SHRP2 SOLUTIONS

BEHAVIORAL/AGENT-BASED SUPPLY CHAIN MODELING RESEARCH SYNTHESIS: MODEL APPLICATIONS

BACKGROUND AND CHALLENGE

Behavioral supply chain models can be used for myriad policy applications. These are dependent upon the specific components that are included and can be categorized into two main types of modeling systems: 1) national supply chain models; and 2) regional truck touring models.

POLICY ANALYSES

The national supply chain models include the firm synthesis, allocation of freight demand, and transportation logistics chain components and can support the following policy analyses:

- **Modal alternatives.** There is direct competition between air, rail, water, and truck for freight movements, and any infrastructure investments being considered should be evaluated in the context of this competition. These alternatives are evaluated nationally and—to a lesser degree—internationally to capture any impacts in a State or region.
- **Pricing.** There are many aspects of pricing that can and should affect statewide freight forecasts. Pricing can be a strategy to manage demand or raise revenues (e.g., toll roads, gas taxes, mileage fees). Pricing affects the travel decisions of drivers, shippers, carriers, and Third-Party Logistics (3PL) establishments differently.
- **Economics**. Policies to improve economic conditions will affect freight and goods movement. Economic conditions could be tested by adjusting these inputs to understand the effects on freight mobility of a greater demand for goods. Higher employment in a State will lead to additional production and consumption of commodities, which can be represented by alternative employment and commodity flow inputs. Policies

such as freight tolling and truck restrictions can be analyzed to understand the effects on freight.

- **Environmental.** Policies to reduce transportation-related emissions can have effects on freight and goods movement. An increase in the gas tax will influence gas consumption and potentially reduce vehicle miles traveled (VMT). The Environmental Protection Agency (EPA) may change fuel standards for trucks, which would affect the transport cost for trucks. Congestion on highways can be evaluated in the context of environmental policy analyses.
- **Safety.** Policies such as driver hours-of-service regulations and technologies to reduce accidents for hazardous materials transport will affect decisions on the cost to transport goods and on what modes to use for certain goods.
- **Airport, Seaport, or Rail Planning.** Policies made by airports, seaports, or rail operators regarding new capacity, intermodal terminals, or environmental effects can be evaluated.

Regional truck touring models can address regional impacts for the following policy analyses:

- **Policies.** Regional policies such as taxes, tolls, or local delivery times will result in different freight mobility in different cities. Truck route restrictions and truck size and weight limits can also affect route decisions.
- **Environmental.** Policies to reduce regional emissions impacts can be evaluated in a similar manner as the national supply chain models.
- **Pricing.** Regional pricing options can be evaluated in a similar manner as the national supply chain models.
- **Airport, Seaport, or Rail Planning.** Regional infrastructure for ground access to ports or rail stations can be evaluated.

PERFORMANCE MEASURES

Freight-related performance measures are linked with economic impacts of freight and are used for policy analyses. These performance measures are often used by agencies to compare scenarios and to evaluate and prioritize policy goals. Freight-related performance measures are often segmented by commodity group and mode. Shares by mode or market is another means to evaluate commodity flows across different scenarios or geographies using a normalized measure. The following performance measures are used to quantify commodity flows:

- Annual tonnage shipped by commodity group and mode to, from, and through the study area.
- Cost per ton of freight shipped by commodity group and mode.
- Annual import and export tonnage, by port.
- Mode shares of tonnage by commodity group, including imports and exports by district/county.
- Market share of international or domestic trade.

Travel time is an important attribute for any freight model; this attribute is also an important means of measuring the performance of the system. Since this is both an input to the system and a measure of performance, it is important to validate travel times against observed data before relying on the performance measures. Typically, these travel times represent an average daily travel time, but these may also be reported by time of day. There are several ways to report travel times for freight:

- Origin-destination travel times, by commodity group and mode.
- Daily truck travel times for select origin-destination pairs.
- Truck vehicle hours of travel.

Advanced freight models that include behavioral or agent-based supply chain methods represent trips as segments of a long-distance supply chain. Such models may also represent the pick-up and delivery system to deliver goods for the last portion of the supply chain. Once the supply chain has been established, each segment is identified as a trip with a specific origin and destination. These trips can be reported by commodity group, mode, and aggregation of zones (i.e., districts or counties) and can be for annual or daily time periods. Truck trips are segmented further by truck type, time of day, and

Table 1: Summary of Performance Measures, by Type

Performance Measure	Commodity Group	Mode	Imports/ Exports	Domestic	External[1]	Internal[2]	Truck Type	Annual	Time of Day
Commodity Flows	✓	✓	✓	✓	✓			✓	
Travel Time	✓	✓		✓	✓	✓			✓
Trips	✓	✓	✓	✓	✓	✓	✓	✓	✓
Truck Volumes						✓	✓	✓	✓

user class—typically for daily time periods. Pick-up and delivery systems for truck travel within a study area can also be reported as stops per tour, tour length, stop duration, and other tour statistics, also typically for daily time periods.

