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CHAPTER 5: ACCESSIBILITY

This chapter was written by The Texas Transportation Institute.

5.1 Technical Guide

5.1.1 Introduction and Purpose

The specific objective for this research is to develop sketch plan approximations to the economic value for market access. To aid that objective, this section provides the technical report documenting the methodology and framework for first determining market access and second determining an order of magnitude approximation of the value of that access. Market access is an important intermediate determinant of regional macroeconomic change. Infrastructure investments can affect the pattern of interregional linkages, location, or expansion of economic activity, and the kinds of activity that develop, in part, because of the implications for cost savings and productivity implications. The argument relies on the logic that one first needs to have access to a market before one can benefit from it. Transportation networks play a crucial role in providing systems and agents linkages in economic space via access to markets and sectors that comprise those markets. The economic value of market access can be drawn from theories of agglomeration, new economic geography, and site selection decisions of businesses. Of these, theories of agglomeration and new economic geography offer the most potential for the development of linkages between access to markets and value attributable to that access.

Access to Buyer-Supplier Markets-Objectives

The objectives of buyer-supplier type market access measures are to provide simple tools to serve as an aid in transportation planning by allowing transportation planners and other users to:

1) Estimate region-based access to markets at any point in time or from a transportation improvement for a set of regions (zones). These are proxies for production, consumption, and distribution related economic triggers (scale, scope, input matching, sharing, etc.) that may be induced by transportation improvements.

2) Measure transport-induced access changes to specialized inputs (labor, in this case), which is useful when there is a specialized industry sector located in the impact region/study area.

3) Facilitate market access comparisons for the same zone and impact area at separate temporal scenarios and/or build scenarios.

4) Facilitate market access (as performance metrics) comparisons at a given point in time across zones.

5) Facilitate market access (as performance metrics) aggregate comparisons for impact area versus another benchmark or control area, data permitting.
6) Provide an order-of-magnitude assessment of the potential economic implications of changes in transportation-induced access, in terms of productivity gains or losses in dollar terms for a study area.

7) Provide value in corridor planning, project planning and visioning exercises when promoting economic opportunity by emphasizing the “where” of the investment.

**Framework for Measuring Market Access and Value**

A broad framework for approximating the effect of market access to determine potential economic value must necessarily draw on theories of agglomeration. The framework is based on following components:

- Identification of the relevant markets and the associated economic triggers for market access to have economic value and the user groups they are applicable to. This is encapsulated in Figure 5-1, Tables 5-1 and 5-2.
- Sensitivity to transportation costs and transportation scenarios.
- Spatial scale for consideration, aggregation, and comparability.
- Spatial unit within the context of spreadsheet driven tools.
- Types of measures and economic Implications of access changes.
- Simplicity in communicating.

**Relevant Types of Markets and Economic Triggers**

Figure 5-1 and Table 5-1 provide a useful starting point for the identification of economically relevant markets from supply and demand perspectives originally laid out by Quigley (1998). Table 5-1 has been adapted from Quigley’s work and includes features (or economic triggers) that were identified by Quigley that allow us to identify the pertinent markets. It also includes dispersion economies identified by Polenske (2003) as an additional trigger. Since firms use factors in the production process (backward linkages) to provide goods and services sold in the final consumption side markets (forward linkage), transportation networks become the mechanisms for enabling linkages between those markets. Table 5-1 attempts to provide a framework for capturing the economic value associated with market access by considering a) the economic triggers and b) the relevant markets from three perspectives of production, consumption and distribution. These are further refined in Table 5-2.

**User Groups**

The three perspectives mentioned above are known to impact all highway users (passengers and freight) since market access associated with transportation cannot occur in a vacuum. The transportation network is characterized by users—passengers (including commuters who provide labor supply) and freight (truckers in the case of highway networks). Hence, the three market types shown in Figure 5-1 and two user groups (passengers and freight) must be effectively connected in meaningful ways so that economic value may be inferred from those
measures. Table 5-2 formalizes these concepts into specific markets and how they may be measured as well as the specific user groups to which they apply.

**Figure 5-1. Highways, Market Access, and Agglomeration Drivers**

Table 5-1. Transportation, Agglomerative Implications from Production, Consumption, Distribution Perspectives

<table>
<thead>
<tr>
<th>Economic Trigger</th>
<th>Urbanization/ Localization</th>
<th>Production Perspective-A</th>
<th>Consumption Perspective-B</th>
<th>Distribution Perspective-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale economies and scope</td>
<td>No/ Indivisibilities leading to higher outputs and benefits.</td>
<td>Occurs within firms with larger plant sizes (industries associated with production-manufacturing) Lower unit costs.</td>
<td>Public goods. Diversity in consumer goods. Lower unit costs with access to larger centers (e.g., retail).</td>
<td>Reduction in transportation costs for large centers (distribution, terminals) (e.g., Walmart distribution center) and for cargo load bundling.</td>
</tr>
<tr>
<td>Shared inputs</td>
<td>Yes/Yes</td>
<td>Shared inputs in production.</td>
<td>Shared inputs in consumption of differentiated goods (amenity markets for example).</td>
<td>Lower unit distribution costs.</td>
</tr>
<tr>
<td>Transaction costs (transportation costs) and pooling labor</td>
<td>Yes/Yes</td>
<td>Lower unit costs by enhances access to suppliers-buyers.</td>
<td>Lower unit prices via access customer markets and shopping districts.</td>
<td>Lower unit distribution costs.</td>
</tr>
<tr>
<td>Law of large numbers-statistical economies</td>
<td>Yes/Yes</td>
<td>Access to large number of suppliers/supply pooling.</td>
<td>Access to more markets for services goods/diversification risk associated with single buyer.</td>
<td>Lower unit distribution costs.</td>
</tr>
</tbody>
</table>

Table 5-2. Transportation/Highways, Specific Markets, and Two Types of Measures to Capture Economic Value of Market Access

<table>
<thead>
<tr>
<th>Linkage Perspectives</th>
<th>Origin Market (Supplier)</th>
<th>Destination Market (Demand)</th>
<th>User Group</th>
<th>Measurable Direct Economic Value in terms of Costs</th>
<th>Measure Type- Isochronal/Local or Relative Access/Gravity-Regional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>Intermediate goods —</td>
<td>Places of Work /</td>
<td>Commuters</td>
<td>Economic costs associated with commuting</td>
<td>Access to key employment centers / work sites within reasonable commute times</td>
</tr>
<tr>
<td></td>
<td>Input Markets- Labor-</td>
<td>Employment Locations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Home locations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>Intermediate goods —</td>
<td>Production Locations</td>
<td>Trucks,</td>
<td>Economic costs associated with shipments</td>
<td>Access to key supplier sites within reasonable travel times</td>
</tr>
<tr>
<td></td>
<td>Input Markets- Raw</td>
<td></td>
<td>Freight</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Materials and Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production-</td>
<td>Final Goods — Production Sites</td>
<td>Locations of Final Demand-Product markets</td>
<td>Trucks, Freight</td>
<td>Economic costs associated with shipments delivery and potential price effects</td>
<td>Access to key customer markets within reasonable travel times</td>
</tr>
<tr>
<td>Consumption</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production-</td>
<td>Final Goods — Production Sites</td>
<td>Distribution Sites/Centers or Transfer points</td>
<td>Trucks, Freight</td>
<td>Economic costs associated with shipments delivery and potential price effects</td>
<td>Access to key customer markets within reasonable travel times</td>
</tr>
<tr>
<td>Distribution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>Final Goods — Distribution Sites/Warehouse Sites</td>
<td>Locations of Final Demand-Product markets</td>
<td>Trucks, Freight</td>
<td>Economic costs associated with shipments delivery</td>
<td>Access to key customer markets within reasonable travel times</td>
</tr>
<tr>
<td>Distribution-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>Final Goods — Distribution Sites/Warehouse Sites</td>
<td>Transfer Sites like ports, airports for reach to other domestic or international markets</td>
<td>Trucks, Freight</td>
<td>Economic costs associated with shipments delivery/ Demand and price effects</td>
<td>Access to key transfer points within reasonable travel times</td>
</tr>
<tr>
<td>Production-</td>
<td>Suppliers of the broadest variety</td>
<td>Buyers of the broadest variety</td>
<td>All</td>
<td>Productivity gains from input matching, sharing, learning</td>
<td>Zone-to-zone access between production-consumption-distribution markets (it captures both multitude, attractiveness and transportation costs). This can be put into a generalized form where it can aggregate interaction between one or more buyer/supplier centers to all other buyer/supplier centers in the study area. Gravity measure with regional access.</td>
</tr>
<tr>
<td>Consumption-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

Note: Cost savings turn into actual economic value pending other factors like ability to substitute, pass on savings and demand elasticity. There are also other dimensions of economic value that may be difficult to measure in predictive settings such as actual employment effects and business attraction effects. In most cases, direct value may end up partly as cost savings that are either entirely disposable income or passed on for additional value. Of course, measurement of costs also requires good data on users themselves.
Comparison with Markets Defined in Earlier Works

Some earlier efforts have identified that, in general, there are four types of markets that can be served or expanded due to a new highway link: labor markets, sales markets, business-to-business markets, and pass-by traffic. They also note that new projects may take many forms—creating an entirely new connection between areas, improving an existing connection, bypassing certain areas, and/or improving access to certain areas. These changes, they note, can lead to any of six major economic market effects by enhancing: a) the reach of residential customer markets (approximated by change in population within 45 minutes of a local business district), b) the reach of supplier markets (approximated by change in supply purchases occurring within a three-hour one way drive time), c) the reach of labor markets (approximated by change in employment living within a 45-minute one-way commute time), d) the reach of recreation and tourism markets (approximated by change in population living within a two-hour one-way drive time), e) service to pass-by traffic (traffic dependent) markets (approximated by a change in annual average daily traffic) and f) connections to other modes (Weisbrod et al. 2001a). This same study also develops a spreadsheet such as worksheets to approximate market areas by change in employment in fixed impact zones relative to a key destination site. These are then used to approximate employment growth or business attraction using a variety of sensitivities (labor, pass-by, etc.). Similar measures are also seen in other studies (Weisbrod et al. 2001b and Weisbrod et al. 2003). The markets discussed in this report include most of those shown in Figure 5-1 and also bring in distribution-related markets from an agglomeration perspective (Table 5-2, Figure 5-1).

