

# 1.0 Introduction

## 1.1 BACKGROUND

The Appalachian Development Highway System was originally designated and funded to help generate economic development in the economically distressed Appalachian region by enhancing access in isolated areas and better connecting Appalachia to the interstate system. Significant transportation, trade and economic analysis of the Appalachian Development Highway System (ADHS) has been completed over the past 15 years, demonstrating the positive economic growth effects of the ADHS and the importance of trade route connections to domestic and international markets outside of the Appalachian Region. With 15 percent of the ADHS yet to be completed, this new study uniquely captures not only the economic benefits (and costs) of completing the remaining segments of the ADHS, but also the network benefits of a fully connected and linked ADHS, including national freight flows benefiting from this major highway system. See Figure 1.1 for a map of the ADHS corridors complete and yet to be constructed and thus open to traffic.

Prior to this current study, the most recent extensive economic impact analysis of the ADHS was a report from July 1998 that found positive economic and travel efficiency returns to ADHS investments.<sup>7</sup> It differs significantly from this current effort in several key ways that are worth noting so as to avoid unproductive comparison:

First, the 1998 study focused exclusively on the 12 completed ADHS corridors and corridor segments rather than completion of the entire system. The earlier study modeled segment-level traffic conditions rather than a fully networked system depicted by a travel demand model.

Second, freight flow data has improved significantly since the 1998 report, thus allowing for a more thorough and detailed estimation of local, regional, and national freight flows. The current study uses the most current Federal Highway Administration (FHWA) Freight Analysis Framework (FAF) historical (2002) and projected freight flow data (2020 and 2035) building on a county-level freight flow database developed for ARC by Marshall University and Wilbur Smith Associates.

Third, while the 1998 study does estimate economic development effects based on travel efficiency gains, it does not include additional regional economic development gains due to improvements in market accessibility and

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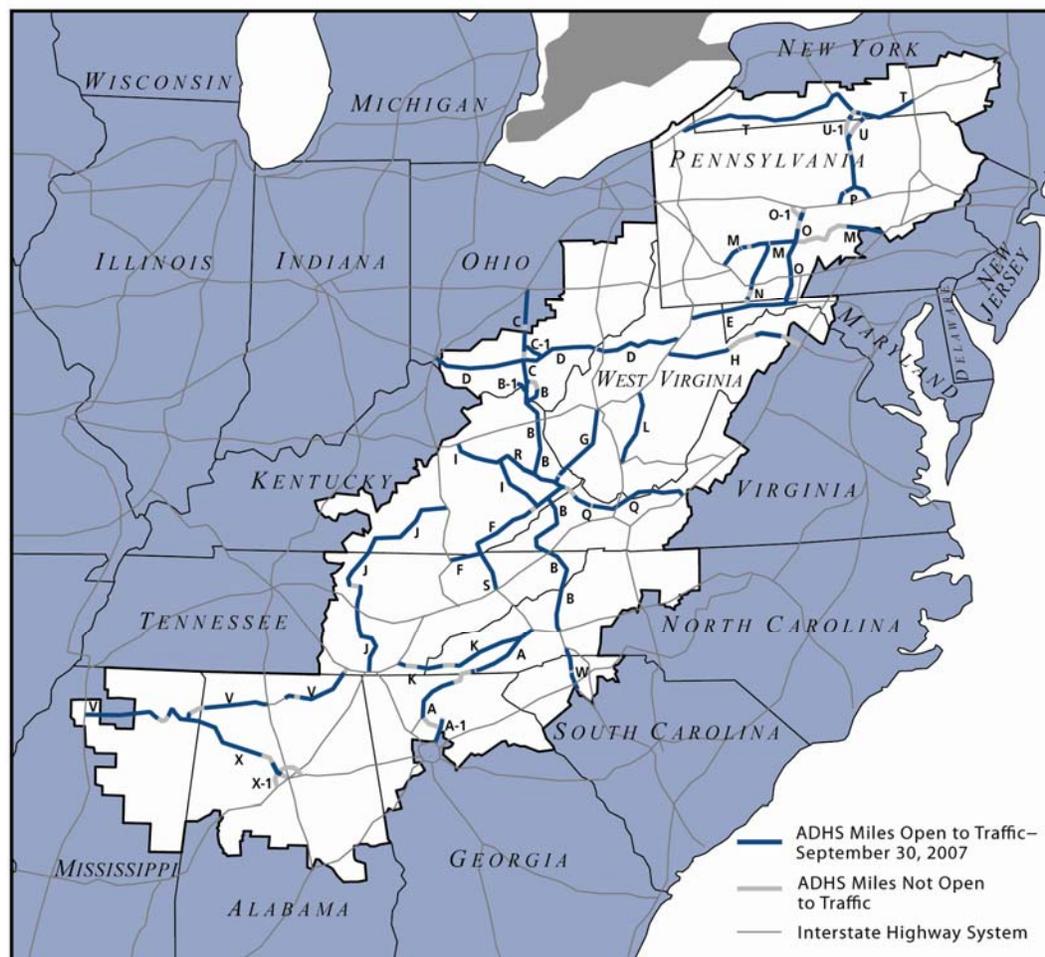
<sup>7</sup> Wilbur Smith Associates, *Appalachian Development Highways Economic Impact Study*, Appalachian Regional Commission, July 1998.

network connectivity. Further, this new study incorporates findings from recent statistical research on how ADHS economic development benefits vary in timing and magnitude depending on the type of county (rural, distressed, adjacent to metropolitan areas, etc.).

Fourth, this study includes three detailed case studies of ADHS corridors that provide real world context for the economic and trade benefits accruing to and expected from corridor completion. These detailed analyses, with input from local businesses, economic development officials and freight shippers and receivers was used to validate and calibrated the economic development benefits estimated in the quantitative modeling approach.

Figure 1.1 ADHS Corridors

*Appalachian Development Highway System as of September 30, 2007*



Source: Appalachian Regional Commission

Outputs from this study include a full range of transportation performance and economic development indicators, including:

Travel-time savings, route diversion, and market accessibility;

Direct user benefits, and additional economic development and tourism effects;

Total economic impacts (e.g., employment by industry, gross regional product, personal income); and

Benefit/cost ratios and net present value.

Results are presented for two perspectives – the ARC region (410 counties in 13 states) and the entire United States. Since the ADHS has specific objectives in terms of increasing economic development opportunities for the Appalachian Region, the regional perspective on benefits of completing the ADHS is essential and informative. In addition, U.S.-level economic efficiency benefits of completing the ADHS are provided to demonstrate the national benefits of ADHS investment. Reflecting the unavoidable uncertainty inherent in any forecast, estimates of future benefits are provided in terms of a range of likely effects.

The remainder of Section 1.0 provides an overview of the study approach, while the report is organized into the following sections and appendices:

Section 2.0 Methodology – Models and Data;

Section 3.0 Detailed Corridor Analysis Summaries;

Section 4.0 Travel Impacts, User Benefits and Accessibility;

Section 5.0 Economic Impacts;

Section 6.0 Benefit/Cost Analysis; and

Technical Appendices – (A) Travel Demand Model, and (B) Market Access and Economic Development Impacts.

## **1.2 STUDY OBJECTIVES AND OVERVIEW OF IMPACT MEASURES**

The primary objective of this study is to estimate the economic impacts of a completed ADHS network, focused on the benefits of completing the final corridor segments. To do so requires the development of two travel and economic forecasts: 1) a “build” scenario with all remaining ADHS corridors fully completed; and 2) a “no-build” scenario that includes ADHS corridors already built or under construction, but does not include the remaining 15 percent of the system. Differences between these two future scenarios are estimated in terms of numerous factors:

**Travel Performance Impacts** - Comparisons of travel performance between the “build” and “no-build” scenarios within the networked travel demand model (which includes a thorough highway network of interstate, state, and local highways in and surrounding the ARC region) produces raw travel efficiency metrics such as vehicle hours of travel (VHT), vehicle miles of travel (VMT), and average speed for all trips (freight, nonfreight truck trips, and automobile).

**User Benefits** - Applying values of time and vehicle operating cost parameters to the travel performance impacts produces monetary benefits to the users of the ADHS corridors (and other regional highways experiencing changing traffic volumes). User benefits are measured in terms of travel-time savings, vehicle operating costs (fuel and nonfuel) and safety, varying by trip purpose (business, personal, commute) and vehicle type.<sup>8</sup>

**National, Regional, and Local Freight Flows** - As briefly mentioned above, this study incorporates comprehensive freight flow data based on FHWA’s FAF historical and projected trade data, as well as detailed county-level origin-destination trade flows to allow the estimation of benefits to short- and long-haul goods movement. For example, over 65 percent of freight benefits are external to the ARC region, reflecting the long-distance nature of the shipments impacted and the national importance of completing the ADHS to facilitate goods movement throughout the ARC region.

