 2007 and 2030 by Chesapeake Megaregion Modeling Zones



Source: Chesapeake Megaregion Model Outputs: 2007 Base and 2030 Reference scenarios.

Together, the shifts in household and employment location point to the need of plans at the megaregion level, these shifts span several states. Activities and land characteristics in one state can significantly influence land use in adjacent states.

3.6.2 Change in Travel

Table 3 shows all trips by type within the Chesapeake Megaregion. Over 90 percent of the trips in the megaregion are for local auto travel. National trips are provided by the long-distance model and cover trips with a length of 50 miles or more. Local trips are generated within the Chesapeake Megaregion and have a trips length of 50 miles or less. Although the national trips for truck and auto are longer in length, there are fewer of them.

Table 3 Number of Trips by Vehicle Type and Length, 2007 and 2030 and Percent Growth between 2007 and 2030

Vehicle	**Class**	**Trips 2007**	**Trips 2030**	**Growth**
Auto	I-I < 50 miles	6160.2	7448.1	21 %
	I-I > 50 miles	43.7	55.2	26 %
	I-E/E-I	38.6	48.3	25 %
Single unit truck	I-I < 50 miles	75.9	89.1	17 %
	I-I > 50 miles	0.5	0.6	26 %
	I-E/E-I	1.1	1.3	15 %
Multi-Unit truck	I-I < 50 miles	68.0	78.8	16 %
	I-I > 50 miles	0.8	0.9	23 %
	I-E/E-I	3.2	3.9	23 %
All Trucks	I-I < 50 miles	143.9	167.9	17 %
	I-I > 50 miles	1.2	1.5	24 %
	I-E/E-I	4.3	5.2	21 %
All Vehicles	I-I < 50 miles	6304.1	7615.9	21 %
	I-I > 50 miles	45.0	56.7	26 %
	I-E/E-I	42.9	53.5	25 %
Total		6392.0	7726.2	21 %