Sensitivity to Transportation Costs and Scenarios

For economic evaluation of transportation projects/policies, market access measures must be sensitive to transportation costs. Transportation projects serve to impact access directly through their influence on costs. It is typical to represent the ease of travel between an origin market and destination market in at least three distinct ways for evaluation including: a) travel time in minutes or hours (this is also the measure always used in traditional benefit-cost analysis); b) distance between markets as a proxy to transportation costs (in miles or kilometers); and c) generalized travel costs (in dollars) that could include any or all of the following: time costs, operating costs, and other incidental costs such as tolls (if applicable for travel within the target markets). These data are typically obtained from travel demand models and in other cases based on the specific measures that may also be developed with commonly available GIS tools. In the absence of travel demand model data, sketch plan mechanisms or default skims can be used. One such default skim is the distance skims provided by Oak Ridge National Laboratory (ORNL) (Table 5-3). Similarly, network layers and zonal layers can be used to approximate distances and speed changes, both of which may be combined to provide an alternate sketch plan travel time approximation.
There are other factors besides types of costs that must be considered if transportation costs are to be of value in an evaluative context. These are shown in Table 5-3 and include:

- **Types of transportation projects or policies** that add or influence capacity provision can vary significantly in terms of transportation costs. Table 5-3 shows the transportation cost elements of highway project types and their linkage to market access measures. Similar concepts may also be developed for transit projects and other projects, but they are not the focus in this discussion. Enhanced connectivity to key regions, removal of access bottlenecks, and congestion alleviation have been associated with economic development or productivity implications in the past. As highways run both ways, enhanced connectivity not only provides market access to firms in lagging areas but also allows firms in leading areas to reach markets. A decline in transportation costs could help competitive firms in leading areas easily scale up production to reach these new markets at lower cost relative to local producers in other areas.

- **Transportation Scenarios- Project/Policy Baseline (no-build) and Alternative (build) scenarios**: The impacts on market access may be examined by exploring transportation cost outcomes under build/no-build scenarios. These may be temporally separated at different time periods (base year and a future reference year) or for the same time period. Additionally, the scope of the project of the project/policy (e.g., within a metropolitan region, connecting multiple regions within a state, within a single county, etc.) would impact how the data are assimilated for assessing transportation costs.

- **Urban-rural configuration**: For instance, connectivity projects that link rural-urban areas (or periphery-center areas) are best assessed using a variety of costs to reflect the shrinking of distance and its relation to change in access to economic markets.

- **Congestion**: Congestion relief projects influence travel times for commuters and freight. In such cases, time-of day factors (peak, off-peak) also influences transportation costs and market access (Weisbrod et al. 2001, for instance, discuss how congestion affects access for the National Cooperative Highway Research Program).
Table 5-3. Project Types, Planning Contexts, and Relevant Transportation Costs, and GIS Based Data Sources for Transportation Costs to be Used for Market Access Measures

<table>
<thead>
<tr>
<th>Capacity Project Type (Line/Point)</th>
<th>Appropriate Transportation Costs</th>
<th>Data Source(s)</th>
<th>Comments</th>
<th>Default Public Data Sources, if any</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add New lanes/links including gateway projects providing landside access to hubs/ports</td>
<td>Distance, time and/or generalized costs (GC)</td>
<td>Statewide, Metropolitan Planning Organization (MPO) travel demand model skims or custom skims Network layers</td>
<td>GC require manual estimation, if not available directly</td>
<td>ORNL highway skims for distances. Custom developed network distances from public domain network data such as National Highway Planning Network (NHPN) or Freight Analysis Framework (FAF) instead of straight line-distances or Statewide and MPO networks (as the scope may be)</td>
</tr>
<tr>
<td>Add New lanes/links (Tolls)</td>
<td>Distance, time and/or generalized costs with tolls</td>
<td>Same as above</td>
<td>GC require manual estimation, if not available directly</td>
<td>Same as above</td>
</tr>
<tr>
<td>Widening only</td>
<td>Travel time and/or generalized costs</td>
<td>Same as above</td>
<td>GC require manual estimation, if not available directly</td>
<td>—</td>
</tr>
<tr>
<td>Widening and Tolls (e.g., General purpose lanes and HOT lanes).</td>
<td>Travel time and/or generalized costs</td>
<td>Same as above</td>
<td>GC require manual estimation, if not available directly</td>
<td>—</td>
</tr>
<tr>
<td>Bypass</td>
<td>Travel time and/or generalized costs</td>
<td>Same as above</td>
<td>GC require manual estimation, if not available directly</td>
<td>—</td>
</tr>
<tr>
<td>Interchange/Point</td>
<td>Travel time</td>
<td>Same as above</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Policy and Planning Context

<table>
<thead>
<tr>
<th>Policy and Planning Context</th>
<th>Appropriate Transportation Costs</th>
<th>Data Source(s)</th>
<th>Comments</th>
<th>Default Public Data Sources, if any</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corridor Studies for collaborative decision making</td>
<td>Distance, time and/or generalized costs with tolls</td>
<td>Same as above</td>
<td>GC require manual estimation, if not available directly</td>
<td>Same as earlier</td>
</tr>
<tr>
<td>Policies that impact transportation costs (e.g., pricing)</td>
<td>Distance, time and/or generalized costs with tolls</td>
<td>Same as above</td>
<td>GC require manual estimation, if not available directly</td>
<td>Same as earlier</td>
</tr>
</tbody>
</table>
Spatial Scope/Scale of Analysis, Aggregation, & Comparability of Measures

In order to measure market access, it is necessary to consider the following factors: a) impact areas and b) spatial scales for influence.

a) Impact areas or study areas are typically defined and developed by the nature and scope of the project itself for measuring travel costs/activity and to measure market opportunities. Impact areas developed based on travel sheds of system users will allow a direct linking between important supply and demand markets/locations within that region. Line and point investments may be evaluated using fixed impact areas defined by travel sheds or typical boundaries considered in corridor studies. Bypasses could require a large impact area compared to other line investments to account for spatial redistributinal effects. Large scale projects with network effects and regional policies are best evaluated for all zones that are included in travel demand skims.

b) Comparisons over space and time – Market access measures must be comparable within and across regions at any given time, if they have to be used in an evaluative context. For instance, gravity based measures may be obtained for individual regions but may be aggregated for all spatial units in a study area and compared to control area. Region scores may be also benchmarked to a maximum score in the study area and discussed in relative terms. Finally, they should also be temporally comparable if they have to be used in an evaluation context—a technicality being that temporal comparisons of measures would have to be able to tease out net contributions of transportation induced access from gross contributions of access and activity changes (labor, population) to see the value-added access.

Spatial Unit for Determination of Measures – Context within Spreadsheet Delivery Format.

The spatial unit for determination is set at the zonal level for which skims are developed (county, tract, or TAZ). This is the most suited unit within the context of tools developed in a spreadsheet format. All of the isochronal measures indicated in Table 5-2 present a difficulty in terms of delivery as in spreadsheet format since the “impact zones” themselves are not independent of the use of GIS. In other words, GIS-network analysis functions aid in identifying these impact zones, also known as market areas. There are several commercial GIS tools that have this part of the functionality.

The reliance on the “zone”, as a unit, arises within the context of spreadsheets and avoids the practical difficulties of having to identify the universe of potential markets and locations (which in reality could be millions of locations). A second advantage of keeping the unit of analysis as the zone for both gravity and isochronal measures is that it ensures that the spreadsheets do not become overly complicated.
Types of Measures and Economic Implications of Access Changes

Table 5-2 column 6 proposes two types of measures of market access to address all three market types and also discusses how the value of those markets may be approximated. The two measures are:

- **Access to Buyer-Supplier Markets (Customer Base)** is a broad-based regional measure that aims to approximate productivity gains from all economic triggers and sources discussed in Table 5-1 Column 1. Transportation projects affect transaction costs and alter the potential for businesses, regions, and individuals to reap the gains or losses from other economic triggers that may be activated. For instance, transportation costs shrink the economic space, reduce the difficulties associated with transacting in that space and may lead to productivity gains. This measure assumes that connectivity to market centers is important and suggests that improving linkages between firms and those centers within the region may lead to productivity gains. While the actual magnitude of effect is still debatable, there is ample evidence to suggest access to economic mass is associated with positive productivity gains.