**Improvements in Market Access** - In addition to more traditional travel efficiency user benefits, this study also estimated improvements in market accessibility due to increased travel speeds in parts of the ARC region. Measuring accessibility is especially important in more remote areas that typically do not have high-traffic volumes or congestion, but where improvements in accessibility to other transportation facilities or destinations can create a more competitive business environment. Market accessibility was measured in terms of:

- Increase in labor force accessible within a typical commute time (e.g., 60 minutes);
- Increase in buyers/suppliers within a three-hour one-way drive; and
- Reductions in travel time to nearest transportation facilities (e.g., airport, marine port, intermodal rail yard, international gateway).

**Economic Development and Tourism Effects** - Improvements in market access for ARC counties and communities increases regional competitiveness and thus can lead to expanded economic growth opportunities. These effects are estimated using the Local Economic Assessment Package (LEAP), a framework originally developed for ARC together with statistical analysis

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<sup>8</sup> Reliability benefits were also estimated as part of this study but are not included in the results within this report based on what were deemed unrealistically large effects.

findings on the timing and size of ADHS economic benefits. These estimates also take into account regional and national offsets (i.e., the extent to which expanded growth in one part of the region could mean lower growth in other parts of the region).

**Total Economic Impacts** - Expansion of economic activity, driven by the direct effects on business cost savings, market access growth, intermodal connectivity improvements and associated economic multiplier effects. The Transportation Economic Development Impact System (TREDIS) was used to estimate both the direct effects on costs, market access, and connectivity, and the total effects on expansion of industry in the region. Economic growth was measured in terms of jobs, business sales, gross regional product (value-added), and wages.

**Benefit/Cost Analysis** - To gauge the economic return on investment and place these benefits in appropriate context, benefit/cost ratios and estimates of net present value are estimated from both the regional and national perspectives. The ARC regional perspective includes economic competitiveness gains not reflected in the national economy, while the national perspective includes all travel-related economic efficiency benefits (including ARC region through-trips). Future predictions of cost-to-complete the ADHS incorporate accelerated construction inflation assumptions consistent with recent historical data on cost escalation.



## 2.0 Methodology - Models and Data

This section describes the overall analysis approach used in the study, and describes how a set of state-of-the-art transportation and economic analysis models were applied to calculate impacts and benefits of completing the ADHS.

### 2.1 GENERAL APPROACH

The general approach for analysis in this study involves two steps:

1. *Classification* of the different ways in which completion of the ADHS can lead to transportation and economic impacts; and
2. *Application* of appropriate tools to estimate the travel efficiency and regional economic impacts of completing the ADHS.

In general, ADHS completion leads to a sequence of changes affecting travelers, households, and businesses that are either located in Appalachia or otherwise using Appalachian Development Highways. The resulting changes in transportation efficiencies, accessibility enhancement, and business productivity lead to broader impacts on the economy of the entire Appalachian region, as well as outside areas.<sup>9</sup> The classes of impacts and the analytical processes applied to estimate them are described below.

**A - Traveler Impacts.** All of the travel impacts are estimated by using a *highway network and travel demand forecasting model* to represent the changes in traffic volumes, distances, speeds, VMT, VHT and safety. This is more fully explained in Section 2.2. The model is applied to represent future conditions for both the existing highway network and an improved network in which all elements of the ADHS have been completed. To accomplish this, traffic growth also is forecast on the basis of population and employment growth projections, which are more fully explained in Section 2.4. This process captures the following effects.

**Travel Distances -** Completion of ADHS routes will reduce highway travel distances between some origins and destinations, which can save time and vehicle operating expense for all vehicles using these routes. The distance reduction effect can occur in three ways: 1) through development of new highway routes that are more direct; 2) through upgraded alignments on

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<sup>9</sup> It is worth noting that the study has made explicit attempts to measure *net* economic changes by accounting for potential spatial reallocation of economic activity within and outside of the ARC region. This is described more fully in Section 2.5.

existing routes that reduce curves in the road; and 3) through development of safer and more reliable highways that divert traffic from alternative routes that are longer in length but previously used because of their safety and reliability. In addition, it is possible that some trips will be diverted to faster, but longer ADHS corridors rather than local highways. All of these impacts on travel distances are captured through use of a highway network and travel demand model that forecasts changes in traffic volumes, travel distances, and route selection – yielding systemwide measure of the change in *vehicle miles of travel (VMT)*.

**Travel Speeds** - Completion of the ADHS routes will reduce average travel times on many routes. The time savings effect can occur in three ways: 1) by raising highway capacity through additional travel lanes, which reduces congestion slowdowns and thus raises normal speeds; 2) by enhancing the capability to pass slow-moving vehicles through broader shoulders and special passing lanes, which also raises daily average speeds by reducing periodic slowdowns; and 3) by reducing highway travel distances and travel times. In addition, speed calculations explicitly account for terrain (flat, rolling, mountainous) which is especially relevant for the many steep ADHS corridors. All three impacts on travel times are captured through the use of that same highway network and travel demand model, as it accounts for changes in driving conditions affecting travel speeds, distances and volumes – yielding a systemwide measure of the change in total daily *vehicle hours of travel (VHT)*.

**Traffic Safety** - Completion of the ADHS routes will enhance safety by improving roadway design geometrics (i.e., curves, embankments and shoulders), as well as roadway capacity (through additional passing and travel lanes). Altogether, these factors act to reduce traffic accidents, including vehicle damage, human injuries, and deaths. Accidents are estimated by first using the highway network and travel demand model to: 1) represent how ADHS completion changes roadway classification in terms of lane width, curves, and inclines; and 2) estimate the traffic volumes (and volume/capacity ratios) along those various roadway classes. Then, average accident rates for the various types of roads are applied. The effective safety impact is expressed in terms of forecast changes in *average collision, injury, and death rates* (per thousand vehicle miles of travel).<sup>10</sup>

**B – User Benefits.** The value of travel benefits depends on the volume and mix of users of the highway system. In the case of passenger travel, users are drivers and passengers of cars, and the passengers of buses. In the case of freight

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<sup>10</sup> It is worth noting that by using average accident rates by functional class, it is likely that safety benefits are understated in this study (which did not have the resources to do a segment-level safety analysis) since it is known that there are segments of the to-be-completed ADHS that have relatively high crash rates.

movement, the users are the shippers and receivers. In both cases, the user benefits are based on the dollar valuation of travel-time (VHT) savings, travel distance (VMT) savings, and safety improvement. However, characteristics of the traffic movement on Appalachian highways also affects user benefits in three ways: 1) the mix of trip purposes (personal or business travel) affects the valuation of time savings; 2) the car/truck vehicle mix affects vehicle operating cost and accident cost savings; and 3) the mix of commodities carried by trucks affects the value of time and reliability savings for shippers. These mix characteristics are tracked by the *highway network and travel demand model*, and generally accepted *unit valuation factors* are applied to calculate the total user benefits. In addition, a distinction is made between benefits that directly affect the flow of dollars in the economy (such as gasoline and business worker time savings) and societal benefits that have value but do not directly affect the flow of dollars (such as personal time savings). The traffic mix is discussed at the end of Section 2.2, freight flow mix is discussed in Section 2.3, and the benefit valuation factors are discussed in Section 3.0. This framework explains the different types of travel savings from which user benefits are computed:

**Business Worker and Vehicle Cost Savings** - Completion of the ADHS routes will save business costs for their “on-the-clock” worker travel, due to faster speeds and more direct routes. The benefits include reduced driver and/or worker labor time costs incurred while traveling for business, as well as measurement of changes to vehicle operating costs (e.g., less fuel costs from less VMT) and safety (e.g., fewer accidents and thus lower insurance costs). This is expressed in terms of reduced *business operating costs*.

**Business Freight Processing Cost Savings** - Completion of the ADHS routes also will save businesses travel-related costs for their freight shipments. This can be expressed as *labor cost* savings from reduced driver time or in terms of greater labor productivity (as more deliveries can be made per vehicle and driver in a given day). It also comes in the form of reduced *logistics-related costs* - which may be expressed as savings in idle loading dock worker time (while waiting for late pickups and deliveries) or in terms of savings in scheduling costs (as there is less padding of schedules to allow for freight delivery time uncertainty). There also may be *vehicle operating cost* and insurance savings for corporate truck fleets.