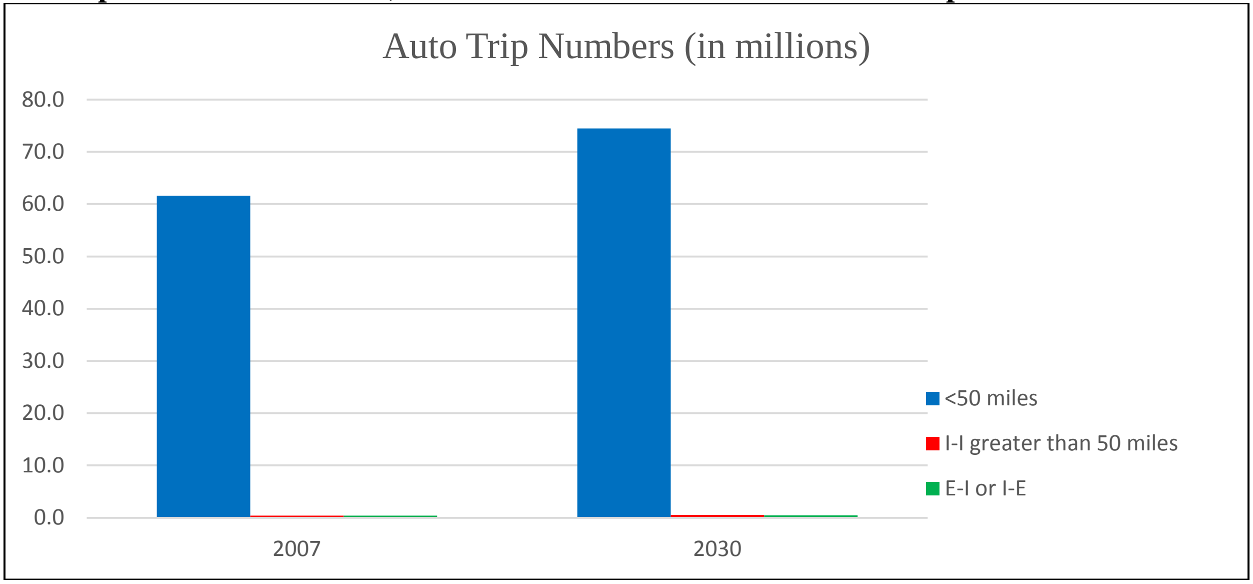
Classes

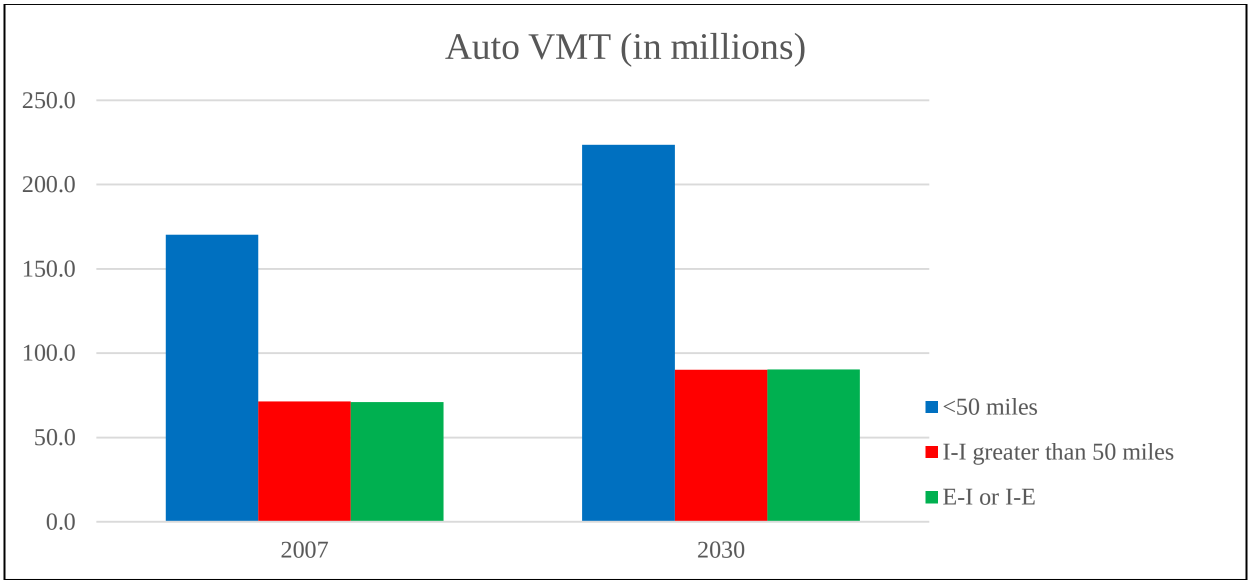
I-I < 50 miles:	Both trip ends are within CBM study area, trip length under 50 miles
I-I > 50 miles:	Both trip ends are within CBM study area, trip length over 50 miles
I-E/E-I:	One trip end is within and one trip outside of CBM study area, regardless of trip length

Source: Chesapeake Megaregion Model Outputs: 2007 Base and 2030 Reference scenarios.

Figure 38 illustrates the growth in auto travel between 2007 and 2030, both in the number of trips and in VMT. The I-I trips identified in this figure have lengths greater than 50 miles but origins and destinations within the megaregion. External trips are those with either an origin or destination outside the megaregion. The figure shows that while the vast majority of trips are less than 50 miles, internal trips greater than 50 miles and external trips account for a very large proportion of VMT.

Figure 38 AutoTravel Demand: Comparison of the Number of Auto trips and Auto VMT for Trips Less than 50 Miles, Greater than 50 Miles and External Trips

