An Overview of the Piedmont Triad Freight Model

Freight Model Overview

- Why? - Existing Freight Model and its limitations

- What does an advanced freight model do?

- How does it work?
  - Freight model process
  - Integration into overall regional model

- Where does the data come from?

- What can we do with it

Why do an Advanced Freight Model

"Creating better data and models will enable state, regional, and local planners to better predict freight movement trends, and make more informed project investment decisions." - PART

"Many current freight demand forecasting models and data sources are more appropriate for passenger transportation than for forecasting freight movements and understanding freight travel behavior." - FHWA

How did PTRM handle freight?

PTRM used a typical trip-based process:

- Trip Generation (based on employment by type)

- Trip Distribution (based on trip length)

- Time-of-Day (trips are split into each time period)

- Trip Assignment (auto, single-unit, multi-unit)

Nearly every model in the US uses a similar methodology

So what is the issue?

1) Truck trips are not strictly based on employment – commodities are important

2) The interaction between distribution centers and businesses is missed

3) Trips aren't "linked" – Each trip has no memory
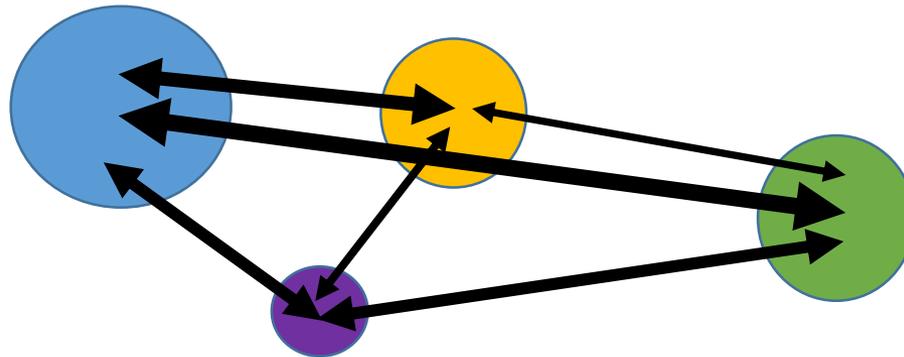
The ability to realistically reflect and analyze freight movements is limited

What do advanced freight models do?

- Represent characteristics of firms and shipments

- Represent supply chains – link buyers and suppliers

- Capture trip-chaining - follow truck "tours" throughout the day

- Differentiate freight versus commercial vehicles - shipments versus goods and services
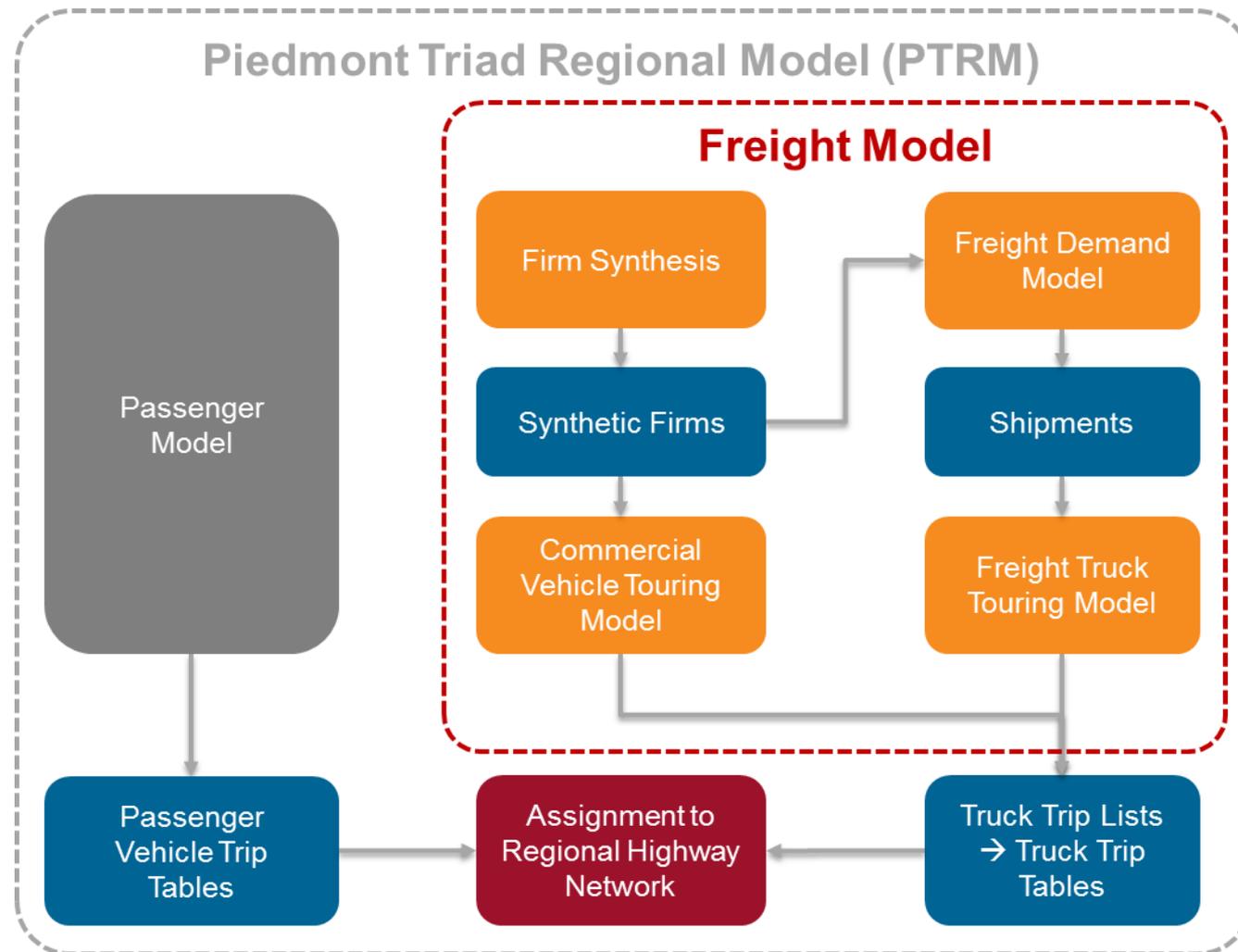
Types of advanced freight models