**Household Cost Savings** - Completion of the ADHS routes will save households vehicle fuel and maintenance expenses insofar as vehicle mileage is reduced, and they also may save on medical or insurance costs insofar as accident rates are reduced through safer roadways. This can be expressed as an increase in *disposable income*, or as a decrease in the *cost of living*.

**Personal Time Savings** - Completion of the ADHS routes, with shorter travel distances and faster travel speeds, also provides a time savings benefit for personal travel (that is not business-related). This is a societal benefit, as the value of *personal time savings* does not directly affect disposable income.

**C – Access Impacts.** Beyond saving time and money for travelers based on existing population and business forecasts, the ARC region will benefit from expanded transportation access and connectivity. These benefits are distinct from travel efficiency impacts in that they do not stem from changes in the routing or speed of trips that already are occurring (or forecast to occur in the future). Rather, they reflect a more dynamic and competitive economic environment in the ARC region, where businesses and consumers are better able to meet their needs. More specifically, ADHS will reduce isolation by enhancing *access* – including population access to jobs, medical care, shopping, and services, as well as business access to customer delivery markets and intermodal facilities. It also will improve transportation system *connectivity* to highway, intermodal rail facilities, airports, marine ports and international border and gateway facilities. In fact, the effects on access and connectivity were core elements of the justification for initial funding of the ADHS. For this study, the access impacts are measured in terms of expanded labor market size and delivery market size for each county population center. The connectivity impacts are measured in terms of travel time reductions to those intermodal connectors and facilities from each county population centers. All of these impacts are calculated using the *highway network and travel demand model* discussed in Section 2.2. This process captures the following effects.

**Job Market Access** – Completion of ADHS routes will provide the residents of Appalachian communities with greater job opportunities. This same effect can be seen as providing business locations within Appalachia with greater workforce access, thus making locations within the region more attractive for business investment. This effect is measured by the highway network model in terms of increased *population markets* within a 60-minute travel time of each county’s population center. This same effect also can be viewed as an increase in availability of shopping and services to residents.

**Business Delivery Customer Market Access** – Completion of ADHS routes also will provide businesses in some locations with broader *truck delivery markets* to buyers and suppliers. This effect is measured at the county-level by the highway network model in terms of increased business activity (measured by employment) within a three-hour delivery time, which represents a maximum for same-day truck runs.

**Connectivity to Intermodal Facilities** – Completion of ADHS routes also will provide businesses improved *access to airports, intermodal rail facilities, marine ports, and international borders or air/sea gateways*. These effects are measured by the highway network model in terms of reduced travel times to the closest commercial facility of each type.

**D – Economic Impacts.** Improvements in the highway network – with their associated transportation efficiencies, user benefits and market access – all lead to changes in business activity and associated income and jobs. These effects occur insofar as ADHS completion affects business volume, operating costs, household spending, and business productivity. These impacts play out differently at both

the regional and national levels. All of these impacts are estimated using a *regional economic impact model*. That model is discussed in Section 2.5. This framework uses the estimates of business-related travel efficiency savings and improved accessibility to compute the economic impacts of completing the ADHS.

**Direct Cost Savings Effects** - Completion of ADHS routes will reduce travel times which will lead to reduced *business operating costs*, although these cost savings differ by the type of business due to variation in their reliance on trucks and workforce costs. In the economic model, the cost savings to business-related transport induce greater worker and business income as a result of enhanced business competitiveness, leading to increases in new investment and resulting industry growth.

**Direct Access Improvement Effects** - Completion of ADHS routes also will lead to enhanced business productivity by generating economies of scale from access to larger population, a more diverse workforce, and delivery markets, as well as enabling greater efficiency of operations with access to intermodal connectivity. In the economic model, these economies of scale generate greater *productivity* and *business attraction*, leading to increases in job and income growth. (Careful calculation is done to isolate the new effect of market and connectivity improvements from the effect of reduced travel times that already is captured under direct cost savings.)

**Regional Economic Adjustment Effects** - Completion of ADHS routes also will lead to additional effects on other sectors of the economy. These include *indirect effects* on expansion of businesses that supply goods and services to the directly benefiting businesses. They also include *induced effects* of greater worker spending on goods and services as a result of the increased jobs and income. In addition, the economic model adjusts for changes over time associated with shifts of business activity locations between the ARC region and rest of the United States, as well as within the ARC region.

**E - Benefit/Cost Analysis.** To place the estimation of economic and total benefits in proper context, standard benefit/cost analysis tools have been applied to measure the economic return on investment to the ARC region and nation as a whole in terms of pure travel efficiency gains and also total economic benefits. Benefit/cost ratios are presented in terms of a likely range, reflecting uncertainties in terms of future demographic forecasts, construction inflation rates, and the discount rate. State-by-state cost-to-complete estimates for 2005 were adjusted to future years by incorporating more realistic assumptions about construction cost escalation based on data from the Bureau of Labor Statistics' bridge and highway construction producer price index (BHWY PPI).

The remainder of this section describes the highway network and travel demand model, the forecasting assumptions, the freight composition calculations, and the economic model processes.

## **2.2 HIGHWAY NETWORK AND TRAVEL DEMAND MODEL**

This section describes the preparation of the travel model that was used to analyze the impacts of interaction of automobile and freight truck travel as a result of the completion of the Appalachian Development Highway System (ADHS). The travel demand model allows the impacts on total travel to be quantified and to identify the travel-time and reliability benefits that will accrue to autos and trucks as a result of the completion of the ADHS.

### **2.2.1 Model Development**

A Travel Demand Model highway network was created in TransCAD. TransCAD is standard package travel demand model software, commonly used in transportation planning that provided the attributes necessary to fully test the impacts of the ADHS completion and to provide measures of its performance as outputs to economic development models. The highway network was based on the TransCAD highway network created for FHWA's Freight Analysis Framework (FAF) project.<sup>11</sup> That highway network provides information, including origin and destination points, for all major highway movements beginning at counties in the ARC region and surrounding areas. By inspection it was determined that the FAF network includes either the ADHS corridors or the highways that ADHS corridor improvements are intended to replace. From the FAF highway network, a ring of major highways surrounding the ARC member counties was selected for inclusion in the ARC travel demand forecasting (TDF) model. The inclusion of highways beyond the ARC region allows the impact of ADHS completion on the diversion of trips to begin at major diversion points, such as the interstate system, outside the ARC region.

Accompanying the highway network, a set of Traffic Analysis Zones (TAZ) was defined at the county level, both inside the ARC region and outside the ARC region extending to the model boundary. These counties served as the points for assigning the origins and destinations of automobile and truck trips that were developed by the TDF model. The highway network and counties are shown in Figure 2.1.