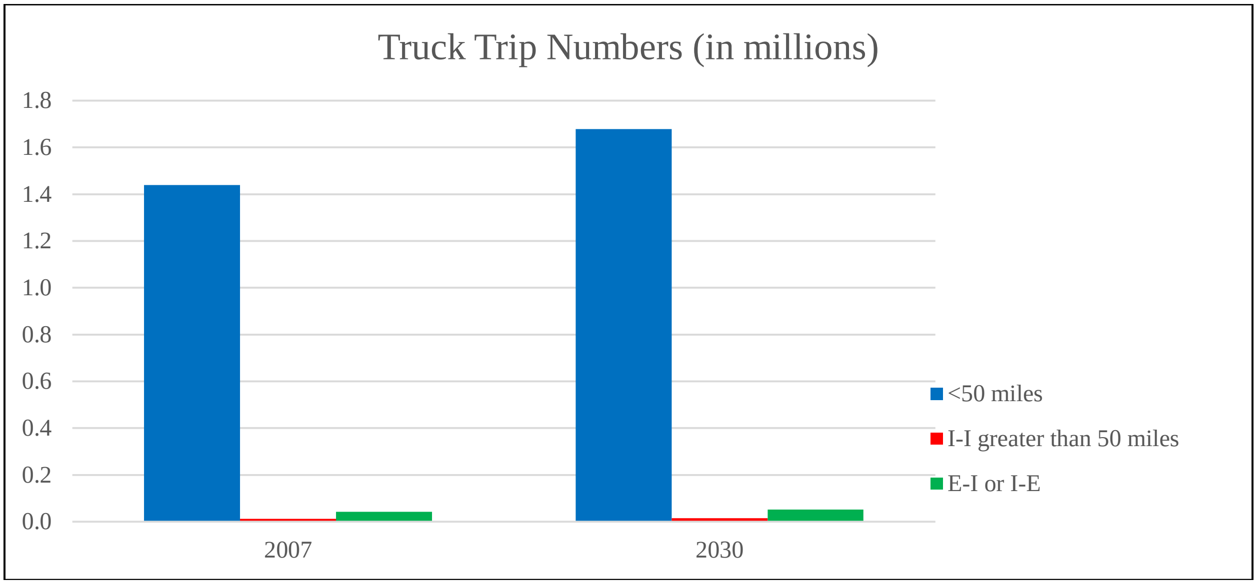


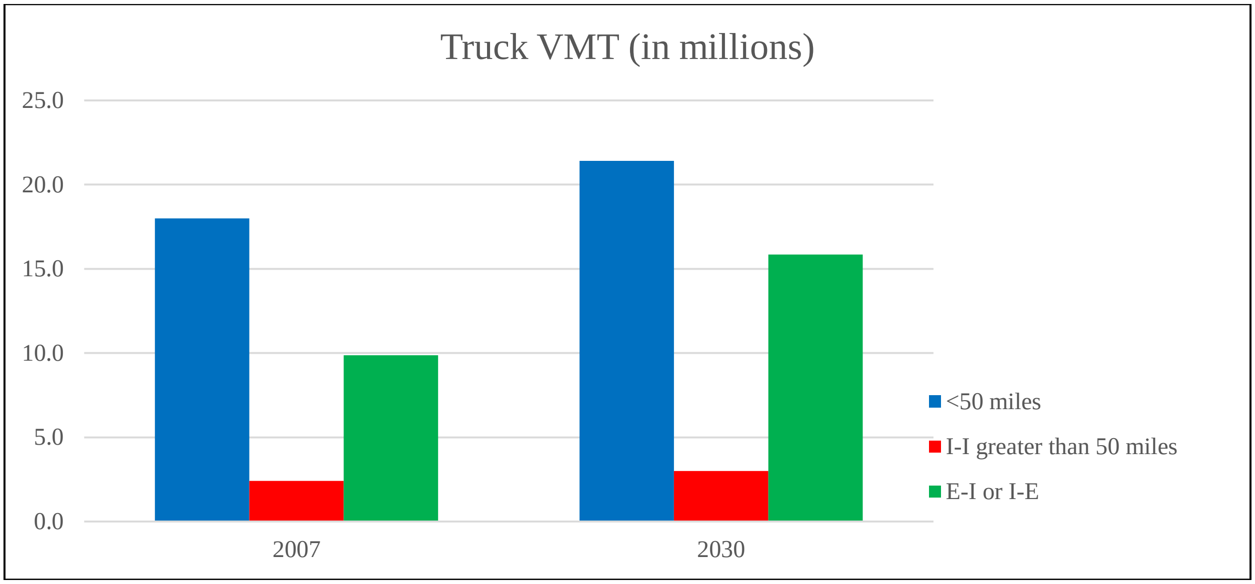


Source: Chesapeake Megaregion Model Outputs: 2007 Base and 2030 Reference scenarios.

Figure 39 shows the growth in truck travel between 2007 and 2030. As with auto travel, short distance trips make up a very large portion of truck trips but internal trips greater than 50 miles and external trips account for a much larger proportion of truck VMT.

Figure 39 Truck Travel Demand: Comparison of the Number of Truck Trips and Truck VMT for Trips Less than 50 Miles, Greater than 50 Miles and External Trips