- **Access to Markets at Demand Sites as a local measure** – This measure suggests that there should be as many separate measures as there would be user groups “suppliers” and “demanders” or “destinations.” Table 5-2 identifies six categories of this type, all of which may coexist at the same time in any given situation based on the specific regional context of an improvement. The report focuses on the tool development of one specific input market in the production process—labor at demand sites—employers or work sites. In this case, a transportation improvement is considered as leading to transportation cost reductions, which in turn implies cost savings in travel time to commuters (labor inputs). These commuter cost savings may lead to higher labor productivity associated with the work sites as long as commuters are able to pass on some cost savings to employers. If not, cost savings end up as changes in personal disposable income.

In the works of Weisbrod et al. (2001b), all the markets are measured as isochronal or contour measures, with reference points such as business districts, to anchor the measurement of highway induced access change from every zone in the drive time area to the anchor district/zone. These market accessibility changes are combined with business sensitivity factors (worker dependency, freight sensitivity, pass-by dependency, etc.) to approximate the extent of potential business cost reduction or revenue expansion for each type of business.

Simplicity and Value in Communication

The framework is driven by a bottom-up approach that is consistent with the access for actors (users and freight) on one hand, and what is easy to understand and communicate. Gravity measures are useful because they are consistent with economic theory. Such measures are increasingly seeing their way into evaluation contexts internationally and are part of many regional models. Cumulative opportunity measures of daily access appeal directly to both the user group and end users. Visual maps of both types of market access measures can serve as
valuable communication tools for scenario analysis, policy assessments, and corridor studies to share with economic development agencies and other interested stakeholders. These visual maps can only be developed with GIS tools either in the private domain (such as ESRI and others) and/or open-source tools. However, the economic value can, at present, only be approximated using the tools developed in these report.

Both the toolkits discussed in this section are developed as spreadsheet tools. As noted earlier, this formulation required that we first develop the tools using zones as the appropriate reference point for assessing markets from a practical standpoint. The second guiding criterion for the tools is built-in flexibility to accommodate zones of any type including user-defined zones so that the sheets could be used for any setting in any location. The third criterion is the development of tools around a framework that could lend itself to being expanded to accommodate more markets, or users as the case may be. The fourth and final criterion is simplicity in use and built-in charting capabilities.

### 5.1.2 Specification of Inputs

**Access to Buyer-Supplier Markets Inputs**

Gravity and isochronal measures require zonal activity data as land use inputs to reflect appropriate markets at the zone level. These may include total population, total employment, or sectoral employment. (The activity unit could also be a ratio of the desired employment group to total employment in any zone.) Activity data are needed for the base year and year(s) for which the analysis is intended to be carried out for all of the zones in the impact area. Table 5-4 provides a list of population/employment/labor force related public data sources and also distinguishes whether the activity units are classified by place of work and place of residence. This analysis recommends that if the links to economic value are to be made, then it is more appropriate to use place of work to the extent possible.

Several private forecast data sources may also be used that provide pertinent data including but not limited to: Woods and Poole and Global Insight. Many Census related databases are now moving to providing high-quality base year data online accompanied by customized mapping (such as the On-the-Map application) to make better quality free data available to make this process easier.
Table 5-4. Public Data Sources for Gravity and Daily Measures of Market Access

<table>
<thead>
<tr>
<th>Market Access Measure</th>
<th>Data</th>
<th>Public Data Activity Sources Base Year</th>
<th>Base/Future-Forecast Years</th>
<th>Place of Residence/Place of Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential Access</td>
<td>Employment / Population</td>
<td>1. Census Tape Files, Metropolitan planning organizations (MPO) demographic layers and other</td>
<td>Base year of analysis and forecasts</td>
<td>Place of Residence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. County Business Patterns and Bureau of Economic Analysis through FedStats</td>
<td>Forecasts from MPO or private sources for years for which scenarios are developed</td>
<td>(Proxies Potential Work Force)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. American FactFinder – Population, Employment</td>
<td></td>
<td>Place of Work (actual workforce)</td>
</tr>
<tr>
<td>Effective density</td>
<td>Employment typically (but population may be used also)</td>
<td>Employment by place of work - Longitudinal Household Employment Dynamics (LEHD)</td>
<td>Base year of analysis and forecasts</td>
<td>Place of Work (actual workforce)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>On-The-Map Data (LEHD) (allows oneline GIS visualization of data)</td>
<td>Forecasts from MPO or private sources for years for which scenarios are developed</td>
<td>Varies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ESRI’s core data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily Access-Labor Market</td>
<td>Employment</td>
<td>LEHD - By place of residence and place of work by sector and worker quality</td>
<td>Base year data and forecast year data</td>
<td>Place of Work</td>
</tr>
<tr>
<td>Daily Access-Labor Market</td>
<td>Commute Thresholds</td>
<td>Census Transportation Planning Package/American Community Survey</td>
<td>—</td>
<td>Not applicable. In house surveys or private sources</td>
</tr>
</tbody>
</table>

The choice of activity inputs, the corresponding decay parameters, and the elasticities requires an understanding of the industry mix in the study area. The more diverse a region, the better positioned it is to use total population and/or total employment in your study. If, however, there is evidence of industry specialization in one or more sectors, it is better to use sectoral employment to approximate market access for those sectors.

**Impedance Inputs.** Skim matrices (impedance matrices) are required for a baseline scenario and an alternate scenario. The skims can be typical travel time skims, distance-based, or based on generalized costs of transportation. The last option is used when monetary costs come into play. When travel times are used for the analysis, they should be obtained from assignment models as they consider the demand between all locations into equilibriums travel times.
While it may be very difficult to obtain separate times/costs for passengers or truckers, it may be possible to recognize that freight costs are different than passenger costs and could include additional components (i.e., user type/trips differentiation is possible). The default mechanism is still to start off with the premise that costs are identical for all user classes—this is what all travel demand models provide and in such cases, the analysis is really applicable to all trips.

**Access to Specialized Labor/Worker Inputs/Employers Inputs**

Specialized labor markets refer to labor pools of skilled labor that provide labor related inputs in the business or production process. These employee/worker markets could envelope several individual categories including but not limited to:

a) Industry specific employment (or labor force in a specific industry sector)

b) Labor force of a specific occupational category

c) Labor force of a specific skill level, age group, or other category

When labor is a critical input in the firm’s production process, access changes to work sites (employment locations) may lead to changes in the commuting costs and labor productivity under certain assumptions. Commuters who travel to work provide the supply markets to those who demand it, the firms or work sites. Henceforth, these work sites will be denoted as employment centers in this report. Transportation projects that improve travel times or shrink distances for commuters can enhance the reach of employment centers to additional specialized labor pools or even the other way around, reach of markets to workforce. At least two studies have used cumulative opportunity measures with critical threshold travel commute times in connection with labor productivity implications (Prud’homme and Lee 1999, Matsuo 2008).

An isochronal daily accessibility measure of labor markets, as an input in the production process, is proposed in Table 5-2. This set of measures reflects the behavior of users (employees/commuters) in terms of how far commuters/users are willing to travel to work sites. It is simple enough to serve as a basis for both communication as well as visualization. However, improvements to employment locations and work sites could enhance productivity by linking markets to the suppliers (commuters) and be associated with other spin-off effects. This does require assumptions on how much is internalized by commuters and how much is passed on to firms and is supported by some empirical evidence on commuting wage differentials.

This measure, being a cumulative opportunity measure, simply indexes the accessibility of labor force according to the number that can be reached from the work site within meaningful travel distances or times. The measure is not without caveats, especially the treatment of all zones identically within the contour. However, it is presented on the basis of its conceptual simplicity. It is defined by a very sharp decay (as a special case of a gravity measure and using a general decay function $f()$) it can be measured as shown in Equation 5-1.
Equation 5-1.

\[ f(d_{ij}) = 1 \text{ if } d_{ij} \leq \text{threshold (e.g., 30 minutes)}, \quad \text{or} \quad f(d_{ij}) = 0 \text{ if } d_{ij} > \text{threshold (e.g., 30 minutes)} \]

5.1.3 Output and Calculations

Access to Regional Markets (Output & Calculations)

The outcomes for both gravity based market access measures presented in this report can be represented using scores as metrics for individual zones (market proxies). These scores can be aggregated across zones in a study area and can be developed for any transportation scenario. They can be compared to each other and also time periods.

Gravity Measures for Assessing Regional Access to Markets. This section discusses the various elements of the “Access to Customer and Labor Markets” measure. The tool approximates region-based access from transportation improvements as guidance for transportation planning. Regions may be defined by using Census geographies (Counties, Census Tracts, and Block Groups, Blocks, or other geographies such as Transportation Analysis Zones [TAZ]) and even user-defined geographies. A powerful way of measuring the regional market access of geographies is a gravity-based measure that combines both the network and the producer, consumer and distributor markets as encapsulated by the surrounding land use. This form of linking is very much in the tradition of new economic geography models, where market potential functions made their appearance as a way to describe changes in economic geography. Gravity measures assume that the potential for economic activity at any location is a function both of its proximity to other economic centers and of their economic size or “mass.” The analogy with the law of gravity is explicit in that the influence of each center on the “economic potential” of a location is assumed to be directly proportional to the volume of economic activity at the former, and inversely proportional to the travel cost separating them. The economic potential of the location is found by summing the influences on it from all other centers in the system. Trip making effects of most new infrastructure are often inversely related to distance and we do observe more trips at shorter distances than we do at longer distances, hence gravity measures may seem a good approximation of access to markets (even though they are not so intuitive).