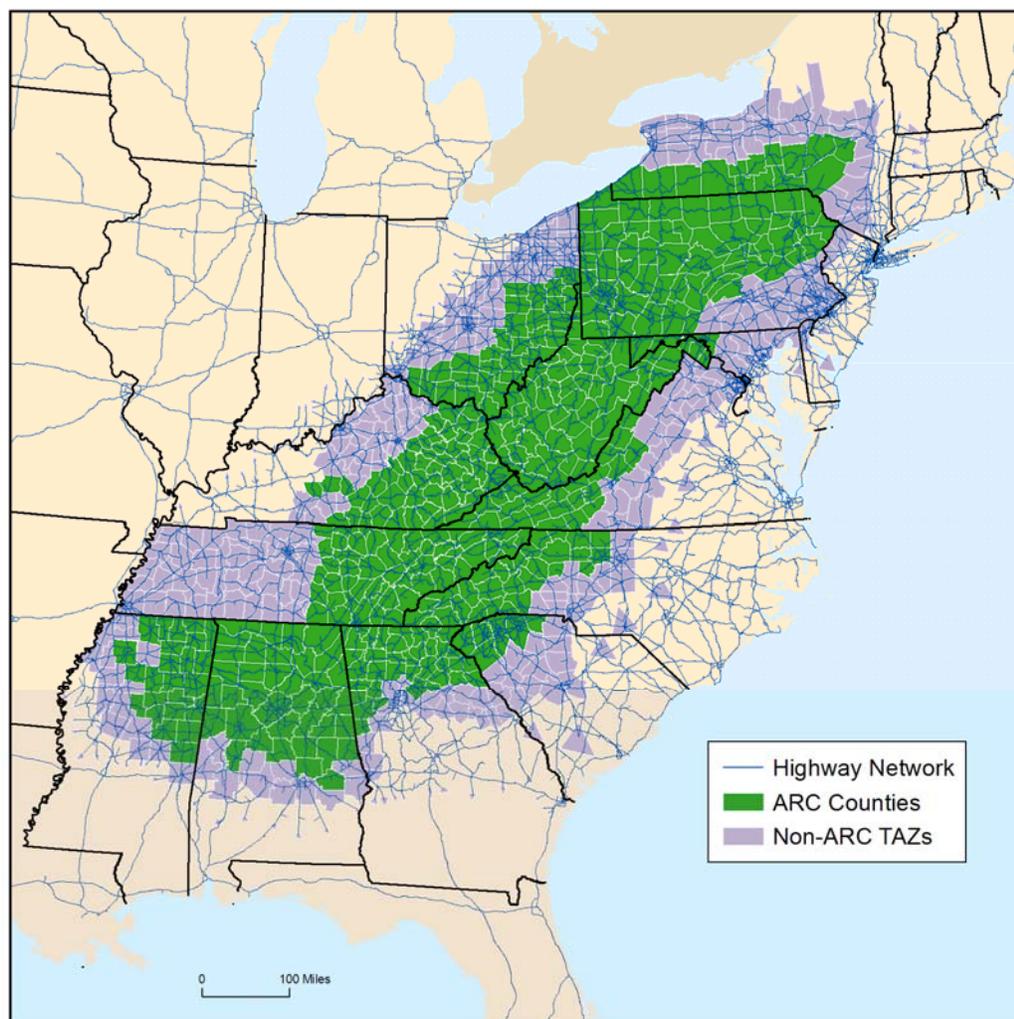
External stations were coded at the edge of the highway network. These external stations serve as the means to assign automobile and truck trips between those counties included within the model and the remainder of the United States. The network of major highway outside of the model boundary was used with national commodity truck patterns (as discussed in the next section) that have an origin and/or a destination outside of the ARC region, to identify the external station(s) which are used to enter or exit the travel model.

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<sup>11</sup>Freight Analysis Framework Version 1.0, TransCAD highway network, FHWA.

To support the analysis of the calculation of accessibility to airports, intermodal terminals, marine ports and international borders, these facilities were coded as zones in the travel demand model. Where the facilities were located within the travel demand model boundaries, the locations were coded directly within the model. When those locations were located outside of the model boundary (e.g., Port of Savannah, Brownsville, Texas border crossing), links representing the distance to these locations were coded into the network.

Figure 2.1 ARC Travel Demand Model Highway Network and TAZs



Links in the ARC travel demand model highway network have an attribute which indicates their status as an ADHS segment, including whether the link is “completed” or “yet to be completed.” TransCAD maintains one master network file where links for scenarios (e.g., base, No-Build/ADHS completed, build/ADHS yet to be completed) were turned on or off as needed. These attributes allowed the travel and performance on the ADHS segments to be readily identified.

The TransCAD software includes a feature known as Origin Destination Matrix Estimation (ODME). ODME can allow the “reverse engineering” of the most likely trip table that would be consistent with treating the observed traffic counts as the assigned volumes of that trip table. The FAF1 highway network used in the development of the ARC travel demand model highway network includes automobile and truck average (annual) daily traffic (AADT) counts as attributes. The ADHS highway segments also include daily AADTs for automobile and trucks that were used to update the FAF1 counts. Since the ODME process estimates trips *between* TAZs, consistent with this process and the county TAZ structure, the counts used in the estimation process were those on links in the model network that cross zone/county boundaries. This estimation process does not include trips that travel completely within a county and, therefore, the estimation process excludes those counts that are likely to include a high portion of those trips.

Suitable preliminary trip tables for automobiles and trucks were developed from socioeconomic data for TAZ/counties quick response trip generation factors of automobile and truck trips per population and employee. The trips were distributed using a simple gravity model and the average travel times between zones. The trip table required no further adjustment since it is adjusted during the ODME process.

### *Non-commodity Trucks*

ODME was run separately for autos and total trucks. The non-commodity trucks were calculated by subtraction of the commodity trucks that are discussed in the next section from the estimated total truck tables.

The FAF2 commodity truck flows do not include trucks handling retail or commercial deliveries, construction equipment or supplies, service trucks, utility trucks, etc. Those trucks are included in the ODME estimate of total trucks. By subtracting the commodity truck table from the ODME truck table a table of non-commodity trucks was created.

### *Forecasting*

Forecast automobile and non-commodity truck trip tables were created by calculating future trip ends using the 2020 and 2035 socioeconomic forecast for the medium- and high-growth scenarios and quick response generation factors of automobile and truck trips per population and employee. The ratio of base year and future year trip ends were applied in an iterative proportional fitting process to create future year automobile and non-commodity truck trip tables.

The commodity truck trip tables were developed by first creating commodity growth rates in trips using the forecast years of the FAF2 and applying these growth rates to individual commodity truck shipments.

The future automobile, non-commodity and commodity truck trip tables were assigned in the travel demand model to the No-build and Build highway net-

works. These assignments were used to create performance measures (e.g., travel times and costs) that were used in the economic analysis.

## **2.3 FREIGHT FLOWS**

This section describes the results of the analysis that developed freight flow projections for the study area. These freight flows were then included in the travel demand model in order to analyze the impacts of interaction of automobile and freight truck travel as a result of the completion of the Appalachian Development Highway System (ADHS). This inclusion of freight flows within the travel demand model allows their impacts on total travel to be quantified and to identify the travel-time and reliability benefits that will accrue to freight trucks as a result of the completion of the ADHS.

The analysis was based on two existing sources of freight flow data: the ARC Commodity Flow database developed by Marshall University;<sup>12</sup> and the FHWA's Freight Analysis Framework 2.2 database.

### **2.3.1 Marshall University Commodity Flow Database**

A database of 1998 county to county flows to, from, and within (but not through) the ARC has been developed by Marshall University data. This database was developed from the FHWA's Freight Analysis Framework 1. Those flows are only for commodities moved by truck. The Marshall University database, which itself was developed from the FAF1 trip tables, uses a commodity classification system known as the Standard Classification of Transported Commodities (STCC).

#### *Truck Data*

The Marshall database includes separate files for originating and terminating traffic for each two-digit STCC. The first letter of the file indicates whether the freight flow is originating, O, or terminating, T; traffic and the last two digits contain the STCC. For example, OFIP\_27 contains records for STCC No. 27 originating in ARC counties or TFIP\_14 contains records for STCC No. 14 terminating in ARC counties.

OFIP files contain the following variables:

OFIP - The originating ARC county;

TST - The terminating state;

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<sup>12</sup>Rahall Transportation Institute, Marshall University and Wilbur Smith Associates, *Report No. 4 in a Series of Transportation and Trade Studies of the Appalachian Region Meeting the Transportation Challenges of the 21<sup>st</sup> Century: Intermodal Opportunities in the Appalachian Region Economic Benefits of Intermodal Efficiencies*, Appalachian Regional Commission, December 2004.

STCC - Two-digit STCC;

SUMTON - Estimated annual tonnage; and

OSTRESS - A 0/1 variable denoting whether or not the originating is ARC county designated as distressed.

TFIP files contain the following variables:

TFIP - The terminating ARC county;

OST - The origin state;

STCC - Two-digit STCC;

SUMTON - Estimated annual tonnage; and

TSTRESS - A 0/1 variable denoting whether or not the originating is ARC county designated as distressed.

### **2.3.2 Freight Analysis Framework 2.2**

Beginning in 1997, and in all subsequent Commodity Flow Surveys (CFS) prepared by the U.S. Census Bureau, a different commodity classification system, the Standard Classification of Transported Goods (SCTG), was used. The update to the Freight Analysis Framework, known as FAF2, developed by the FHWA which has a base year of 2002 and forecast years of 2010 through 2035 in five-year increments, also uses the SCTG.

The FAF2 database includes geographic data, as origins or destinations, for 114 regions in the United States. Each record contains the originating region, the destination region, the mode of transport, and the annual tonnage for 2002 and each forecast year. The ratio of the base year and forecast year tonnage for records using the truck mode can be used to develop growth factors for those flows.