An important performance measure for highway planners is average daily truck volumes, reported by road segment, screenline, or facility type. Truck volumes can also be summarized by geography (i.e., district or area type). Truck volumes are typically not segmented by commodity group, but if an agency was interested in this performance metric, then it could be developed by assigning truck trips for a single commodity group or by assigning several commodity groups using a multiclass assignment technique.

In addition to the performance measures considered in modeling, there are also performance measures related to the operation of highways, including: travel time index, planning time index, buffer index, average hours of delay for freight vehicles, and safety measures. Table 1 summarizes the performance measures sorted by type.

The public sector primarily utilizes performance measures to quantitatively assess progress toward agency goals. Though there are several performance measures, most typically fall into the following categories:[3] Transportation System Performance (efficiency and reliability), Safety, Environmental Sustainability, Economic Indices, and System Preservation.

Important components of performance management are longitudinal measurements and trends analysis. An agency may determine that additional investment or a policy change is required based on positive or negative changes in an individual measure over time. For example, an agency may decide to invest in highway improvements in situations where highway infrastructure is demonstrated by a performance measure to be either degraded or inefficient in terms of operations.

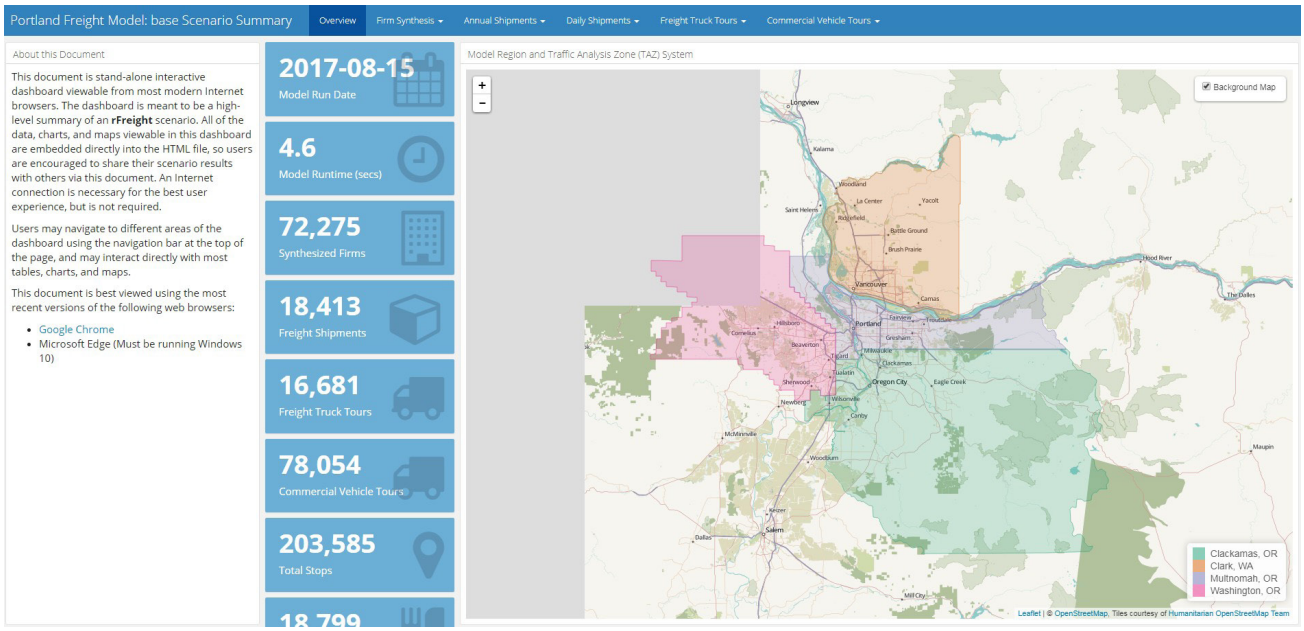
Private sector performance measures typically fall into one of the following categories: Operations, Financial, or Safety. Additional variation in private sector performance measures is introduced by different business models or financial practices, such as per-load or per-mile compensation metrics.

[1] External refers to the segment of the freight movements that have some portion of the movement outside the study area but travel through, into, or out of the study area.

[2] Internal refers to the segment of the freight movements that are entirely within a study area.

[3] Katherine Turnbull. "Performance Measurement of Transportation Systems: Summary of the Fourth International Conference," 2013.

Figure 1: Portland Metro Freight Model Dashboard



Source: RSG (2017)

Some behavioral supply chain freight models include a dashboard of model outputs to visualize performance. The dashboard displays charts, maps, tables, and graphs that summarize a model run based on the model output file. It can also display model data alongside other model runs or the reference datasets to show the performance measures of different scenarios modeled. Figure 1 above shows a snapshot of the Metro's freight model dashboard.

FOR MORE INFORMATION

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