Market Access Performance Measures to Assess Planned Projects. This tool uses a Hanson like gravity-based representation for highway induced access based on a fixed functional form—inverse distance for measurement of market access for the time being. The measure, based on employment and population, can be used to approximate external economies of scale and scope that may be brought about due to large transportation investments. Such measures of market access account for both the transportation network as well as surrounding land use (Handy and Niemeier 1997). Planners can also use these metrics to facilitate comparisons across zones in a variety of spatial and temporal settings. To that extent, these measures can be used as performance measures.
Effective Density. Effective density (ED) is one such measure and is synonymously used as a measure of accessibility to employment (place of work employment) as the activity unit. This measure, originally proposed by Graham and since then has become incorporated in the Department of Transport (DFT), was the United Kingdom’s sole measure of accessibility used to approximate agglomerative implications from transportation projects. The effective density (Graham 2007) of employment or population accessible to any firm in industry located in a zone \( I \) as given by an inverse power function gravity measure.

\[
\text{Effective Density} = \text{Scale Factor} + \sum_{j \neq i} \left( \frac{E_j}{d_{ij}^\alpha} \right)
\]

where: \( E_i \) is the employment in zone \( I \), \( E_j \) is the total employment in ward \( j \), \( d_{ij} \) is the impedance (distance, time or generalized cost) between \( I \) and \( j \), and \( \alpha \) is the impedance decay parameter. The scale factor is defined by scale factor, calculated as shown in Equation 5-3.

\[
\text{Scale factor} = \frac{E_i}{(\sqrt{A_i/\pi})^\alpha}
\]

where, \( E_i \) and \( A_i \) are the respective activity and area of the zone for which effective density is calculated. ED may also be estimated at the sector level using sectoral employment (at present, only one functional form is considered). Since transportation networks alter local access, the scale factor may be important in evaluating highway projects.

Potential Access. Potential Access (PA) is identical to ED when the scale factor is suppressed and the activity unit is set to population or employment. Similar to PA, Drucker and Feser (2012) propose a region access to labor pools using the shares of sectoral or specific type of employment to total employment instead of employment or population as in Equation 5-2.

Effective Density and Potential Access Approximate Buyer-Seller Markets. Both measures are identical (with the exception of the scale factor) and both approximate markets through land use based activity proxies. Higher density of activity (population, employment, etc.) are assumed to imply more, bigger markets or activity centers that bring buyers and sellers together and also allow for greater input matching, sharing, and learning. Further, Keeble et al. notes that the mass or activity component in these measures could be conceived as “a broad surrogate indicator of possible markets for traded goods and services, of input sources and opportunities for component linkages, of the availability of commercial information and business service...” (Keeble et al. 1988) and that ... “the index should seek to measure regional accessibility to economic activity in terms of transport costs of all kinds... rather than narrowly or simply as transport costs of the type implied by traditional Weberian industrial location theory.” If the focus is only on the change, then either of the two measures may be used.
Economic Implications of Change in Market Access- Productivity. Productivity implications from changed proximity to denser markets (Graham and Van Dender 2011), population, and/or centers of economic activity (external economies) through a shrinking of space for all zones in the impact area (P) is expressed by Equation 5-4.

\[
P = \sum \left[ \left( \frac{E_b}{E_{nb}} \right)^\mu - 1 \right] \times \text{per worker (GRP}_i \times E_i
\]

Where: \(E_b, E_{nb}\) are the effective densities or potential access measures for a project build (b) scenario and a project no-build (nb) scenario. This equation can be used to compare economic outcomes from large or small changes in access or for small or large time intervals. Analogous to cost-benefit analysis (CBA), the build and no-build scenarios may refer to a base year (t) and a reference year (s) with \(s \geq t\). Per worker (GRP) is the per employee gross regional product in zone \(i\). \(E_j = \text{Zone}(i)’s \text{total employment}\). \(\mu\) is an elasticity or response parameter reflecting response of productivity to changes in market access.

\(\mu\) – Elasticity of Productivity. In the implementation of ED and PA related productivity outcomes, the DFT guidance does not differentiate between investment types and suggests using the same value for all types of investments, new or improved. Under such a rule, adding investments will continue to add value as long as access benefits are positive. Two factors impact the choice of elasticity: a) the activity unit used in access measurement—population, total employment, or sectoral employment—and b) whether it is a completely new link versus an improved link. Other things equal, it is well documented that the potential economic outcomes from subsequent investments is typically lower. Although, further work is needed to ensure robustness of measures and specification for intra-urban settings. In such cases, the value of \(\mu\) is to be treated identically to a sensitivity parameter and the base value must be lowered. The value of \(\mu\) is also dependent on the activity unit. If the activity unit for the market access and productivity assessment is sectoral employment, then \(\mu\) must reflect productivity responses for that sector—current estimates are guided by studies that are either dated or pertain largely for manufacturing sector (Graham 2007 and Melo et al. 2009). If the interest is only in changes in access, \(\mu\) may be set to 0 and the residual outputs of productivity may be ignored.

\(\alpha\) – Estimates of Decay. Estimates of \(\alpha\) (distance or cost decay) are required. \(\alpha\) is a behavioral parameter. Those with access to MPO travel demand models may use the data from those models to calibrate decay. However, this is impractical in most cases, because most planners and users often may not be able to invest time and resources into this effort. Simple rules of thumb must guide the effort, followed up with sensitivity analysis since the results of these measures are sensitive to this parameter. These rules of thumb should include average trip lengths for the study area if: a) most of the trip lengths for the study area are short, then alpha is typically higher than 2 and could even go as high as 5 or 6 (should most of the trips be longer trips, then, alpha is lower); or b) the study area is categorized by specialized industries (industry related alphas vary and it is more appropriate to treat the activity in these industries separate from other sectors, which may be combined). Most studies sidestep the issue altogether and
set this value at one (Gutiérrez, 2001). This report suggests that this parameter and the results must be subjected to sensitivity tests. Higher values of alpha place more emphasis on markets in close proximity, while low values of alpha place more emphasis on markets farther away. As an example, if alpha = 1 and using distance as an impedance variable, activity at a market that is 5 miles away has 1/5\textsuperscript{th} of an impact relative to activity at a market that is just 1 mile away. With a value of alpha = 2, the 5-mile market only has 1/25\textsuperscript{th} of the impact. Clearly, the value of alpha has much to do with economic connectivity between markets and associated trip making behavior and will vary region-to-region. Given this uncertainty, the best approach to the alpha is to develop a sketch plan assessment of the alpha based on commuting profiles for the region.

**Determine Economic Implications of Planned Investments.** Not all investments can generate equal returns since regions are fundamentally different in their economic landscape. Even within regions there are significant differences. The market access measures combine density, speed and/or other network attributes into simple constructs that can be used by transportation planners and engineers to understand the potential broader economic implications of planning transportation investments. The broader economic measure is a baseline assessment of potential productivity gains/losses attributable to transport-induced access changes only. Simply, higher levels of access (regardless of type) to key markets are more conducive to economic opportunity than lower levels, all other things equal \textit{(ceteris paribus)}. The productivity estimates obtained from this toolkit developed in this report are an order-of-magnitude estimate.

This toolkit is helpful for project evaluation that induces significant change to the structure of the regional economy, such as:

- Connectivity projects or new improvements (with or without tolls).
- Planned network improvements.
- Improvements – Widening (with or without tolls).

**When the Gravity Measure Is Appropriate.** The use of these measures is justified where it is relatively easy to develop or extract required travel demand data inputs from metropolitan planning organization (MPO) or statewide planning models (SPM), from pre-calculated skims like those provided by Oakridge National Laboratories (ORNL), or user created impedances from networks. They are not recommended for small local projects. Furthermore, it is important to have background understanding of the regions and the industries that serve those regions to the extent that they influence trip making behavior of passengers/commuters and freight. The United States Department of Agriculture Economic Research Service (USDA-ERS) provides a typology that helps understand and analyze industry concentrations. Additionally, the Bureau of Economic analysis (BEA) also provides several resources that allow one to understand industry specializations for county-based regions using location quotients (LQ). The more diverse a regional employment base, the more important it becomes to analyze gains in those industries separate from specialized sectors.

**Value in Corridor Studies, Visioning, and Alternatives Analysis.** The measures developed are also useful for corridor planning studies to identify projects for inclusion in metropolitan
transportation improvement programs (TIP) and statewide improvement programs (STIPs) or for corridor studies, in general. Corridors typically have study areas that are anchored by transportation routes and can serve multiple jurisdictions and modes. They connect population, customer, seller, labor and work markets, and have a core focus of facilitating movement between markets.

**Access to Specialized Labor/Worker Inputs/Employers (Output & Calculations)**

First, as a departure from prior work in this area, firm access to labor markets is measured by three metrics using an isochronic formulation with three elements:

a) the change in the effective labor market area in terms of number accessible zones for the threshold, measured by change in number of zones in the build and no-build scenario.

b) the change in the available workforce at that threshold travel time, measured as the change in employment in the build and no-build scenario.

c) the change in the threshold of specific concentration indices (Equation 5-5), approximated as threshold of specific location quotient for the sector selected.

Both metrics a and b are highly visual concepts in that they may be visually communicated to stakeholders. Metric c, concentration measures, on the other hand is very industry specific and of greater value for specialized industry sectors. In order for the indices to be useful for competitive advantage of regions or to be meaningful, it is important to consider all pertinent centers. All metrics may relate to the ability of enhanced matching between employers and employees/commuters and reduction in search costs.