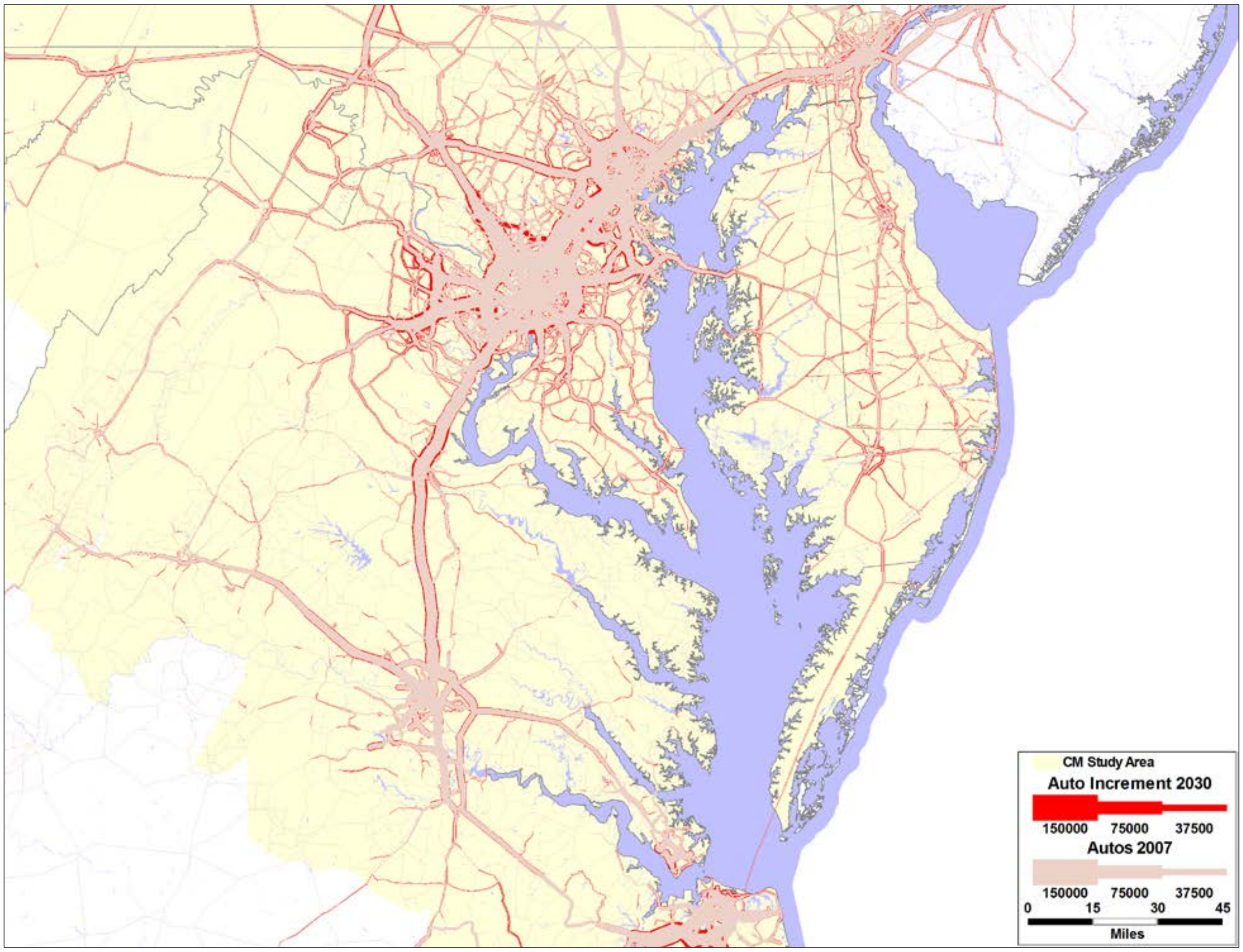


Source: Chesapeake Megaregion Model Outputs: 2007 Base and 2030 Reference scenarios.

3.6.3 Growth of Travel on the Highway Network

Figure 40 shows the growth in auto travel on the highway network. As shown, there will be significant travel volumes along the I-95/I-64 corridor in the future.