### **2.3.3 ARC Commodity Truck Database**

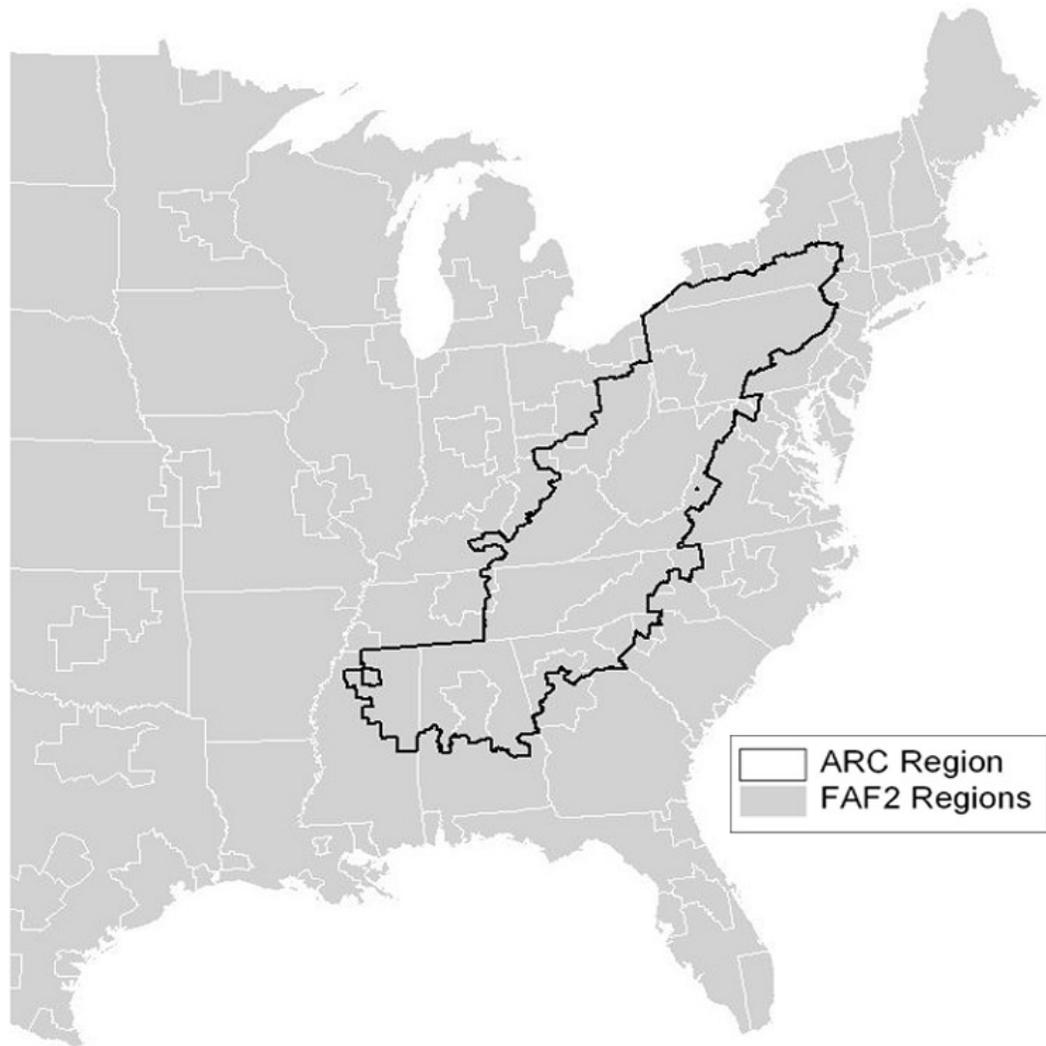
A crosswalk table between the Marshall STCC commodity Codes, the FAF2 SCTG commodity codes, and the summary commodity codes was developed for use in this study. This table, shown as Table 2.1, was used to accumulate the commodity totals into 11 basic truck commodity flows.

Tables of freight flows in terms of tonnage were obtained from FAF2 for the 2002 base year and for the 2020 and 2035 forecast years. The FAF2 has 114 U.S. zones. An equivalency table of U.S. counties to FAF2 zones was created (see Figure 2.2). This table was used to disaggregate the FAF2 tonnage flows to ARC counties using the 1998 ratios of county to FAF2 zone totals from the Marshall database.

Table 2.1 Commodity Code Equivalencies

SCTG2	FAF2 Abbreviation	STCC2	FAF1 Name	ARC Name	ARC Commodity
1	Live Animals/Fish	1	Agriculture	Agriculture	1
2	Cereal Grains	1	Agriculture	Agriculture	1
3	Other Agricultural Products	1	Agriculture	Agriculture	1
4	Animal Feed	20	Food	Food and Tobacco	2
5	Meat/Seafood	20	Food	Food and Tobacco	2
6	Milled Grain Products	20	Food	Food and Tobacco	2
7	Other Foodstuffs	20	Food	Food and Tobacco	2
8	Alcoholic Beverages	20	Food	Food and Tobacco	2
9	Tobacco Products	21	Tobacco	Food and Tobacco	2
14	Metallic Ores	10	Metallic Ores	Mining	3
15	Coal	11	Coal	Mining	3
10	Building Stone	14	Nonmetallic Minerals	Mining	3
11	Natural Sands	14	Nonmetallic Minerals	Mining	3
12	Gravel	14	Nonmetallic Minerals	Mining	3
13	Nonmetallic Minerals	14	Nonmetallic Minerals	Mining	3
16	Crude Petroleum	13	Crude Petroleum	Petroleum and Chemicals	4
20	Basic Chemicals	28	Chemicals	Petroleum and Chemicals	4
21	Pharmaceuticals	28	Chemicals	Petroleum and Chemicals	4
22	Fertilizers	28	Chemicals	Petroleum and Chemicals	4
23	Chemical Products	28	Chemicals	Petroleum and Chemicals	4
17	Gasoline	29	Refined Petroleum	Petroleum and Chemicals	4
18	Fuel Oils	29	Refined Petroleum	Petroleum and Chemicals	4
19	Coal-n.e.c. <sup>1</sup>	29	Refined Petroleum	Petroleum and Chemicals	4
24	Plastics/Rubber	30	Rubber/Plastics	Other Durable Manufacturing	5
31	Nonmetal Mineral Products	32	Clay, Concrete, Glass	Other Durable Manufacturing	5
32	Base Metals	33	Metal	Other Durable Manufacturing	5
33	Articles-Base Metal	34	Metal Products	Other Durable Manufacturing	5
34	Machinery	35	Machinery	Other Durable Manufacturing	5
38	Precision Instruments	38	Instruments	Other Durable Manufacturing	5
40	Miscellaneous Manufacturing Products	39	Miscellaneous Manufacturing Products	Other Durable Manufacturing	5
25	Logs	24	Lumber	Wood and Paper	6
26	Wood Products	24	Lumber	Wood and Paper	6
27	Newsprint/Paper	26	Paper	Wood and Paper	6
28	Paper Articles	26	Paper	Wood and Paper	6
29	Printed Products	27	Printed Goods	Wood and Paper	6
35	Electronics	36	Electrical Equipment	Electrical Equipment	7
36	Motorized Vehicles	37	Transportation Equipment	Transportation Equipment	8
37	Transport Equipment	37	Transportation Equipment	Transportation Equipment	8
30	Textiles/Leather	23	Apparel	Other Nondurable Manufacturing.	9
39	Furniture	25	Furniture	Other Nondurable Manufacturing.	9
41	Waste/Scrap	40	Waste	Waste	10
43	Mixed Freight	41	Miscellaneous Freight Shipments	Miscellaneous Freight Shipments	11
42	Unknown	0	N/A	N/A	

Figure 2.2 FAF2 Zones and ARC Region



As can be seen from the map, while some FAF2 zones are completely within the ARC region (e.g., Pittsburgh, Pennsylvania; West Virginia; Birmingham, Alabama; Greenville, South Carolina) most of the ARC counties are located in FAF2 zones that also include areas outside the ARC region. It was necessary to estimate the portion of the tonnages for these split zones that is originating or terminating in counties outside the ARC region in order to develop allocation ratios from the Marshall database. The 2002 FAF2 zonal totals, by ARC commodity, back to 1998, was scaled using information from the Marshall University databases for those zones wholly with the ARC regions to develop estimated 1998 tonnages for the portion of the FAF2 zone outside the ARC region. Allocation ratios were developed for ARC counties and the non-ARC portion were applied to the 2002 FAF2 data.

The ARC county to county tonnages were converted from annual tonnages by trucks to daily trucks. The annual to daily conversion was 306 working days (6 days per week for 52 weeks less 6 major holidays). The tonnage totals was converted to trucks using payload factors (tons per truck) developed from the Vehicle Inventory and Usage Survey database.