**Equation 5-5.**

\[
CI_{k, \text{threshold}} = \frac{E_j,\text{threshold} / \sum_j E_j,\text{threshold}}{\sum_k \frac{E_j,\text{threshold}}{\sum_j E_{k,\text{threshold}}}}
\]

This metric is a proxy for the strength of agglomeration with feasible work commute times and distances that may be influenced by transportation projects and has been used to assess and confirm the potential for transportation induced firm relocation (Bok and Oort 2011). Hence, the Concentration Index (CI) could be used as a useful predictor for positive economic implications in terms of business attraction when the time periods in comparison are not too far removed and as long as the economic climate in the region can support the higher availability of workforce.

Much like gravity measures, these measures may also be partitioned and customized to study daily access changes with respect to:

- Special categories of workforce (quality differentiators such as age group, sector, and occupational categories) as long as public domain or private data sources may be leveraged for this purpose.
• Effects of congestion and time-of-day effects through the consideration of daily time-dependent travel times.

These metrics are part of Toolkit 2. Toolkit 2 serves as a complement to Toolkit 1: Access to Markets. Toolkit 2 is important when a) the transportation link serves an important role in work commute—linking place of work to place of residence—to work sites and b) the study area is specialized in specific industry sectors.

Finally, the fourth metric is change in commuter costs. The economic value associated with changes in labor markets to work sites can be approximated by changes in commuter costs. These commuter cost changes may only be partially internalized by commuters and firms leading to changes in labor productivity. The standard rule-of-half has been adapted to provide estimates of commuter cost savings for both passenger commute trips and business trips coming into the employment centers. For any trip type (personal, work, commute, or business) the weighted costs are assessed using Equation 5-6. This outcome is provided as an optional outcome measure and is most reliable when good quality information is provided on commuter trips for work to the employment centers. The analysis, however, allows one to enter as a default the origin-destination daily trip table matrix using the home-based work trip purpose or a more appropriate user class.

Equation 5-6. Commuter costs change

\[
1.2 \times \left( \frac{w_1 + w_2}{w_2} \right) \times \text{value of time adjustment} \times (C_{ij,T}^0 - C_{ij,T}^1) \left( T_{ij,T}^0 + T_{ij,T}^1 \right) + 1.2 \times \left( \frac{w_1 + w_2}{w_2} \right) \times \text{(value of time adjustment)} \times (C_{ij,OT}^0 - C_{ij,OT}^1) \left( T_{ij,OT}^0 + T_{ij,OT}^1 \right)
\]

Where: \( C_{ij}^0 \) is cost between origin (i) and employment center (j) before investment; \( C_{ij}^1 \) is cost between origin (i) and employment center (j) after investment; \( T_{ij}^0 \) is demand (flow) between origin (i) and employment center (j) before investment; \( T_{ij}^1 \) is demand (flow) between origin (i) and employment center (j) after investment; \( T = \) refers to the commute threshold, and \( OT = \) outside threshold average commute threshold; \( w_1 \) and \( w_2 \) refer to weights (average trip length or time).; Value of time adjustment (personal commute trip) = assumed at 50% of the wage rate per Office of Management and Budget; Value of time adjustment (business trip) = assumed at 100% of the wage rate per Office of Management and Budget.

The suggested percent allocations for valuation of travel time savings can be user-specified. However, these are the percentages the team recommends. Finally, factor 1.2 is an assumed constant for automobile vehicle occupancy. These costs are annualized for the entire year using 260 work days in the year. At present, only time related costs are considered, and subsequently, vehicle operating costs could be considered.
5.1.4 GIS Usage for Visualization of Study Area, Data, and Measures

**Study Areas and Data**

GIS provides the natural mechanism to showcase the study area around the project and its economic characteristics including locations of buyer and supplier markets. Locations of major consumer markets such as city and population centers and metro regions can now be mapped with relative ease. Similarly, there is ongoing revolution in GIS-led data visualization effort for most Census Bureau data that allows viewing study area general characteristics and allows for enhanced graphics and mapping. An excellent example is the Census Bureau’s On-the-Map application ([http://onthemap.ces.census.gov/](http://onthemap.ces.census.gov/)). Similarly, the Economic Research Service—United States Department of Agriculture also provide excellent data.

**Measures**

Using GIS for developing market access measures, like those discussed above, has a number of advantages, including: a) assessment of transportation options is easy, as represented by a digital road network, b) data can be handled in a generally more flexible way, including a wider range of options for integration of data and other types of measures from different sources, and finally c) enables cartographic presentation of results, which again opens for visual interpretation and error assessment. None of these are currently possible within a spreadsheet environment. Beyond charts, all the outputs from these tools will need to be exported to GIS tools to aid visualization.

Illustrations of market access visualization are shown in Figures 5-2 and 5-3. The first illustration is the demonstration of the gravity representation for a rural-urban connectivity project in the Appalachian region. The second illustration is with reference to access of work sites to commuters in an urban area such as Houston (Harris County). The depictions presented in Figures 5-3 and 5-4 are illustrations of market reach of employment centers at various commute time thresholds.
Figure 5-2. Study Area

Figure 5-3. Illustration of Gravity Market Access to Customer/Labor Markets Showing Two County Markets with Higher Gains in Access Relative to Other Region Markets in the Study Area
(Example: Appalachian Development Highway System – Corridor B Rural-Urban Connectivity)
5.1.5 Future Research

Subsequent improvements are certainly warranted to these measures and tools to facilitate the tool to consider:

- Automatically visualize an inherently spatial distribution of an improvement.
- Consider other types of functional forms.
- Consider other types of costs that can be linked to economic outcomes.
- Extend to consider freight markets.
- Consider actual case implementation of these tools in a variety of settings
- Consider planning applications and exercises of these measures in specific applications such as corridor studies.
- Consider development of toolkits within a GIS environment. This is to integrate the calculation, mapping, and viewing all within the same framework.
- Consider further within the context of traditional benefit-cost analysis.
5.2 Access to Buyer-Seller Markets Module User’s Guide and Instructions

5.2.1 Introduction and Purpose

Disclaimer

This tool is designed to provide preliminary guidance for computing market access to customer and labor markets at the regional level for a base year and a reference year resulting from a new or improved transportation improvement impacting those regions. Three measures of access are provided, which can all be developed for any impact region as performance measures as such and may be used in planning exercises. The tool can also be used to generate an “order of magnitude” economic implication in terms of potential productivity gains from transportation strategies. The results provided by this tool should not be used as the sole basis to make a decision on a project, since other factors can lead to economic impacts. If the results of this tool are positive, the implementing agency may take it as only one indication of the likely effects from an anticipated project from access changes and must temper the result with local knowledge on market conditions for inputs, and products. For instance, higher levels of input access are meaningful if firms can actually utilize those additional inputs. This same tool may be used for any number of zones for measuring market access of given zone with its neighbors; however, this tool is not appropriate when number of regions (zones) exceed 30. These users are urged to conduct sensitivity analysis and assess robustness of outputs.

Objectives

The objectives of this tool are to serve as an aid in transportation planning by allowing planners to:

1) Estimate region-based market access at any point in time or from a transportation improvement for a set of regions (zones). These are proxies for scale economies that may be induced by transportation improvements. To that extent, the tool allows the calculation of two proxy measures of general market access: effective density (ED) and potential access (PA).

2) Measure transportation-induced access changes to a specialized labor pool, which is useful when there is a specialized industry sector located in the impact region/study area. The measures can be used as stand-alone performance measures.

3) Facilitate market access (as performance metrics) comparisons for the same zone and impact area at separate temporal scenarios and/or build scenarios.

4) Facilitate market access (as performance metrics) cross-sectional comparisons across zones.

5) Facilitate market access (as performance metrics) aggregate comparisons for impact area versus another benchmark or control area, data permitting.
6) Provide an order of magnitude assessment of the potential economic implications of changes in transportation induced access in terms of productivity gains or losses in dollar terms for a number of user specified zones and years.

7) Provide value in corridor planning, project planning and visioning exercises to promote economic opportunity under the condition that this performance measure is only one of requisites for ensuring positive outcomes from transportation investments by emphasizing the “where” of the investment.

For an in depth discussion of what this tool is capable of providing, as well as what it is and when it should and should not be used, see the introductory section of the technical guide above.

5.2.2 Entering Inputs

Introduction and Purpose

Upon opening the Access to Buyer-Seller Markets tool, users see a brief set of instructions for the tool, including which tabs to enter data into and the Results tab. To begin entering data, click on the tab labeled “2 – Data Entry” and follow the instructions listed by each button.

This toolkit is currently highway mode-oriented but could be extended to include transit as long as travel times are reflective of transit.

In this worksheet, activity is a representation of economic markets (customer, buyer, product-based markets as well as inputs and seller markets), which are linked together in space through transportation networks. Activity data may include total population, total employment, or sectoral employment. If the interest is to know how access to a specific regional labor pool will change, the activity unit could be a ratio of the desired employment group to total employment in any zone. Activity data should be for the base year and year(s) for which the analysis is intended to be carried out for all of the zones in the impact area. These data are available from a number of public and private domain sources. The current capability of this tool allows users to analyze two time periods for which there are corresponding skims. Users may also obtain some of these activity inputs if you have access to trip generation data or they can easily assembled from other sources.