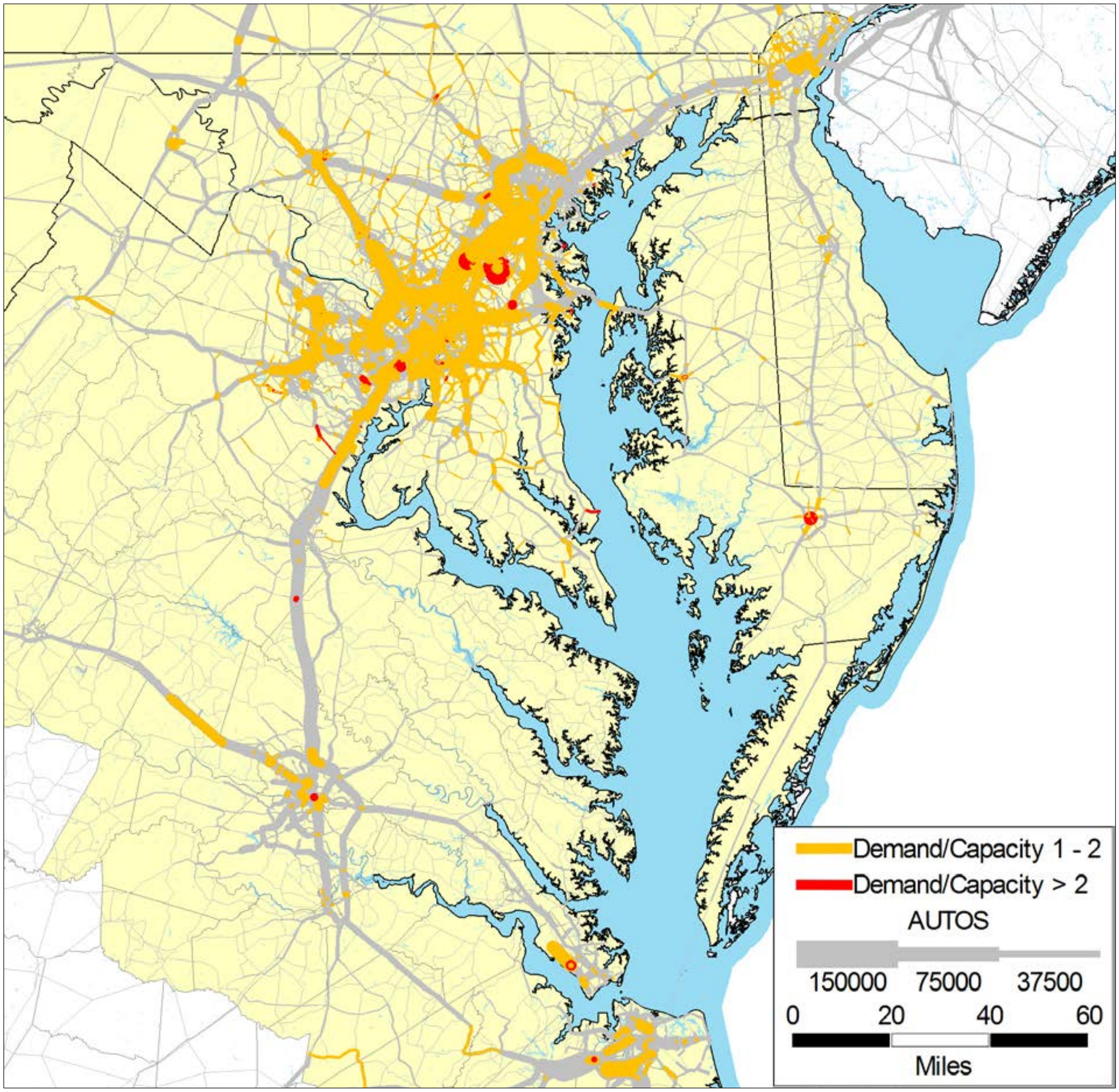
Figure 40 Growth in Auto Traffic on I-95 and I-64 and other Major Routes from 2007 to 2030



Source: Chesapeake Megaregion Model Outputs: 2007 Base and 2030 Reference scenarios.

Figure 41 shows the forecast volume to capacity ratios in 2030. Congestion in the Washington area and in the Baltimore-Washington corridor will witness significant growth. This congestion growth will affect movements up and down the entire I-95/I-64 corridor and could have a major impact on economic movements within the megaregion.

Figure 41 Volume to Capacity Ratio on Major Routes within the Chesapeake Megaregion in 2030