By allocating the FAF2 database of national truck flows, converted from annual tons to daily trucks, to counties in the ARC by using the Marshall database, trip tables of daily truck vehicle flows to, flow, within and through, the ARC region were created for each of the Commodity Groups listed in Table 2.2 was created. These tables of truck flows were integrated with the table of all truck flows described in the Section 2.1 Travel demand Model. The development of the travel demand model created trip tables of autos and trucks. The trucks included those that carry freight, according to the definition of the Freight Analysis Framework which is primarily long-distance shipments and those trucks that carry local movements of freight not included in the FAF database and trucks that travel for other purposes (for example service trucks, utility trucks, construction trucks). The freight truck trip tables were subtracted from the total truck table to create a table of non-freight trucks. The freight and non-freight trucks were used in to report the forecast volumes and performance measures used in the economic modeling.

**Table 2.2 Truck Payload Factors**  
*Tons per Truck*

ARC Commodity Code	ARC Name	Payload
1	Agriculture	16.75
2	Food and Tobacco	14.62
3	Mining	19.92
4	Petroleum and Chemicals	17.45
5	Other Durable Manufacturing	15.47
6	Wood and Paper	16.04
7	Electrical Equipment	13.61
8	Transportation Equipment	11.95
9	Other Nondurable Manufacturing	11.77
10	Waste	15.03
11	Miscellaneous Freight Shipments	15.03

## 2.4 ECONOMIC AND DEMOGRAPHIC FORECAST

A key input to the travel demand network model is the economic forecast for the relevant region. A forecast of future employment and population is needed to determine the number of automobile and truck trips through the ARC region and was essential in developing future year trip tables. The four concepts used within the travel demand model were: total population, number of households, total employment, and retail employment.

Since the ARC region is a fairly large area covering multiple states, it is important to consider the potential economic forecast options available for use in the travel model. In the past, ARC has used the REMI model to obtain vast historical and future year economic data. These efforts have typically grouped the ARC counties into south, central and north subregions comprising the entire 410 counties. In the tables presented below, recent regional REMI forecast data is presented along with other forecast options. However, it was cost-prohibitive to obtain a REMI model with every ARC county individually, so additional county-level forecasts were required.

Other readily available regional and county-level forecast options include:

**Woods and Poole** – This commercially available data covers all counties, MSAs, and states in the United States and can be combined with regional forecasts to produce county-level differentiation in growth rates. The forecast methodology is not as sophisticated as other options, and often produces aggressive projections.

**Economy.com** – This Pennsylvania-based company provides economic forecasts that are commonly used by states and counties. Its cost is more than Woods and Poole but typically less than REMI or Global Insight.

**Global Insight** – Typically considered the national leader in economic forecasting, though similar to REMI the costs make it an unlikely choice for every ARC region county individually.

For this study, we compared Global Insight and REMI regional data, and Woods & Poole county-level data for all of the ARC region. The tables provided below are for three options:

1. **Woods & Poole (W&P)** – Aggregating Woods and Poole county-level data to the three ARC regions;
2. **REMI** – Using the existing REMI regional forecast as control totals, and adjusting W&P county-level forecasts to match those regional totals; and
3. **Global Insight** – Using the obtained Global Insight regional forecast as control totals, and adjusting W&P county-level forecasts to match those regional totals.

**Forecast Ranges and Sensitivity Testing.** As mentioned in the study objectives above, an important analytical goal was to develop the ability to test the implications of different forecasts. For example, a careful critic of the analysis might suggest that the transportation and economic benefits are dependent on the forecast and that a lower or higher forecast of growth and fewer trips would result in lower benefits. For this study, the Global Insight regional forecast totals were deemed the most reasonable and generally fall between the more conservative REMI forecast and the more aggressive W&P forecast. Therefore, the Global Insight forecast was used as the primary forecast for this study. In addition and to provide contrast, the W&P forecast was used as a “high” forecast scenario.<sup>13</sup>

These economic and demographic data forecasts are used to construct current and future year automobile and non-commodity truck trip tables. These were created by calculating future trip ends from the socioeconomic forecast year data for each county TAZ in the model and applying quick response trip generation factors. These future trip ends were applied in an Iterative Proportional Fitting process (IPF) to create future year trip tables for both the medium (Global Insight) and high (Woods & Poole) forecasts.

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<sup>13</sup>The “low” forecast from REMI could have also been tested in the travel model but the research team decided that it was not necessary for two reasons. First, that forecast was out-of-date compared to the more current Global Insight and W&P forecasts. Second, the relationship between the Global Insight and W&P forecast results are proportionally similar in a downward direction if comparing REMI and Global Insight.

Table 2.3 Alternative Demographic and Economic Forecasts

Population			W&P	W&P	REMI	REMI	GlobIns	GlobIns
		POP02	POP20	POP35	POP20	POP35	POP20	POP35
Count	Central	2,165,769	2,410,785	2,669,888	2,323,094	2,433,729	2,309,899	2,427,303
	North	10,077,276	10,466,602	11,025,625	10,599,617	11,418,720	10,092,273	9,833,318
	South	10,971,926	13,391,408	15,770,329	13,428,789	14,893,420	13,239,487	14,750,803
	<b>Total</b>	23,214,971	26,268,795	29,465,841	26,351,500	28,745,869	25,641,659	27,011,423
Growth	Central		11.3%	10.7%	7.3%	4.8%	6.7%	5.1%
	North		3.9%	5.3%	5.2%	7.7%	0.1%	-2.6%
	South		22.1%	17.8%	22.4%	10.9%	20.7%	11.4%
	<b>Total</b>		13.2%	12.2%	13.5%	9.1%	10.5%	5.3%

Households			W&P	W&P	REMI	REMI	GlobIns	GlobIns
		HH02	HH20	HH35	HH20	HH35	HH20	HH35
Count	Central	865,705	999,905	1,083,904	928,591	972,814	970,466	1,030,465
	North	4,013,531	4,278,849	4,362,083	4,221,567	4,547,795	4,157,974	4,067,324
	South	4,299,382	5,374,975	6,130,505	5,261,419	5,834,652	5,391,069	6,023,310
	<b>Total</b>	9,178,618	10,653,729	11,576,492	10,411,576	11,355,262	10,519,509	11,121,098
Growth	Central		15.5%	8.4%	7.3%	4.8%	12.1%	6.2%
	North		6.6%	1.9%	5.2%	7.7%	3.6%	-2.2%
	South		25.0%	14.1%	22.4%	10.9%	25.4%	11.7%
	<b>Total</b>		16.1%	8.7%	13.4%	9.1%	14.6%	5.7%

Table 2.3 Alternative Demographic and Economic Forecasts (continued)

Total Employment			W&P	W&P	REMI	REMI	GlobIns	GlobIns
		TOTEMP02	TOTEMP20	TOTEMP35	TOTEMP20	TOTEMP35	TOTEMP20	TOTEMP35
Count	Central	966,345	1,170,517	1,387,724	1,032,674	1,056,712	1,074,091	1,236,565
	North	5,316,258	6,200,182	7,168,746	5,748,103	6,078,130	5,823,792	6,374,838
	South	5,975,375	7,534,110	9,118,174	6,701,051	7,065,052	7,051,703	8,213,877
	<b>Total</b>	12,257,978	14,904,809	17,674,644	13,481,827	14,199,895	13,949,585	15,825,280
Growth	Central		21.1%	18.6%	6.9%	2.3%	11.1%	15.1%
	North		16.6%	15.6%	8.1%	5.7%	9.5%	9.5%
	South		26.1%	21.0%	12.1%	5.4%	18.0%	16.5%
	<b>Total</b>		21.6%	18.6%	10.0%	5.3%	13.8%	13.4%

Retail Employment			W&P	W&P	REMI	REMI	GlobIns	GlobIns
		RETEMP02	RETEMP20	RETEMP35	RETEMP20	RETEMP35	RETEMP20	RETEMP35
Count	Central	165,581	196,529	228,022	168,166	148,596	174,003	188,022
	North	947,835	1,076,318	1,210,660	934,222	832,948	935,319	955,421
	South	1,025,637	1,264,088	1,492,874	1,088,815	1,000,942	1,094,403	1,170,236
	<b>Total</b>	2,139,053	2,536,935	2,931,556	2,191,203	1,982,486	2,203,724	2,313,679
Growth	Central		18.7%	16.0%	1.6%	-11.6%	5.1%	8.1%
	North		13.6%	12.5%	-1.4%	-10.8%	-1.3%	2.1%
	South		23.2%	18.1%	6.2%	-8.1%	6.7%	6.9%
	<b>Total</b>		18.6%	15.6%	2.4%	-9.5%	3.0%	5.0%

## 2.5 ECONOMIC DEVELOPMENT IMPACTS

Following the results of the travel demand model described in the previous section, economic impacts to the ARC region were estimated using the Transportation Economic Development Impact System (TREDIS). TREDIS is a computational framework for estimating economic impacts to a well-defined geography following a change in transportation facilities and operating conditions. The overall modeling framework is separated into four “modules” that interact to produce results. Figure 2.3 shows the relationship between four key economic modeling components:

The analysis of transport cost savings and associated travel efficiencies;

The analysis of market access improvements and associated economic growth;

The allocation of the above two benefits among various sectors in the economy; and

The application of an economic model to estimate total impact of the above factors on future economic growth.