In this worksheet, the time inputs are set for facilitating comparisons between two time periods. These time periods are referred to as base year (a time period that is reflective of a situation that can be considered a baseline do-nothing or no-build scenario) and reference year. The reference year corresponds to a do-something or build scenario and is typically a year that could be the same as the base year or a year in the future. The base and reference years correspond to the time frames and scenarios for the no-build and build scenarios from the accompanying travel demand models. A multitude of scenarios may be developed for comparison and evaluation.
Set Impact Area

In this exercise, the impact area is set to be the six (6) abutting counties and the first order of adjacent neighboring 16 counties (See Figure 5-6 and 5-7). Other methods may be used to set impact area such as those based on commute thresholds, buffer set regions or yet other measures.
Overview of the Effective Density Calculation Tool – Tutorial and Illustration

Figure 5-5. Spatial Location of the Study Area (22 counties with Economic Research Service (ERS) Defined Rural-Urban (RU) Continuum Codes around Corridor –X (ARC region)

Example Project Description:
The length of the new transportation improvement shown in the map is approximately 80 miles (Corridor X in Alabama, which has been open since 2007). This new corridor connects counties in the rural regions to the counties in the urban regions, and also enhances intermodal connectivity with the existing airports in the surrounding 22 counties. This illustration is evaluating it under the assumption that it is built sometime in the 2002–2035 interval and uses travel times corresponding to that.

Project Type: New Link- (Rural-Urban Connectivity) (Part of the Appalachian Development Highway System (ADHS))
Project Location: Varies- Urban –Rural (Set in the Appalachian Regional Commission (ARC) Region)
Study Area Economic Evaluation: ERDS Typology and Manufacturing Industry Specialization in the Impact Area

Figure 5-6. ERDS Typology and Location Quotient for Manufacturing for the Study Area
Parameter Inputs and Other Specifications

On the tab labeled “2 – DATA ENTRY”, click the “Parameters and Selections” button.

Enter the impedance decay factor, base year of analysis (which is usually no-build scenario year), Reference year of analysis (which is usually Build scenario year), productivity elasticity and finally, select either Effective Density or Potential Access that you wish for the tool to calculate. The parameters and selections must be saved by clicking the ‘SAVE PARAMETERS IN THE SPREADSHEET’ button.

Click on ‘CLOSE’ once done. All inputs and selections get saved automatically in the worksheet tab labeled “3-PARAMETERS”. See snapshot in Figure 5-7 for example.
As mentioned before, this tool uses a Hanson like gravity-based representation for highway induced access based on a fixed functional form. For a discussion of this topic and inputs—such as, Effective Density, Potential Access, Distance Decay, Productivity and Elasticity of Productivity—refer to the technical guide earlier in this section. See Table 5-5 for suggestions on the elasticity ranges to use in your evaluation.
### Table 5-5. Suggested Elasticity Ranges for Evaluation

<table>
<thead>
<tr>
<th>Activity</th>
<th>μ Range</th>
<th>New Capacity or Improved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>0.20-0.01</td>
<td>0.06 for new capacity; 0.03 or less for improved.</td>
</tr>
<tr>
<td>Employment</td>
<td>Similar to above</td>
<td>Similar to above</td>
</tr>
<tr>
<td>Manufacturing Employment</td>
<td>Mean estimate 0.03</td>
<td>0.03 for new and lower for improved.</td>
</tr>
<tr>
<td></td>
<td>(Min -0.36 Max 0.319)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Value selected must be</td>
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</tr>
<tr>
<td></td>
<td>based on how specialized</td>
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<td></td>
<td>the industry is within</td>
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<td></td>
<td>the region. Suggested</td>
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<tr>
<td></td>
<td>value is 0.03 and</td>
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<td>subjected to sensitivity</td>
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<td>analysis.</td>
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<td>Other sectors</td>
<td>Limited guidance is</td>
<td>Limited guidance is available at this time.</td>
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<tr>
<td></td>
<td>available at this time.</td>
<td></td>
</tr>
</tbody>
</table>

**Entering Activity Data (Employment or Population)**

Enter data if number of zones is less than or equal to 10. If the user friendly window (shaded in blue on the user’s screen) is used just type zones and their activity value 10 or less in number, the zones and the corresponding data gets printed automatically.

For the other option, when the number of zones is more than 10, the user is taken to the worksheets titled “4-INPUT ACTIVITY NO-BUILD” and “5 – INPUT ACTIVITY BUILD.” In this sheet the user is required to enter information about zones and their activity levels, either by directly entering values or by copying and pasting values from elsewhere in the spreadsheet, as shown in Figure 5-8. A similar procedure is required for both the Build and No-Build scenarios.
Impedance Inputs

Skim matrices (impedance matrices) for a baseline scenario and an alternate scenario both need to be entered into the tool. The skims can be typical travel time skims, distance-based, or based on generalized costs of transport. The last is used when monetary costs are the method of measurement for transportation impedance. These skims can be obtained from the MPO (projects within MPOs) or State Department of Transportation (Statewide focus). For generalized costs, all skims need to be monetized to facilitate comparisons especially when tolls are involved. When using skims, it is important to ensure that intra-zonal (diagonal) elements are non zero when entered into the worksheets and an accurate representation of intra-zonal distances, times, or generalized costs is estimated.
When travel times are used for the analysis, they should be obtained from assignment models, as they consider the demand between all locations into equilibrium travel times. Those conducting the analysis should be mindful of the following when obtaining skims:

- Spatial resolution or zones will be the level at which the accessibility evaluation will be conducted,
- Intra-zonal travel times, which represent the diagonal elements of the skim matrix and refer to the time taken for intra-zonal trips. A typical approach is to use the nearest-neighbor approach and approximate intra-zonal travel time as half of the average of inter-zonal travel times of $n$ nearest neighbors to any given zone (where $n$ can be any 2, or 3, or 4 of the nearest neighbors). For example, if we are interested in approximating intra-zonal travel time for zone 1, the nearest spatial neighbors (based on centroid-to-centroid distances of zones) are zones 3 and 4, and inter-zonal travel time from zone 1 to zone 3 ($t_{13}$) is 4 minutes and the inter-zonal travel time from zone 1 to zone 4 ($t_{14}$) is 3 minutes, then the intra-zonal travel time for zone 1 is 1.75 minutes, the calculation is given in Equation 5-10.

$$ \frac{1}{2} \left( \frac{t_{13} + t_{14}}{2} \right) = t_{11} $$

This option is provided in TRANSCAD and other travel demand models have similar algorithms. When distance impedances are used, area of the zone in consideration and $\pi$ (3.14) are both often used to approximate intra-zonal distance (see Scale Factor on in Equation 5-3).

- The study area, which is the area for which the analysis is to be conducted, is distinctly different from MPO or Statewide travel demand model study areas. The only time when both are identical is when system-wide or network-wide improvements are being evaluated at the same time. If evaluating a single capacity project, the main factor that determines what the zone’s study area should include is primarily based the project type (new link with or without tolls, bypass, widening). A second associated factor is the travel shed associated with the project.
- Origin-destination matrix (or demand representation) represents the build and no-build demand scenarios and the time frames for which the build (reference) and no-build (base) scenario impedances can be developed.
- Time periods

For new links in the roadway, it is suggested that first a simpler distance based skim be used followed up by a travel time skim or generalized cost skim. In any case, link travel time inputs are vital for the rigor of benefit-cost analysis, and, similarly for any study of access, the transportation induced zone to zone impedances (whether time or distance or generalized costs) are valuable and of critical importance.
**Entering Impedance Data**

Similar to activity data use the clickable box to enter impedance data as it is shown in Figure 5-9 (No-build and Build case).

**Figure 5-9. Entering Impedance Data for Impact Zones (For No-Build & Build Scenario) – Tabs 6 and 7**

**Entering Per Capita GRP and GRP Proxy Data**

Enter the GRP data or its equivalent proxy data similar to activity data as shown earlier. See the image in Figure 5-10 for reference. The GRP data are used for productivity calculations, as mentioned previously. If regions are smaller than metropolitan statistical areas (MSA) then per capita gross regional product proxies have to be used. Due to lack of better metrics, we recommend the use of average annual wages as the per capita GRP proxy. Much of the theoretical economic literature suggests that inter-urban wage differences reflect productivity.
differences. Hence, the common wage assumption in inter-urban settings must be approached with caution.