- Supply Chain Models
    - Tend to be national in scope
    - Some State and Regional examples

- Tour-Based Models
    - Tend to be Regional in scope
    - Some State and National examples

- Hybrid Models
    - Combined supply chain and tour-based models
    - For regional and statewide planning purposes but with a national component
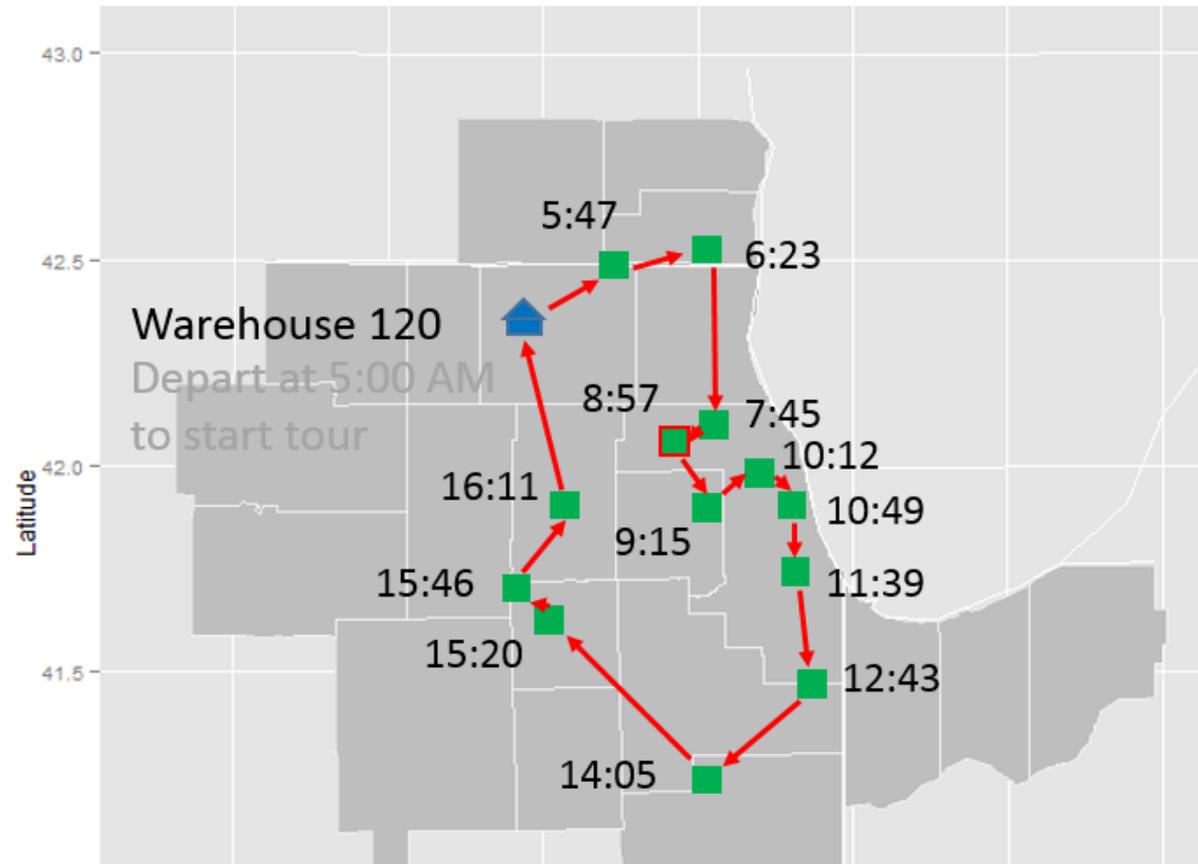
The Piedmont-Triad Freight Model

Main model components:

- Firm Synthesis
- Freight Truck Touring Model
- Commercial Vehicle Touring Model

Piedmont Triad Regional Model (PTRM)

Freight Model

Passenger Model

Firm Synthesis → Freight Demand Model

Synthetic Firms → Shipments

Commercial Vehicle Touring Model

Freight Truck Touring Model

Passenger Vehicle Trip Tables → Assignment to Regional Highway Network ← Truck Trip Lists → Truck Trip Tables

What is a tour?