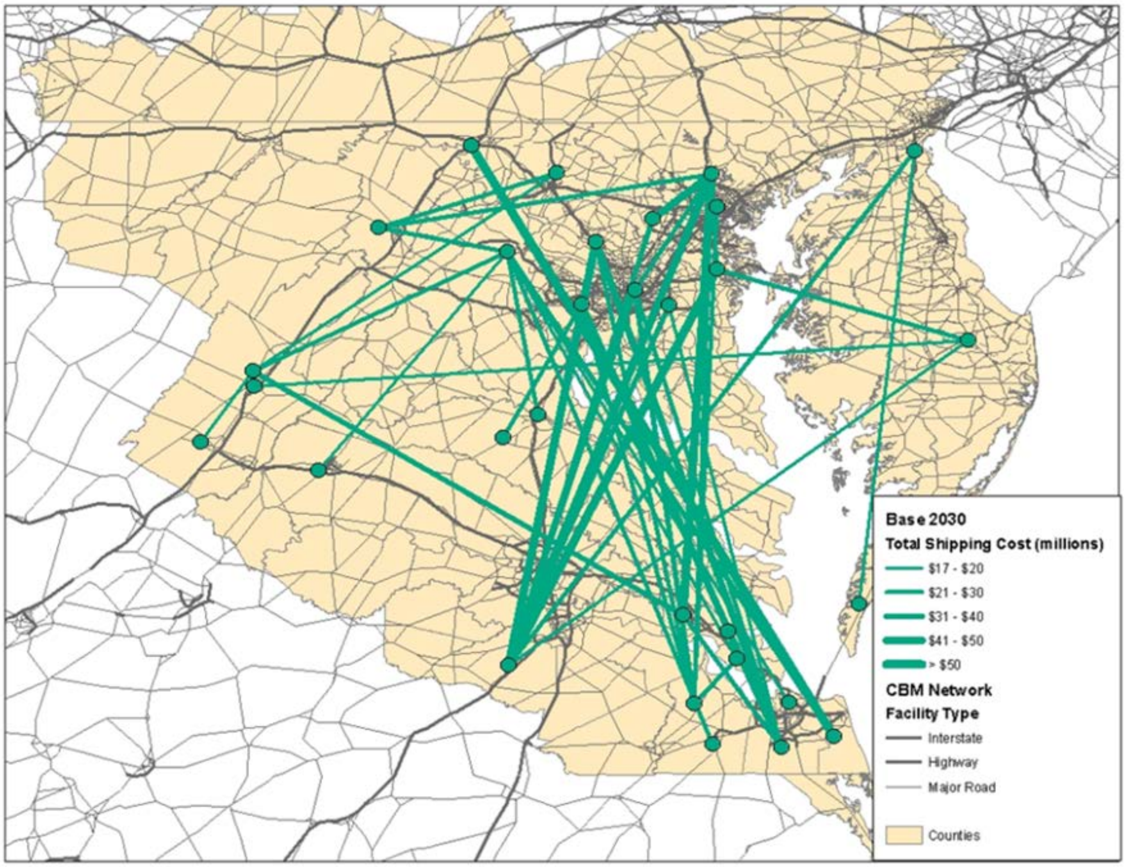


Source: Chesapeake Megaregion Model Outputs: 2007 Base and 2030 Reference scenarios.

3.6.4 Change in Goods Shipment Costs

Figure 42 represents the county pairs with the 25 highest generalized shipping expenditures in 2030. The expenditures include both time and vehicle operating cost, and the volume of goods shipped. The total expenditures therefore represent the weight of the shipments multiplied by the generalized cost. The figure highlights how the largest flows predominantly utilize I-95 and I-64. If either of these routes have a significant growth in congestion, the economic movements will be jeopardized. While there are east–west movements among the top 25, the bulk of the movements are in the north-south direction.

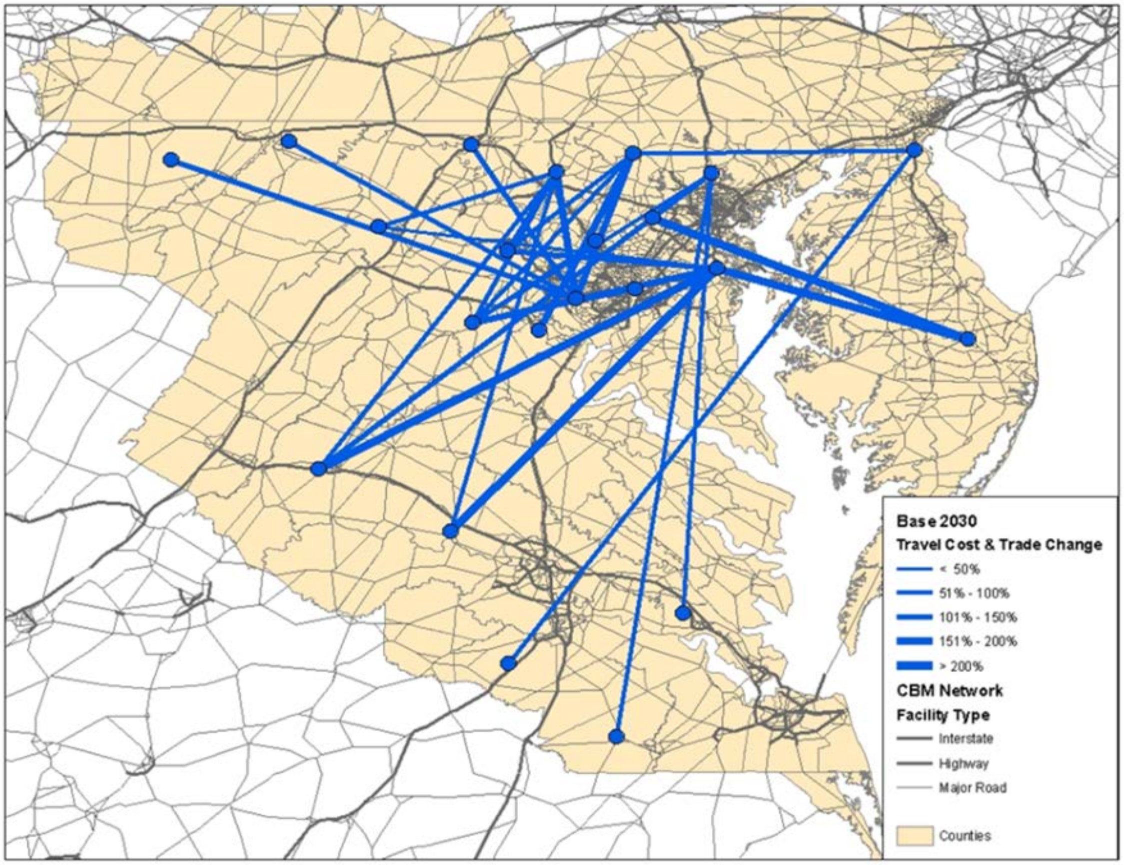
Figure 42 Cost of Shipping Goods by Truck between the Twenty Five County Pairs with the Highest Costs (Tons x Generalized Cost)