Figure 5-10. Entering per Capita or per Worker GRP /GRP Proxy Data – Tab 8

Getting the Output (Market Access / Productivity)

Click on the dialog box, shown in Figure 5-11, to see the outputs. Please note that loading a large number of zones might slow the computations. With 22 zones shown in the example exercise (on system processor Intel Core2 Duo), the time taken for a single run is approximately 20 seconds. To clear all the saved data and output click the dialog box shown in Figure 5-12. Remember using the ‘CLEAR DATA &OUTPUT’ button would cause all entries in the spreadsheet to become blank. It is recommended that users save the file loaded with data for use later.
5.2.3 Obtaining Results

The output consists of Effective Density and/or Potential Access values for each of the zones and the total. The outputs are for both No-Build and Build case scenarios (see Figure 5-13). A separate column also shows the Productivity output in terms of monetary values (dollars) against each zone. The toolkit also has built-in dynamic charting capabilities. The chart provided alongside access measures and productivity outputs allow easy comparisons between the calculated effective density values across the two scenarios (Figure 5-14).
Figure 5-13. Toolkit Output (Market Access to Labor/customer Markets), Total Estimated Productivity Gains/Losses ($) – Tab 8

<table>
<thead>
<tr>
<th>ZONES</th>
<th>EFFECTIVE DENSITY</th>
<th>EFFECTIVE DENSITY</th>
<th>TOTAL PRODUCTIVITY ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2012</td>
<td>2045</td>
<td></td>
</tr>
<tr>
<td>1009</td>
<td>6970</td>
<td>14133</td>
<td>$29,483,575</td>
</tr>
<tr>
<td>1033</td>
<td>5980</td>
<td>9417</td>
<td>$82,572,197</td>
</tr>
<tr>
<td>1043</td>
<td>8153</td>
<td>12021</td>
<td>$82,440,402</td>
</tr>
<tr>
<td>1057</td>
<td>6137</td>
<td>10818</td>
<td>$20,758,304</td>
</tr>
<tr>
<td>1059</td>
<td>5835</td>
<td>9947</td>
<td>$40,612,607</td>
</tr>
<tr>
<td>1073</td>
<td>14466</td>
<td>19520</td>
<td>$1,183,070,834</td>
</tr>
<tr>
<td>1075</td>
<td>5079</td>
<td>8746</td>
<td>$18,278,836</td>
</tr>
<tr>
<td>1079</td>
<td>6616</td>
<td>10219</td>
<td>$24,998,675</td>
</tr>
<tr>
<td>1093</td>
<td>5803</td>
<td>10824</td>
<td>$48,962,619</td>
</tr>
<tr>
<td>1103</td>
<td>8092</td>
<td>11769</td>
<td>$168,662,104</td>
</tr>
<tr>
<td>1107</td>
<td>5722</td>
<td>8554</td>
<td>$21,557,414</td>
</tr>
<tr>
<td>1115</td>
<td>8611</td>
<td>9719</td>
<td>$12,242,539</td>
</tr>
<tr>
<td>1117</td>
<td>11519</td>
<td>14416</td>
<td>$155,615,611</td>
</tr>
<tr>
<td>1121</td>
<td>6539</td>
<td>9128</td>
<td>$79,721,936</td>
</tr>
<tr>
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<td>7378</td>
<td>10207</td>
<td>$228,228,606</td>
</tr>
<tr>
<td>1127</td>
<td>7634</td>
<td>12587</td>
<td>$66,625,581</td>
</tr>
<tr>
<td>1133</td>
<td>6125</td>
<td>10539</td>
<td>$37,073,151</td>
</tr>
<tr>
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</tr>
<tr>
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<td>4867</td>
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</tr>
<tr>
<td>28141</td>
<td>5132</td>
<td>8054</td>
<td>$19,666,888</td>
</tr>
</tbody>
</table>

TOTAL 157412 242398 $2,738,520,856

Figure 5-14. Dynamic Charts of Outputs – Tab 8
5.2.4 GIS Mapping

A GIS mapping output is also shown in Figure 5-15. This capability is currently conducted externally by exporting all outputs to ESRI’s ARCGIS. Other open source tools can be used when ARCGIS or other similar tools are not available.

Figure 5-15. GIS Mapping of Effective Densities as Measure of Market Access – Tab 8

5.3 Access to Labor Markets Module User’s Guide & Instructions

5.3.1 Introduction and Purpose

Disclaimer

This tool is designed to provide a spreadsheet driven approach to computing transportation-induced changes in access of work sites/employment centers to specialized labor markets for a base year (no-build scenario) and a reference year (or build scenario) resulting from a new or improved transportation projects. The tool may also be used to obtain an order-of-magnitude measure of economic consequences (costs/savings) that may accrue to passenger users who commute to those sites. The tool is most useful when all key employment centers within a given, specific category in the study area are evaluated at the same time. However, it will involve overly long computational times when there are more than 30 employment centers. Transportation projects in regions with specialized industry sectors (with a need for specialized labor inputs) could use this as a preliminary assessment of how the productivity at work sites may be impacted.
**Objectives**

The objective of this tool is to measure the influence of transportation on access to specialized labor markets. The value of the tool lies in its ability to approximate the value for commuters and employers when new or improved transportation projects impact commute to work sites.

Additionally, planners could use this toolkit to analyze transportation projects in regions with specialized industry sectors. They could also use this as a preliminary assessment of how much more or less connected they are to their input markets (workers, in this case) and how transportation projects could alter that connection. Industry clusters interact with business within their own sectors and at the same time interact with other related sectors. This tool does not compute the productivity implications. Follow up work is certainly required to consider productivity implications and other input, such as user markets. However, one important feature of this toolkit is the time-of-analysis aspect into peak, off-peak, and entire day for determining variations during peak periods.

This tool, which measures access to labor markets, serves as a complement to the previously presented tool, which measures access to buyer-seller markets. This tool is important when a) the transportation link serves an important role in linking place of work to place of residence for commuting trips and b) the focus within the study area is concentrated on specialized industry sectors.

The following section discusses three main measures that this toolkit is designed to provide, assuming work sites locations are identifiable for the study area. In other words, this toolkit does cannot be used to identify the employment centers themselves or any degree of specialization of industries in the study. The user must know this information and enter it into the toolkit. The industry mix analysis is considered to be an important requirement before using any of the tools produced. Alternatively, local knowledge of the strength of industry clusters would be both useful and valuable.

### 5.3.2 Entering Inputs

The screenshot which follows will appear when you open the Access to Specialized Labor markets tool. Here users see a brief set of instructions for the tool, on which tabs to enter data into and on the Results tab. To begin entering data, click on the tab labeled “2 – DATA ENTRY” and follow the instructions listed by each button.

On the “2 – DATA ENTRY” worksheet, click on the button titled “CLICK TO ENTER PARAMATERS AND MAKE SELECTIONS.”

**Entering Input Parameters and Selections (Tab 2)**

Click on the box shown in Figure 5-16 to enter inputs and make selections.
1) Enter the Base Year as shown in Figure 5-17. The Base Year is same as the No-Build year. The default Base Year is 2002.

**Figure 5-17. Base Year Selection**

![Base Year Selection](image1)

Type/Print ‘Base Year’ inside the box which also stands for No-Build year

2) Enter the Reference Year as shown in Figure 5-18. It is determined by the travel demand model’s build year analysis. Both Base and Reference years refer to the years for which no-build and build scenarios are developed from travel demand models.

**Figure 5-18. Reference Year Selection**

![Reference Year Selection](image2)

Type/Print ‘Reference Year’ which stands for Build year

3) Select **Industry Sector** for the employment center(s) in the study area. The drop-down list and the details of 20 different 2 digit NAICS sectors appear in Figure 5-19. The default selection is industry sector ‘NAICS 31-33: Manufacturing.’ This example uses manufacturing because the study area is specialized in manufacturing (See Figure 5-19). As noted earlier, the toolkit analyzes all employment centers in a given group or
category in the study area at one time. It is only under these conditions that the Concentration Index (CI) is representative of agglomerative or concentration aspects associated with employment locations. Other industry categories can be analyzed separately and saved separately. If more than one industry sector will be analyzed, we recommend saving the file with a new file and re-starting from step 1 for each sector.

Figure 5-19. Select Industry Sector for Employment Centers

4) Select the type of labor force data as shown in Figure 5-20, which needs to be examined or for which access effects must be determined. The first option is ‘Potential/Population Labor Force.’ The second option and the default selection is ‘Employed Labor Force.’

Figure 5-20. Selection of Labor Force Market

5) If you selected “Employed Labor Force” in Step 4, you will be required to specify that further by selecting the specific type of employment ‘By Place of Residence’, shown in Figure 5-21. The default selection is ‘By Place of Work.’

Figure 5-21. Selection of Type of Labor Force Data

6) Select the specialized labor category data type. The image in Figure 5-22 shows various categories that you may specify that are available for the user to choose from the drop-down list. The default selection is made ‘By Industry Sector.’ These subcategories are designed in such a way that the user’s only input labor force data is for the specific subcategory selected and for the time periods selected. In this case, the quality of employment data inputs is important. While public domain datasets like Census Labor Employment and Household Dynamics (LEHD) and other Census data can provide base year data, high quality inputs are required for projected year data. Additionally, occupational categories are hard to obtain at any resolution lower than at the county level, hence private domain data may be used as inputs, when available.
7) If you selected industry sector in Step 6, you will be required to identify whether you wish to study “own” industry employment versus employment in any closely related sector or category. Various options available under each of the sub-category from (6) are shown in Figure 5-23. The default selection is made for ‘NAICS 31-33: Manufacturing.’

Figure 5-23. Specification of Labor Force Sought in Specific Industry Sectors in Relation to Employment Center Industry

Figure 5-24 shows the contents of all the drop-down selections in their expanded form.

Figure 5-24. Combined Screenshot for All Options for Labor Force Categorization
8) Enter the **threshold impedance** around each employment center, in terms of minutes or miles (see Figure 5-25). This selection is required to identify the labor market area associated with this commute threshold. This is the typical commute time or distance to all the employment centers. The Census Transportation Planning Package and now the American Community Survey provide typical commute times or distances to work by mode and may be input here. Alternatively, in-house surveys or origin/destination surveys may be used in lieu of public domain data, when available.

**Figure 5-25. Enter Threshold Value**

Steps 9 through 14 are required only if the user wishes commuter cost implications. See Figure 5-26 for details about the inputs needed.

**Figure 5-26. Enter Inputs for Commuter Cost Calculations**

9) Select the type of trip and the corresponding overall share of these trips (Figure 5-27) for the study area.