Figure 2.3 Components of Economic Impact

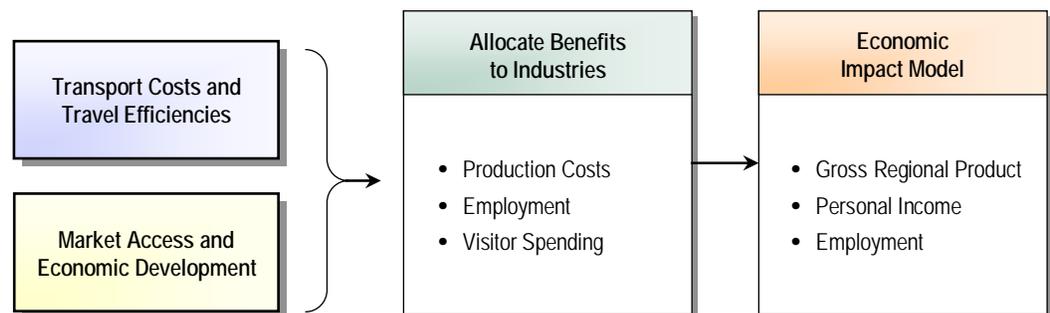
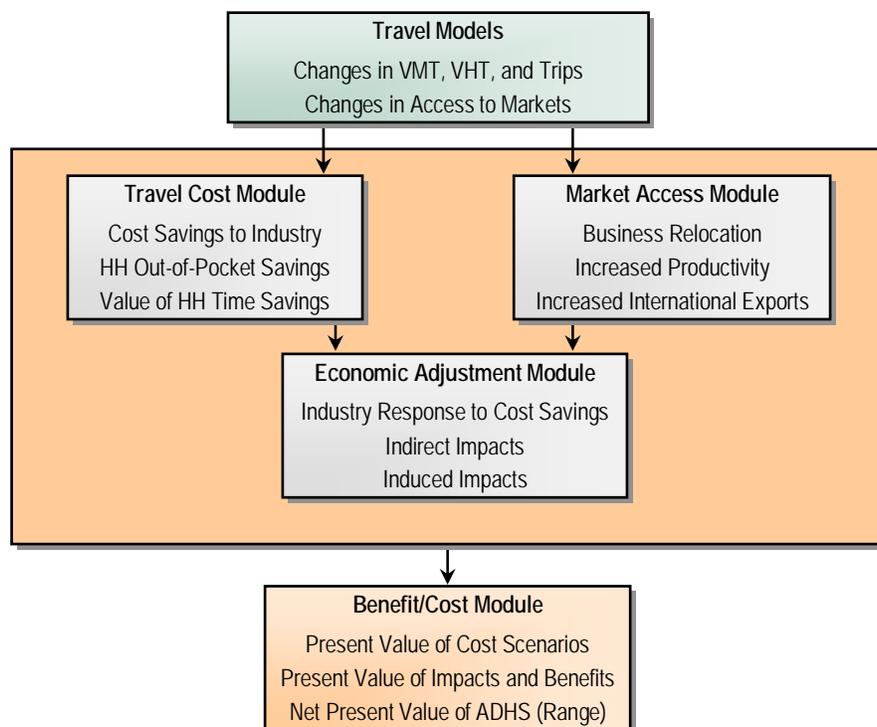


Figure 2.4 outlines the five steps in the economic impact analysis process:

1. A travel model and GIS system was applied to calculate changes in VMT (reflecting travel distance improvement) and VHT (reflecting speed improvement), as well as impacts on market access and connectivity improvements;
2. A travel-cost analysis was conducted to calculate the net value of the time and cost savings for businesses and households, based on forecasts of expected future trips;
3. A market access analysis was conducted to calculate how changes in access to population centers, delivery areas and access to intermodal terminals affect regional competitiveness and economic growth opportunities;

4. A regional economic model was applied to estimate the long-range economic impacts and adjustments expected to result from the regional business cost and regional access changes; and
5. A benefit/cost accounting process was applied to calculate benefits and impacts from alternative perspectives, and compare them to projected costs.

**Figure 2.4 Economic Development Impact Modeling Approach**



Results from Step 1 are covered in Section 4.0, the other steps are summarized in the rest of this section with results in Section 5.0. Appendix B offers a more detailed discussion of the economic analysis methodology with emphasis on market access.

### 2.5.1 Travel-Cost Response Module

The Travel-Cost Response Module translates travel demand characteristics for future scenarios into direct cost savings that accrue to households and businesses. The travel demand characteristics are derived from the travel model described above, and they include VMT, VHT, Trips, congestion levels, vehicle occupancy, and freight loads. These interact with values of time and operation costs of travel to determine direct dollar savings to households and firms. In addition, the module also estimates the benefits of improved travel-time reliability, as well as safety benefits. Industry benefits are further segmented among industrial sectors based on the region's commodity mix and each industry's utilization of different travel modes.

## **2.5.2 Market Access Response Module**

The second module estimates benefits to the ARC region from improved transportation accessibility and connectivity. These impacts are distinct from those estimated by the Travel Cost Module in that they do not stem from changes in VMT or VHT. Rather, they reflect a more dynamic economic environment in the ARC Region. Because firms have better access to labor, inputs, and consumers, and because consumers have better access to goods, the region as a whole becomes more attractive place for business location. These changes further enable firms to sell more products abroad increase productivity. Results are estimated at the county level based on changes in the following five variables (see Appendix B for a more thorough description):

- Access to population within 60 minutes;
- Access to employment with 180 minutes;
- Drive time to closest intermodal rail facility;
- Drive time to closest commercial airport;
- Drive time to closest marine port; and
- Drive time to closest international land gateway.

The analysis of market access impacts on economic growth are estimated using the Local Economic Assessment Package (LEAP), an ARC-supported tool that is widely used by economic developers to assess regional competitiveness factors affecting future business attraction and economic growth opportunities. It has the unique feature that it distinguishes how changes in local access interact with other local characteristics of business cost and infrastructure quality to affect economic growth opportunities. It functions within the broader TREDIS framework that has been previously discussed.

Graphs describing the nature of local access changes associated with ADHS completion are shown in the Appendix. For each of the 410 ARC counties, these variables were estimated for build and no-build scenarios. Changes were used to estimate three types of impact: increased productivity, increased international exports, and growth through the relocation of productive factors.

**Productivity.** Transportation improvements have been linked to increased productivity by enabling economies of scale. Improved access can increase the industrial and labor force density in an area, which may in turn facilitate better labor force matching, enable businesses to share and build knowledge, and improve the quality of goods that firms depend on in production. These mechanisms can thereby increase the productivity of firms, raising output, value added, and wages per worker. For this type of impact, the first two access variables (to population within 60 minutes and to employment within 180 minutes) were used to estimate the change in effective density in labor, consumer, producer, and supplier markets. Impacts are based on the magnitude of those changes, characteristics of the county, and characteristics of other relevant nearby counties.

**International Exports.** Improved access to international gateways may enable firms to increase production by growing international exports. Empirical research has established functional relationships between access to international gateways (as measured by driving time) and the total amount of shipments to overseas locations on a port-specific basis. Based on this research, changes in drive time to an airport, marine port, or international land gateway (to Canada or Mexico) are used to estimate potential increased sales (output) in each county. Industry-specific impacts are estimated based on the county industry mix and utilization of freight modes by each industry.