Source: Chesapeake Megaregion Model Outputs: 2007 Base and 2030 Reference scenarios.

Figure 43 represents the 25 county pairs with the largest increase in shipping expenditures in 2030 when compared to 2007. The increase in expenditures results from a combination of increased generalized travel cost and more goods being shipped. This demonstrates that in 2030, while most of the movements remain north – south, the greatest growth is in the east-west direction. The need for this east-west goods movement seems to be the result of the more dispersed growth of the 2030 reference scenario. However, much of the goods flow in the east-west direction may not be well served by the current roadway network. In an area concerned with economic growth, this points to the need to view economic issues at a scale different from the MPO perspective. With the projected growth in congestion along I-95, particularly in the Washington DC area, and along I-64, the ability of the transportation network to support projected economic changes will be called into question.

Figure 43 Twenty Five County Pairs with the Largest Forecast Increases in Shipping Expenditures from 2007 to 2030



Source: Chesapeake Megaregion Model Outputs: 2007 Base and 2030 Reference scenarios.

4. CONCLUSIONS

This case study has identified significant conclusions about Megaregions, generally, the Chesapeake Megaregion. The need for the megaregion view and an analytic framework to address megaregion issues, the construction of a megaregion model; the ability to construct a megaregion model using available resources and issues involved in determining megaregion boundary.

Megaregion is a new planning geography. It is tied together by economic interactions, commodity flows, traffic flows (particularly commute trips), identity, or environment, which often go beyond the scope of state boundary and administrative regions.

4.1 The Chesapeake Megaregion

The characterization shows that the economy binds the Chesapeake Megaregion together. The diagrams of economic flows illustrate this. The north south economic linkages along the I-95/I-64 corridor in particular illustrate the economic interconnections. In looking to the future the east west freight movements are likely to be more critical to the Chesapeake Megaregion economy than they are today. With forecasts of additional traffic in the future and the need for economic growth, the Chesapeake Megaregion should be concerned that there is adequate infrastructure to support freight movements, a critical factor in the growth of the economy. The characterization also shows that the Chesapeake Megaregion includes not only metropolitan areas, as defined by MPOs, but also influence areas surrounding the metropolitan areas. While these conclusions apply to the Chesapeake megaregion, they also point to more general conclusions about megaregions and the need for an analytic framework.

4.2 Need for the Megaregion View

The economic flows analysis also shows that when an understanding of the economy and economic interrelationships is desired, the analysis must take place at the megaregion level, larger in area than a typical MPO analysis. When mapped, the economic flows show linkages between the Baltimore, Washington and Richmond areas and other parts of the Chesapeake Megaregion which go beyond the commuter sheds of a typical MPO. A metropolitan analysis would not identify these flows and would not support decisions needed to improve the economy or address transportation, land use, social and environmental issues, which arise at a megaregion level.

4.3 Issue Identification

Carefully defining the issues to be addressed forms the most critical step in the market analysis. The issues affect the boundary definition, type of model to be constructed and the analyses to be completed. (As an example, had the issue been water quality in the Chesapeake Bay the boundaries would have covered the entire Chesapeake Bay watershed.) Other megaregions, in applying this framework, may have different concerns, which would in turn cause different methods of boundary definition and lead to alternative model structures.