A sequence of trips connecting activities that starts and ends at the same location

TourID	TripID	Vehicle	Scheduled	TAZ.Origin	TAZ.Destination	Activity	MAMDepart	MAMArrive	TravelTime	Distance	StopDuration
1	1	Heavy	1	4281	2011	Pick-up	400.68	478.00	77.32	51.55	10
1	2	Heavy	1	2011	2182	Pick-up	488.00	491.67	3.67	2.44	32
1	3	Heavy	1	2182	2138	Pick-up	523.67	529.12	5.45	3.63	38
1	4	Heavy	1	2138	2138	Pick-up	567.12	567.12	0.00	0.00	17
1	5	Heavy	1	2138	2686	Pick-up	584.12	589.50	5.38	4.48	21

PTRM Freight Model Process

- Synthesizes Firms

- Simulates Freight Touring Trips - truck movements within the PART region that deliver and pick up freight shipments at business establishments

- Simulates Commercial Vehicle Touring Trips - the remainder of the travel of light, medium, and heavy trucks that is for commercial purposes, i.e., providing services and goods delivery to households and services to businesses

- "Aggregates" tours to time periods and reformats for assignment in the passenger trip-based model

Both the freight truck and commercial vehicle touring models follow a similar general sequence:

1. Establish demand
    - freight model – shipment pick up and delivery
    - commercial vehicle model – service activity, home deliveries
2. Estimate activity durations at stops
3. Allocate appropriate vehicles types to support the activity
4. Group and sequence stops into tours
5. Establish time of day
6. Add in intermediate stops for breaks, refueling etc.
7. Finalize the trip timing with both scheduled and intermediate stops

Where does the Data come from?

- Four primary types of data used to develop the freight model:
  - Survey data describing travel behavior
  - National data describing business and freight travel behavior
  - Data describing current demand and transport supply in the region
  - Data describing future demand and transport supply in the region and nationally

Where does the Data come from?

- Survey data describing travel behavior
  - How do trucks travel?
  - Dimensions such as how are trips arranged in tours, what time of day, what type of vehicles are used for different activities

- Sources:
  - Ohio Establishment Survey (2003-2004): 24-hour diaries for drivers at 562 establishments
  - Texas Commercial Vehicle Survey (2005-2006): 24-hour diaries for 1,711 commercial vehicles

- Usage:
  - Model estimation, model calibration

Directions: Please print in ink and fill in bubbles completely: ●

B Form

Statewide Travel Forecasting

If you traveled on your travel date as part of your work, please enter the following information:

1. Employee Name: _____

2. Vehicle type used for the trip:
   ○ Car, Small Van, Truck < 8,500 lbs
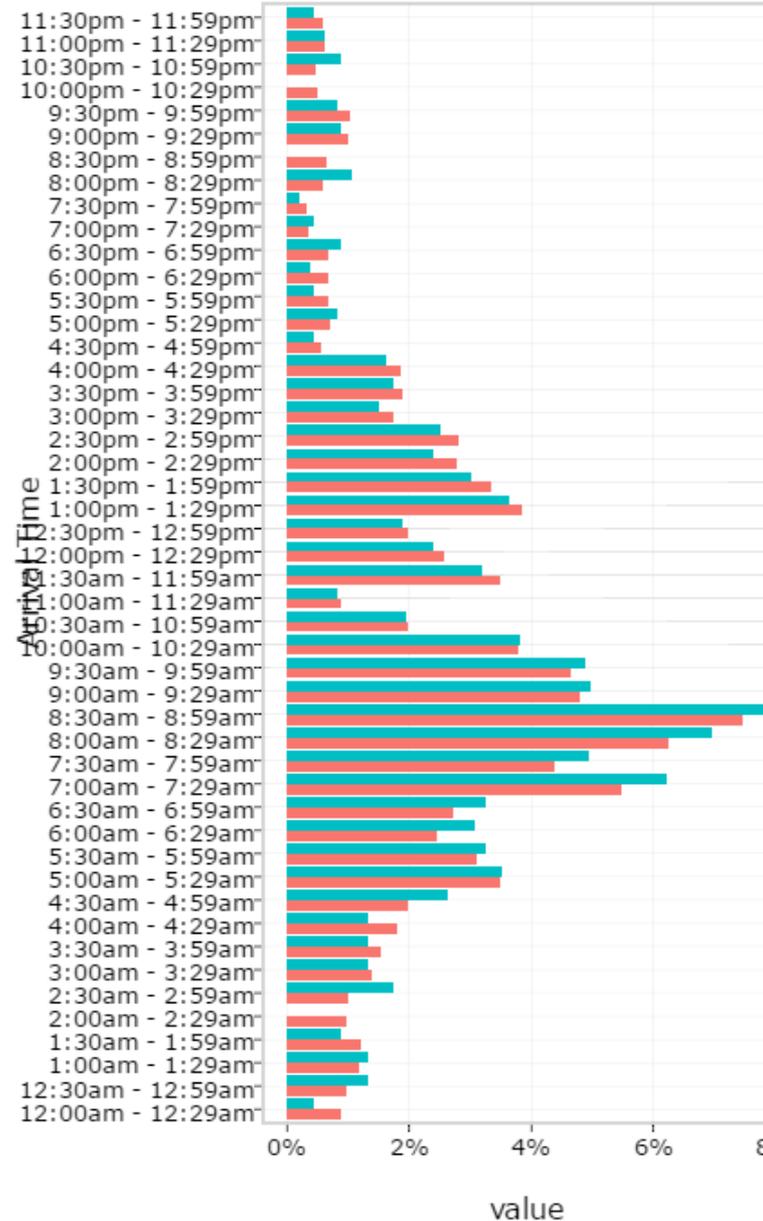   ○ Single Unit Truck > 8,500 lbs
   ○ Multi-Unit Truck
   ○ Other _____