**Figure 5-27. Choose Type of Commuter Trip**

10) Enter the wages per hour or value of time proxy in dollars per hour (Figure 5-28) that is most appropriate for the sector in consideration, as set for employment centers. This is used for valuing commuter costs (see equations in the introductory section of this section’s technical guide).

**Figure 5-28. Enter Wage Rate**
11) Enter the fraction of the wage rate that will be used in the valuation of time costs (Figure 5-29). The default value is 50 (i.e., 50%). Personal trips are valued at 50% of the wage rate while business trips are valued at 100% of the wage rate, per Office of Management and Budget guidance.

   **Figure 5-29. Fraction of Wage Rate for Valuation of Time Costs**
   
   ![Fraction of Wage Rate](image)

12) In this step, the specific time-of-day (period) for which the analysis is to be carried out (see Figure 5-30) may be selected. Three options are provided: Peak, Off-peak, and Entire day analysis. These periods correspond to the time periods (or slices) from which the travel demand model skims (travel time) and trip tables are obtained and for which the analysis needs to be carried out. In most cases, the selection is entire day. However, in specific conditions, like assessing the effects of congestion, specifying the specific time-of-day may be required.

   **Figure 5-30. Selection of Time Period of Analysis of Changes in Specialized Labor Markets**
   
   ![Selection of Time Period](image)

13) Enter the average speed for all the links in the network if threshold/impedance table input is in miles (see Figure 5-31). This allows the tool to convert the impedance tables into hour units of time for commuter cost calculations. The default value for the average speed is 55 mph. Users may override this by inputting more appropriate values.

   **Figure 5-31. Enter Average Speed**
   
   ![Enter Average Speed](image)

14) Save and close the above settings and selections using the dialog box as shown in Figure 5-32. This option allows one to save all entries and automatically transfers them to another worksheet (Tab 3) (see Figure 5-33).

   **Figure 5-32. Save and Close the Inputs and Parameters**
   
   ![Save and Close](image)
The overall process is laid out in Figure 5-34. The toolkit currently allows for a maximum of 30 centers to be analyzed at the same time. For the sake of simplicity, if number of centers/ zones are less than or equal to 10 use the path identified on left column of Figure 5-34. If, on the other hand, the numbers of centers exceed 10, the path identified in right hand column of Figure 5-34 should be used. When the study area is large, such as several counties or metro region, the number of zones could exceed 30 very quickly.
Enter the list of zones as employment centers in the desired box or print directly into the worksheet on the tab labeled “7-INPUT EMPLOYMENT CENTERS” (see Figure 5-35). Enter data within the required boxes. Entering data elsewhere other than the assigned boxes would result in error for the outputs. Note that the employment centers selected should be within the zones that are used within the tool. Use the user interface box (shown in blue on the user’s screen) only when the zone size is less than or equal to 10.
**Entering Desired Specialized Labor Market Segment Data (Tab 2 & Tab 4)**

Enter total employment in all industries and for the segment selected earlier (Step 7). See example shown in Figure 5-36. Use the user interface box (shown in blue on the user’s screen) only when the zone size is less than or equal to 10. You will be required to provide activity inputs for both the base period and the reference period for all zones in your study area.

**Figure 5-36. Labor Market Data Entry**
**Entering Impedance Matrix Data (In minutes or miles) (Tab 2 & Tabs 5-6)**

Enter impedance matrix data both for the no-build and build scenarios as shown in Figure 5-37. Note that these data need to be entered within the assigned cells of the spreadsheet to avoid error flags. Use the user interface box (shown in blue on the user’s screen) only when the zone size is less than or equal to ten. Please note that this is the impedance matrix for the entire study area.

![Figure 5-37. Impedance Matrix For No-Build & Build Scenario](image)

**Entering Trip Table Matrix Data (Optional) (Tab2 and Tabs 8-9)**

*Use this exercise only when the commuter costs are to be calculated.*

Enter trip flow matrix data both for the no-build and build scenarios as shown in Figure 5-38 for the entire study area. Note that these data need to be entered within the assigned cells of the spreadsheet to avoid error flags. Use the user interface box (shown in blue on the user’s screen) only when the zone size is less than or equal to 10. Since the user market in this example is labeled as “work commute,” it is appropriate to enter the home-based work trip purpose category origin-destination daily trip volumes for the duration selected (or more...
appropriate user class segmentation if available). In this case, the analysis is only as good as the data provided. These data along with the skims are to be obtained for both the build and no-build scenarios from the travel demand model. For peak period analysis, a peak period trip table is appropriate.

Figure 5-38. Enter the No-Build and Build Trip Table (Work Trip)

5.3.3 Obtaining Results

Obtain Desired Outputs (Market Area/ Labor Access/Concentration Index) and Commuter Costs (Tab 2 and Tabs 10-11)

Use one of the selections shown in Figure 5-39 to perform the task of calculating the Zone Accessibility, Employment Accessibility, and Concentration Indices. Users can use either of the options to fulfill their requirements. The concentration indices are provided at the employment center level. A higher value in build relative to no-build suggests enhanced concentration of workers of the specified category at the center. Ultimately, some may gain more relative to the others based on how transportation actually changes access to those centers; the average effect on all centers is of importance in the study area.
Outcome Measures. The toolkit measures the change in market area/trade area for work sites as the first outcome measure. This is the ease with which labor can access the work sites with given travel time or distance budgets. The change in the trade area is what is made possible due to transportation improvements. In the toolkit, this outcome measure is called zone accessibility (market area, trade area, or effective market area). The second related outcome measure is the expanded labor pool (additional opportunity) that is made available due to the larger trade area, referred to as employment accessibility. Both of these outcome measures are often used by businesses and industries to ascertain their reach to key markets, consistent with travel budgets. A third outcome variable is an index that measures the change in concentration of a specific labor pool type or category for an industry within a specific zone relative to the share of that same labor category across all sectors (k) and zone (j).

The tool also connects the suppliers (commuters) with the demand sites (work sites) so that it becomes possible to determine economic implications in terms commuter cost changes.

Zone Accessibility (Market Area/Effective Trade Area). Zone accessibility is computed as the number of zones (which could be a TAZ, Block Group or County) that are accessible before and after the investment for a given threshold distance from the employment centers. This is a set of all zones that are within equal time/distance from the work site. It is often visualized as a map of equal time/distance budgets and resembles a contour map. However, this toolkit provides a spreadsheet driven preliminary approach determining this areas at the zonal level before and after a transportation-related intervention. Most Geographic Information System (GIS) tools can be directly used to provide this outcome measure as long as there are network and land use layers indicating zones or locations of work sites.

Employment Accessibility (Access to Additional Labor Pools). Employment accessibility accounts for the total employment of the desired type within a given zone that becomes accessible before and after transportation investment. In principle, a large market area and access to a larger and or thicker labor pool, should allow for a better labor matching at the firm level and for reduced search costs for commuters (under the assumption that the firm is economically able to utilize the additional labor resources that may become available).
**Concentration Index (CI).** The CI with respect to an employment center in any industry sector (j), zone (k), and commute threshold (threshold) is expressed by Equation 5-5 (shown in the Technical Guide of this section).

The snapshot shown in Figure 5-40 shows the output for the four employment centers identified in the example for an assumed 100 minute commute threshold. These outputs are namely for Zone Accessibility, Employment Accessibility, and Concentration Index, which the user is directed to automatically immediately after the calculations are done by the tool once the clickable button of Figure 5-39 has been used. There are charts produced beneath each output item for quick and easy interpretation of results.
Figure 5-40. Sample Outputs for the Example

<table>
<thead>
<tr>
<th>EMPLOYMENT CENTERS</th>
<th>ZA (No-Build)</th>
<th>ZA (Build)</th>
<th>Difference in ZA</th>
<th>EA (No-Build)</th>
<th>EA (Build)</th>
<th>Difference in EA</th>
<th>Base Year CI (No-Build)</th>
<th>Reference Year CI (Build)</th>
<th>Difference in CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1093</td>
<td>6</td>
<td>8</td>
<td>2</td>
<td>35,109</td>
<td>28,418</td>
<td>(6,691)</td>
<td>1.25</td>
<td>1.39</td>
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<td>0.76</td>
<td>(0.35)</td>
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<tr>
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<td>11,565</td>
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<td>0.50</td>
<td>(0.18)</td>
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<tr>
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<td>56,058</td>
<td>(23,615)</td>
<td>4.24</td>
<td>5.98</td>
<td>1.74</td>
</tr>
</tbody>
</table>

ZA = Zones Accessible
EA = Employment Accessible
CI = Concentration Index
Commuter Costs. As mentioned earlier, in the Technical Guide of this section, the standard rule-of-half from Benefit-Cost Analysis has been adapted to provide estimates of commuter cost savings for both passenger commute trips and business trips coming in the employment centers. For more information on commuter costs, refer back to the technical guide. The Commuter Costs Change is calculated as shown in Equation 5-6.

The snapshot shown in Figure 5-41 shows the cost savings for the four employment centers and overall (in $).

Figure 5-41. Sample Output for Commuter Cost Savings

Reset Data and Outputs

Use any of the appropriate clickable buttons in Figure 5-42 to reset the entered data and/or outputs for performing tasks.
Figure 5-42. Resets Outputs and Inputs and Outputs

CLICK TO RESET
ALL OUTPUTS ONLY

CLICK TO RESET
ALL INPUTS AND OUTPUTS