**Relocation of Productive Factors.** Finally, changes in accessibility alter the relative profitability of location for businesses. By increasing access to consumers, producers, and intermodal facilities, firms may realize increased revenue potential or cost savings. For example, increased accessibility may expand the consumer-shed of a company, allowing it to increase sales, or firm may use the accessibility improvement to improve freight logistics (a process that is dependent upon, but distinct from direct travel savings). These changes in the economic landscape may induce firms to relocate to the more productive region. In practice, this relocation may be the result of physical firm migration, or firm expansion in one location at the expense of another (possibly coupled with sectoral decline). This type of impact is estimated by simulating the costs and sales for firms in different industries at various locations within and outside of the ARC region.

**Accounting for Interregional Effects.** The market access impacts described above reflect changes in international exports, increased business productivity, and the migration of industrial activity. However, because impacts are estimated at the county level, when aggregating the results to the broader study region (ARC), they must be integrated in such a way as to account for economic “reshuffling” to avoid double-counting impacts. Of the three types of impacts listed above, the first two are assumed to aggregate without double-counting. For the third impact type, net ARC impacts are estimated by subtracting interregional migration (inside the ARC region) from gross impacts. Any remaining (net) impacts, therefore, reflect migration of productive factors from outside the ARC region to within it. This is done following the same methodology described in the previous section, where inter-county migration is estimated for each pair of ARC counties (on an industry by industry basis). The final result is *net* market access impacts to the ARC region that do not double-count across counties (see Appendix for further description of methodology).

### 2.5.3 Economic Adjustment Module

The third module compiles the direct travel benefits and market access impacts described above, and then uses those results to estimate indirect and induced effects. Indirect effects reflect economic activity generated through regional business-to-business linkages through the supply chain. As an example, if the automobile manufacturing sector is forecast to grow in the ARC region, then businesses that supply materials and products to that sector also will benefit (as

well as their suppliers, etc.). To the extent that these “upstream” suppliers are located within the ARC region, it will gain additional benefit.

Induced impacts stem from increases in local consumer spending following a gain in personal income in the region. To follow the previous example, the automobile manufacturing sector also may increase total wage outlay. To the extent that the increase in wages is spent locally on goods and services, ARC gains an additional benefit. These “secondary” economic impacts were estimated by the Cost-Response Input-Output (CRIO) model, which uses recent research findings by Economic Development Research Group that show how various industries absorb costs, invest in their own growth, and/or pass on the costs to other industries. Then multipliers from a multiregional version of the IMPLAN® model are applied to calculate the indirect and induced impacts to the region.

## **2.6 BENEFIT/COST ANALYSIS**

### **2.6.1 General Methodology for Comparing Costs and Benefits**

As a final step, the Benefit/Cost accounting module was used to summarize the time streams of future impacts, benefits, and costs of transportation investment in the ARC region. This module gathers information from the first three modules and organizes them in terms of various economic impact and economic benefit measures. It then combines them with cost measures to develop net present values and benefit/cost ratios.

First, all impacts and benefits were estimated for the years 2020 and 2035 (the forecast years for travel modeling) and itemized by type: A) industry savings; B) out-of-pocket household savings; C) household time savings; D) market access impacts; and E) secondary economic (indirect and induced) growth. All benefit types were calculated separately for the ARC Region and for the Total U.S. For the first three (A through C) which comprise direct travel efficiency savings, the portion of benefits accruing to the ARC region was determined based on the number of local versus nonlocal trip ends. The last two (D and E) reflect additional sources of regional economic growth, and for those impacts it was assumed that all benefits to the ARC region related to the attraction of business activity will cancel out at the national level, leaving only productivity gains and increases in international exports.

Second, each type of impact or benefit was given a time path between forecast years and extending out to the year 2045 to facilitate analysis of the present value of future benefit and cost streams. These extended values were estimated on the basis of: 1) estimated growth rate in the underlying traffic volumes; 2) the planned program completion schedule; 3) empirical research on the timing of market access impacts (see below); and 4) research on the timing of indirect and induced impacts. The application of these phase-in schedules yields dollar levels for each impact type for all years in the analysis horizon.

In the third step, costs were estimated for each year between 2007 and 2045 based on two inflation scenarios. In the “low” inflation scenario, nominal price increases in the construction sector are assumed to parallel those of prices in general at 3 percent per year. In the second case, prices in the construction sector were assumed to increase faster than general inflation. This scenario assumes price increases of 10 percent per year between 2007 and 2010, and 4.5 percent thereafter. These rates follow from recent price trends in the construction sector.

In the fourth step, all values were converted to constant 2007 dollars, and a discount rate was applied to determine the present value of the benefit or cost stream. The discounting was performed for each of type of impact or benefit (A through E), for the high- and medium-growth scenarios, and for two cost inflation scenarios. In addition, calculations were made with two alternative real discount rates – 5 percent and 7 percent. The result of this step is a matrix of present values of impacts, benefits, and costs for all the scenarios.

Finally, impacts, benefits, and costs were compared to determine net present values (present value of benefits minus costs) and benefit/cost ratios. The analysis specifically calculated four types of comparisons:

- Comparison of *regional travel efficiency benefits* to project costs – counting only benefits accruing to beneficiaries in the ARC region;

- Comparison of *national travel efficiency benefits* to project costs – counting all travel benefits, including those accruing to beneficiaries outside of the ARC region;

- Comparison of *total regional economic benefits* to project costs – counting net increases in economic growth projected for the ARC region regardless of whether they are due to economic productivity benefits or business relocation effects (in addition to personal non-business travel efficiency gains); and

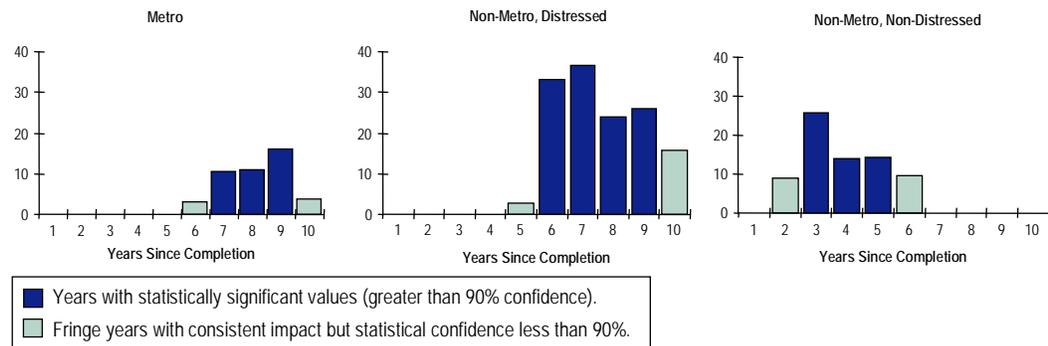
- Comparison of *total national economic benefits* to project costs – counting only economic productivity benefits of improved market access and connectivity as an additional benefit to travel efficiency gains.

The first two comparisons represent benefit/cost analyses using traditional transportation efficiency concepts. The third comparison represents a mixed form of economic impact and benefit/cost analysis, but can here be considered an indicator of regional economic return on investment insofar as a primary goal of the ADHS is to promote economic development in Appalachia. The fourth comparison effectively represents a more comprehensive economic benefit/cost analysis in which industry productivity benefits are added to the transportation efficiency benefits.

## 2.6.2 Estimation of Market Access Time Lag Effects on Economic Growth

To better support the analysis of economic growth impacts, a special analysis was done for this study to investigate the amount of time and size of impact that highway projects had in Appalachia from 1970 to 2000 (see Appendix B for further detail). This involved estimating the differences in effects based on ARC counties' level of distress and metropolitan status thus applying empirical findings of already completed ADHS corridors to help estimate future economic effects. The results, shown in Figure 2.5, show the number of years that a highway project took to affect a county's economic growth as well as the amount of impact that the project had on growth. The counties were assembled into three groups: *metro*; *non-metro – non-distressed*; and *non-metro – distressed*.

Figure 2.5 Years of Significant Impact Along with Fringe Years Before and After Impact



As seen in the charts, economic growth in non-metro and non-distressed counties was affected the earliest of the three groups, with primary impacts occurring in the first five years. Interestingly, metro counties (which showed no significant differences based on ARC's economic distress categories) took approximately the same time to react as non-metro distressed counties. Distressed counties took longer for economic growth impacts to be evident, with most impacts occurring in years 6 through 10. However, they ultimately showed a much larger impact when those impacts finally occurred.

The time lag results shown above were used to generate estimates of the economic growth impacts of improved market access over time. More specifically, market access impacts were phased in based on the anticipated project completion schedule and the timing of impacts based on the three categories of development.