3. Location of departure for first business trip or tour: ○ Began at work ○ Other (provide address below)
   Other address: (if not work)
   Name: _____   Address: _____
   City: _____   State: _____ Zip Code: _____

4. Time of departure for first business trip or tour: [____] ○ A.M. ○ P.M.

5. For each work-related trip on survey day, please provide the following:

Arrival Time	Location	Activity (check all that apply)	Value of Trip	Departure Time
First Destination [____] ○ A.M. ○ P.M.	Name: _____ Address: _____ City: _____ State: _____ Zip Code: _____	○ Business Meeting ○ Sales/Marketing Visit ○ Provide Services ○ Break/Meal ○ Vehicle Service/Refueling ○ Pickup Material or Equipment ○ Drop off Material or Equipment ○ Return to Work Location ○ Return to Home ○ Other	$ [____] **Did you travel...** ○ Alone ○ With others	[____] ○ A.M. ○ P.M.
Next Destination [____] ○ A.M. ○ P.M.	Name: _____ Address: _____ City: _____ State: _____ Zip Code: _____	○ Business Meeting ○ Sales/Marketing Visit ○ Provide Services ○ Break/Meal ○ Vehicle Service/Refueling ○ Pickup Material or Equipment ○ Drop off Material or Equipment ○ Return to Work Location ○ Return to Home ○ Other	$ [____] **Did you travel...** ○ Alone ○ With others	[____] ○ A.M. ○ P.M.

Arrival Time chart (horizontal axis: value, 0% to 8%):

- 11:30pm - 11:59pm
- 11:00pm - 11:29pm
- 10:30pm - 10:59pm
- 10:00pm - 10:29pm
- 9:30pm - 9:59pm
- 9:00pm - 9:29pm
- 8:30pm - 8:59pm
- 8:00pm - 8:29pm
- 7:30pm - 7:59pm
- 7:00pm - 7:29pm
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- 4:30pm - 4:59pm
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- 3:30pm - 3:59pm
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- 1:30pm - 1:59pm
- 1:00pm - 1:29pm
- 12:30pm - 12:59pm
- 12:00pm - 12:29pm
- 11:30am - 11:59am
- 11:00am - 11:29am
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- 1:30am - 1:59am
- 1:00am - 1:29am
- 12:30am - 12:59am
- 12:00am - 12:29am

Y-axis label: Arrival Time
X-axis label: value
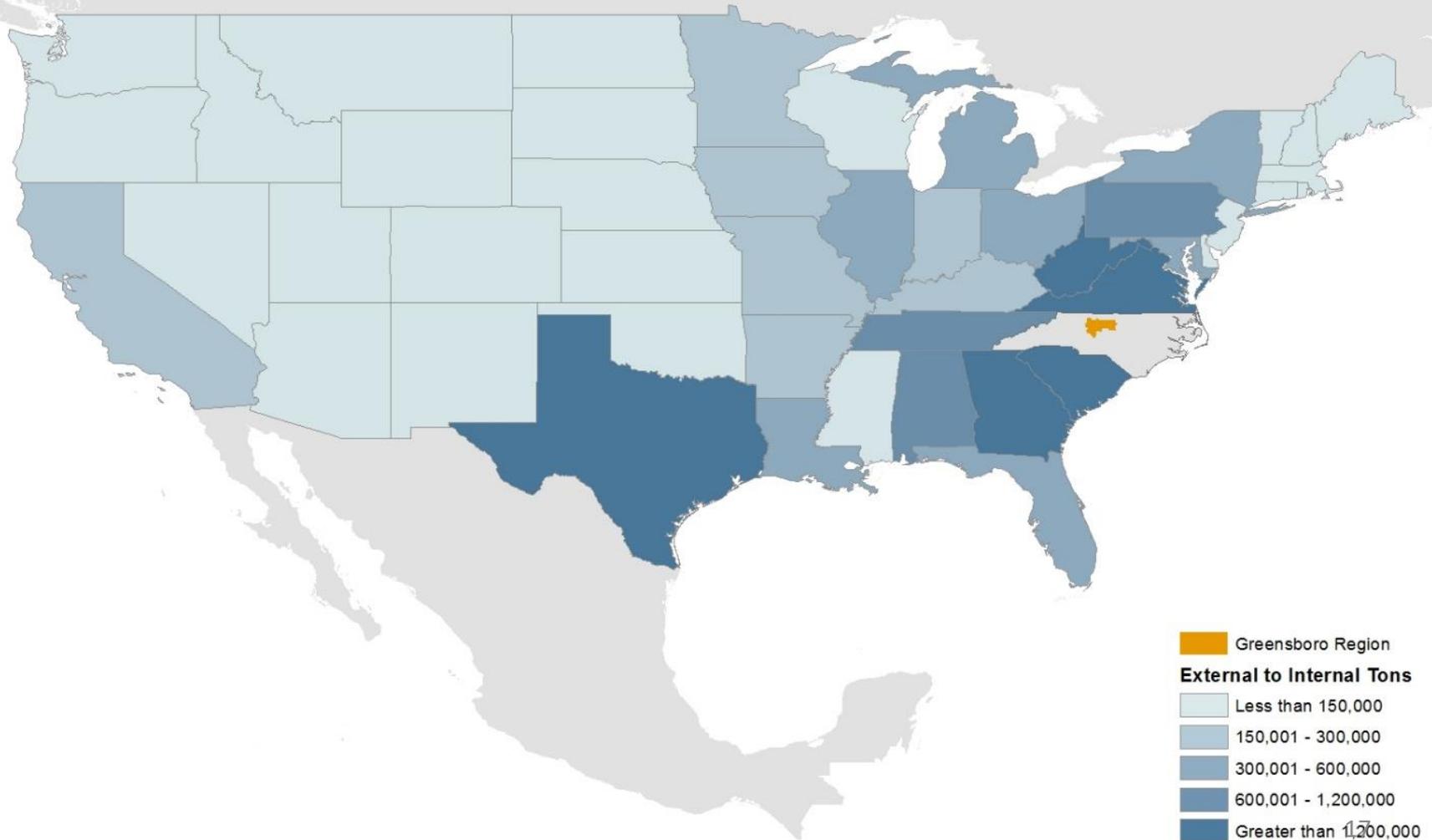
Where does the Data come from?