4.4 Boundary Definition

At the beginning of this study the boundary as defined by Ross, along with the expanded area covered by the MSTM, were used. This study points to the importance of including Wilmington in the study area, even though it was not contained within the original boundary definition. Because one of the concerns of the study was economic movements, this boundary expansion was important. Consideration to including Philadelphia in any future studies of the Chesapeake Megaregion should also be given. This also leads to the conclusion that in conducting megaregion market analysis, the initial boundary should not be 'written in stone' but should remain flexible as the analysis develops. The issue of boundary definition also ties into the issues to be analyzed and the elements of the framework used. For example, if the study were strictly on economic linkages within the Chesapeake Megaregion, perhaps a larger study area, but one which focused on the economic movements without the transportation detail, would initially be more appropriate. Alternatively if the focus had been on a different issue, for example the water quality of the Chesapeake Bay, the boundary would likely have been tied to the Chesapeake Bay Watershed and the analysis would have focused much more on changes in land use and land cover.

4.5 Need for Analytic Framework

The case study also demonstrates need for the framework and the applicability of the framework. By taking portions of the framework a model can be developed which can analyze economic and transportation issues within the Chesapeake Megaregion. While the general framework would be applied in most cases, it can be tailored to specific issues. In this case, the characterization and the application of the framework emphasized economic flows and discussed changes in economic flows in the forecast year.

4.6 Model Construction

The case study also demonstrated the ability to construct a model from readily available methods and information. The model was developed by taking the existing Maryland Statewide model and expanding it to cover eastern and southern Virginia. The model yielded reasonable results with the existing parameters and enhanced data. The model constructed, while not developed to the same level of fidelity which would be used in an MPO model, nevertheless would prove very useful for analyzing policies at the megaregion level. While this study focused on the economy, other issues which could be analyzed with the same tool include air quality, land use policies, provision of new transportation infrastructure and megaregion wide tolling actions.

Endnotes

[1]Sassen, Saskia. 2007. Megaregions: Benefits beyond sharing trains and parking lots? In The Economic Geography of Megaregions, Keith S. Goldfeld, ed. Princeton University: Princeton, NJ.
[2] A Framework for Megaregion Analysis: Development and Proof of Concept Report to the Federal Highway Administration, 2013, Appendix A, literature review.
[3]Amekudzi, A., L. Thomas-Mobley & C. Ross. 2007. Transportation planning and infrastructure delivery in major cities and megacities. Transportation Research Record 17-23.
[4] Federal Highway Administration (FHWA) Strategic Plan, FHWA-PL-08-027. (Revised, March 2010)
[5]Ross, Catherine L. 2008. Mega-regions: Literature review of the implications for U.S. infrastructure investment and transportation planning. U.S. Department of Transportation Federal Highway Administration.
[6] Lang and Nelson. 2007 Lang, Robert E. and Arthur C. Nelson. 2007. The Rise of the Megapolitans. Planning (January): 7-12.
[7]http://www.chesbay.us/
[8]http://www.i95coalition.org/i95/Default.aspx
[9] American Community Survey. http://www.census.gov/acs.
[10] Note: The estimates produced by IMPLAN and HaulChoice differ from other data bases such as FAF and TranSearch. The IMPLAN data focuses on estimating the intercounty dollar flows, and then derives tonnage from these flows. FAF, for example, divides the country into FAF zones then develops interzonal tonnages from variousdata sources. If the analytic need is to get national movements correct, the FAF would be a better tool. If the need is to understand the intercounty economics, IMPLAN would be the better tool.
[11] Federal Aviation Administration 2011
[12] American Association of Port Authorities, 2011
[13]U.S. Census Bureau, Census2010, http://www.census.gov/2010census/
[14] U.S. Census Bureau, County Business Patterns, http://www.census.gov/econ/cbp/
[15]U.S. Department of Commerce, Bureau of Economic Analysis, 2010, http://www.bea.gov/iTable/index_regional.cfm
[16] US Department of Agriculture, Economic Research Service, Atlas of Rural and Small-Town America, http://www.ers.usda.gov/data/ruralatlas/about.htm
[17]FAF data includes shipments from a private sector establishment to military, but excludes military-to-military shipments.
[18]

IMPLAN/EconNWhttp://implan.com/V4/index.php?option=com_multicategories&view=article&id=632:632&Itemid=10
[19] Note: The impact of economic change in output in a modeled megaregion from the locus of the shock (a particular county) to other counties is implemented directly in IMPLAN using proprietary IMPLAN methods. The IMPLAN model then traces the change through indirect linkages to other counties and their constituent industries. An arbitrary shift (as a percentage of total county output) is used but can be scaled to a particular known or hypothesized shock using linear scaling, since IMPLAN production relationships are all linear.
[20] A Framework for Megaregion Analysis: Development and Proof of Concept Report to the Federal Highway Administration, 2013