- National data describing business and freight travel behavior
  - Commodity flow data: Freight Analysis Framework v4
  - Input/output data: Bureau of Economic Analysis Input/Output Accounts
  - Average payloads: Vehicle Inventory and Use Survey
  - Correspondences between industrial classification and commodity coding systems: Census Bureau, US BEA, FHWA, TRB NCHRP/NCFRP reports, RSG

External to Internal Commodity Flow (Tons)

Greensboro Region
External to Internal Tons
Less than 150,000
150,001 - 300,000
300,001 - 600,000
600,001 - 1,200,000
Greater than 1,200,000

Internal to External Commodity Flow (Tons)

Greensboro Region

Internal to External Tons
- Less than 150,000
- 150,001 - 300,000
- 300,001 - 600,000
- 600,001 - 1,200,000
- Greater than 1,200,000

12

Where does the Data come from?

- Data describing current demand and transport supply in the region
    - TAZ level SE data: from the PTRM
    - Business location data: InfoUSA data
    - Freight node data: Phase 1 survey, InfoUSA data
    - Network travel times and distances: from the PTRM
    - Truck traffic counts at external stations and count stations within the region: NCDOT, etc.

Industrial Employment by TAZ
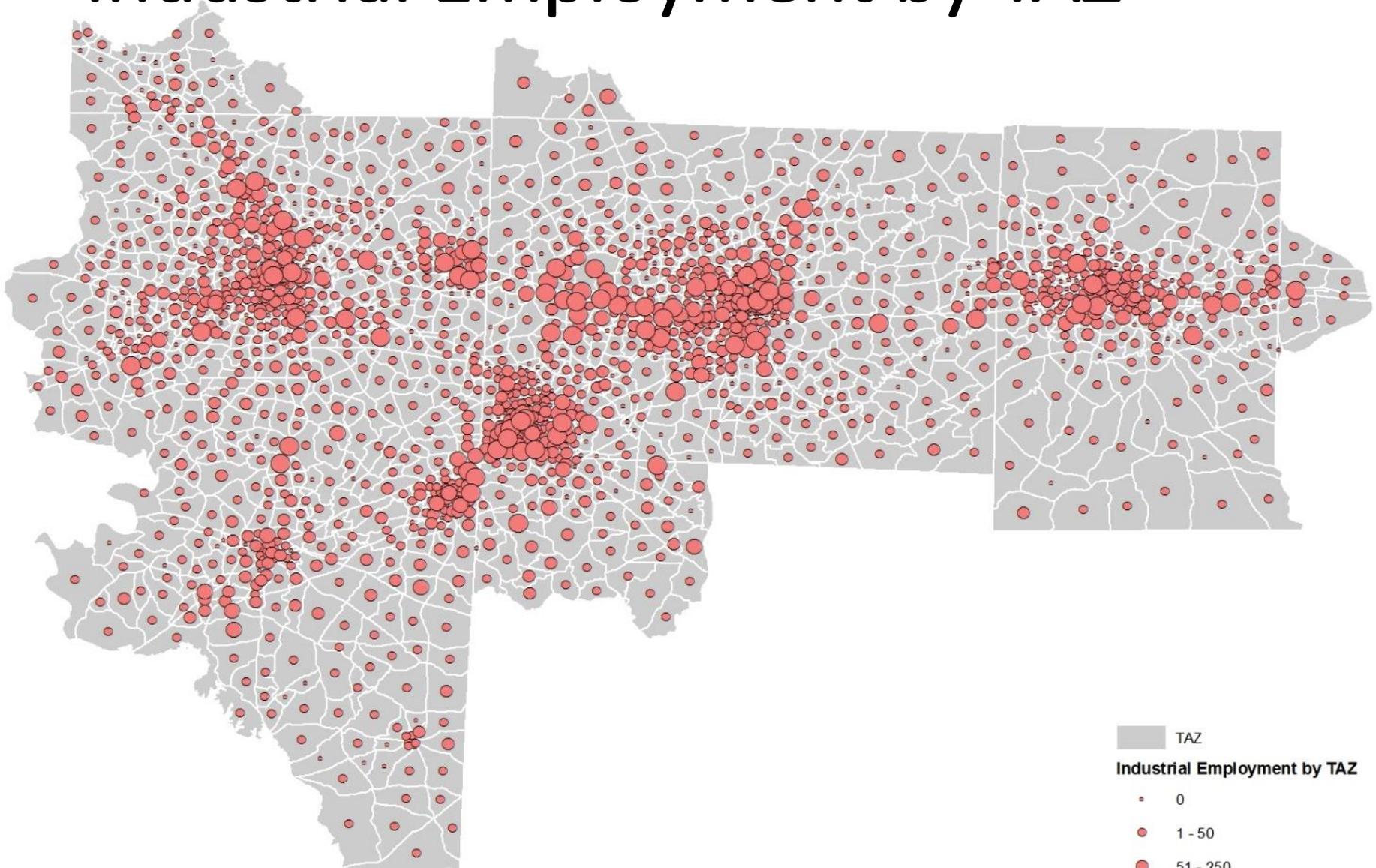
Freight Nodes by Category
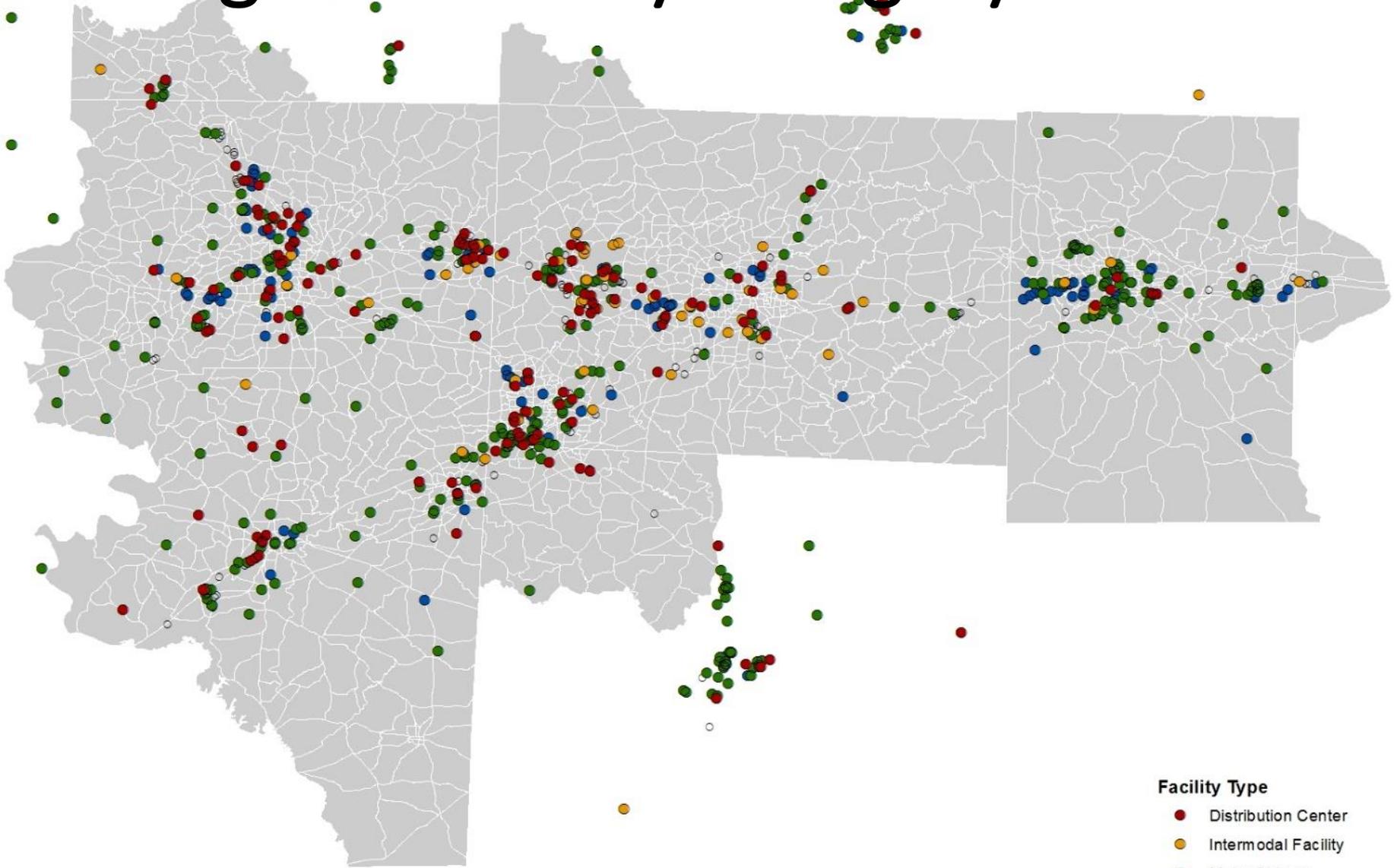
Facility Type
- Distribution Center
- Intermodal Facility
- Major Shipper
- Retail
- Unknown

Where does the Data come from?

- Data describing future demand and transport supply in the region and nationally
  - TAZ level SE data: from the PTRM interim and future scenario SE data
  - Network travel times and distances: from the PTRM interim and future scenario networks
  - Commodity flow forecasts: Freight Analysis Framework v4 future year forecasts

Growth in Employment by Type

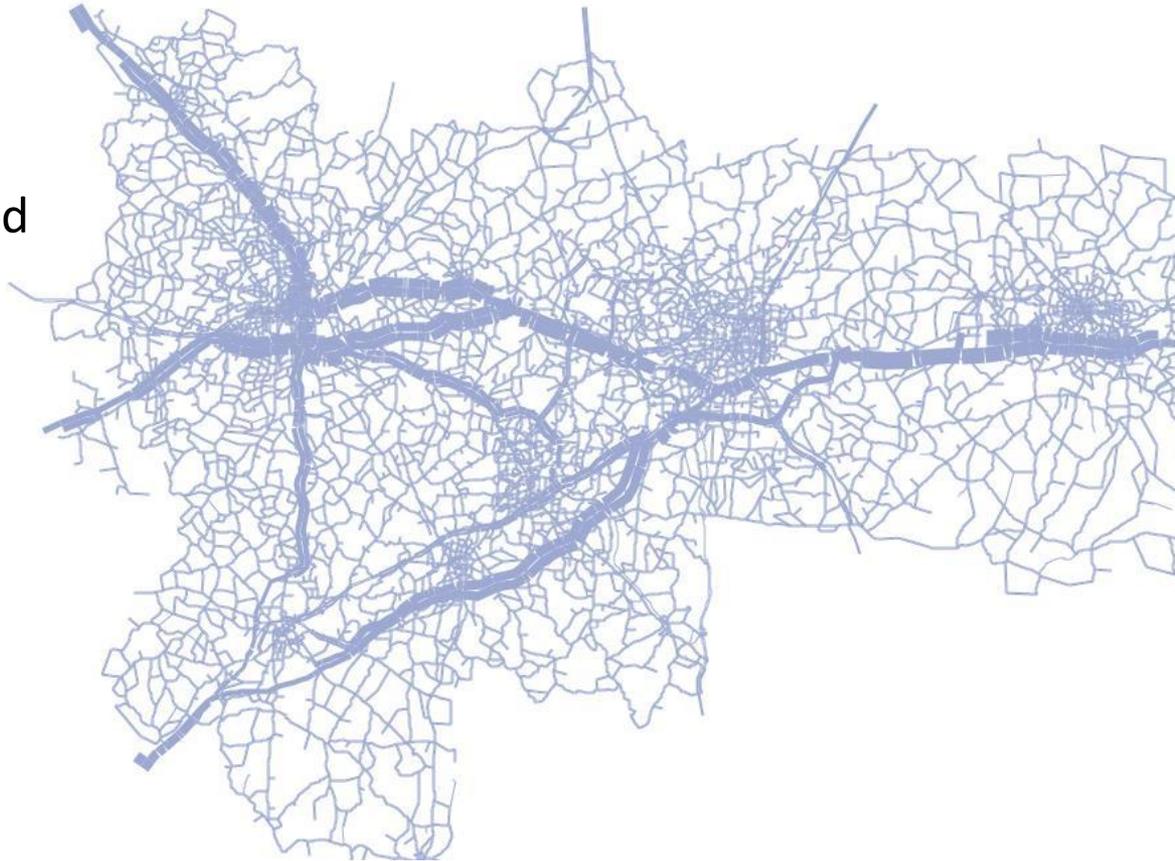Future Employment by Employment Type — Forecast Growth by Employment Type
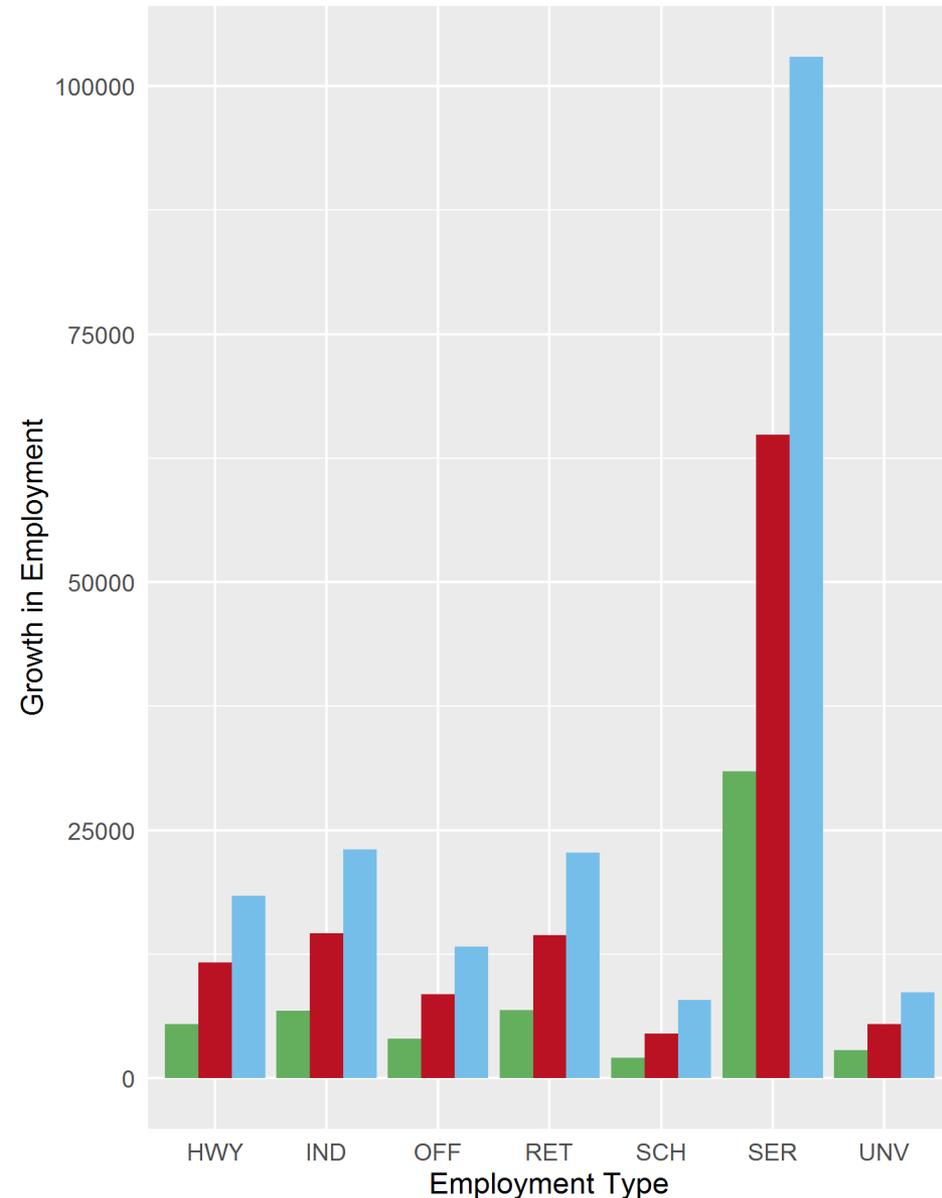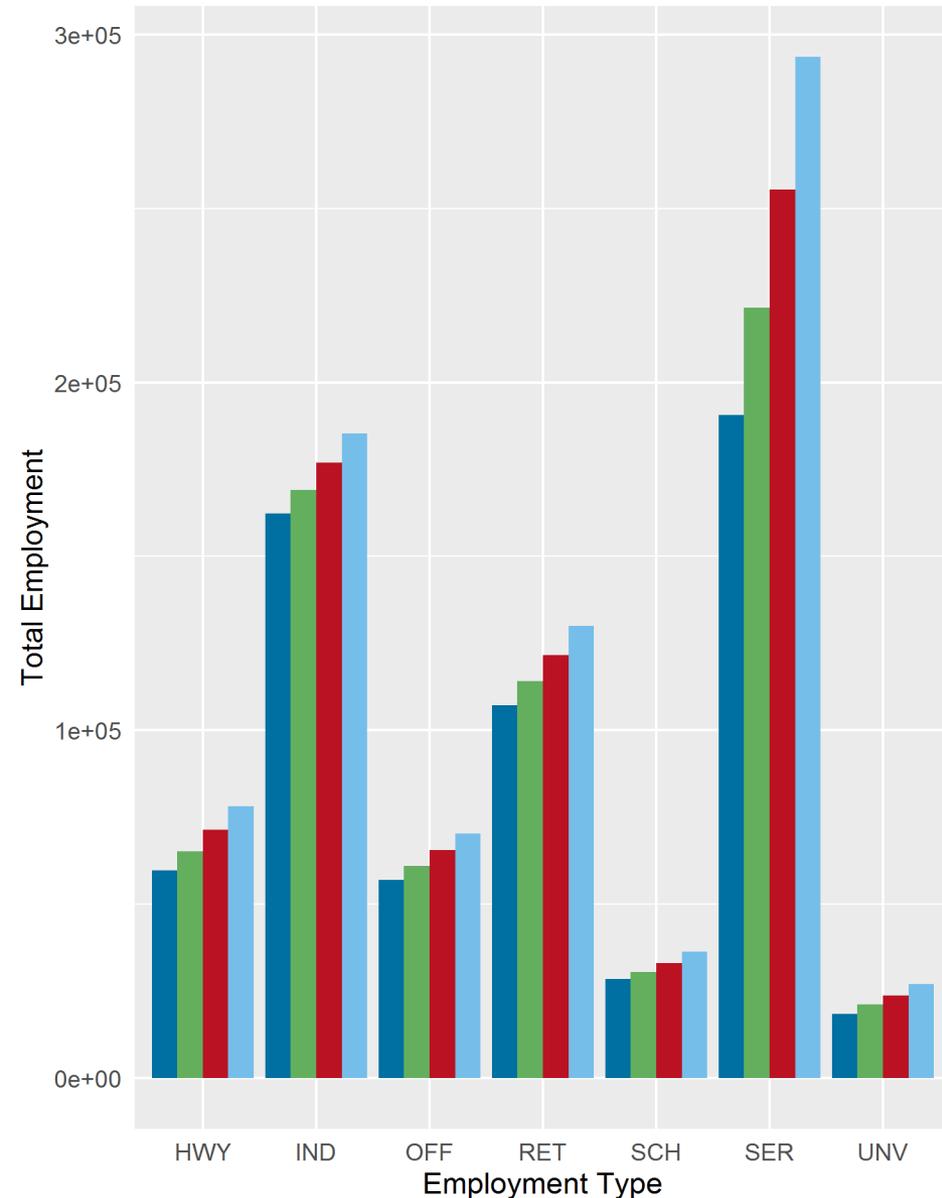
What does the output look like?

You can look at all the data the previous model could provide:

- Total Truck Trips by Type

- Overall Vehicle-Miles Traveled

- Truck Vehicle-Miles Traveled

- % of Traffic by model link

- Select Link Analysis

- Overall Truck Demand

What does the output look like?

But now additional data is available for analysis:

- Tabular, disaggregate data from the four model components:

    1. Firm synthesis: firm location database matched to TAZ SE data with additional synthesized variables

    2. Freight demand: annual shipment database for shipments to and from all freight shipping and receiving businesses in the region

    3. Freight truck touring: tour and trip roster database for all freight truck movements to, from, and within the region

    4. Commercial vehicle touring: tour and trip roster database for all commercial vehicle movements within the region

Firm synthesis Output

Firm location database matched to TAZ SE data with additional synthesized variables
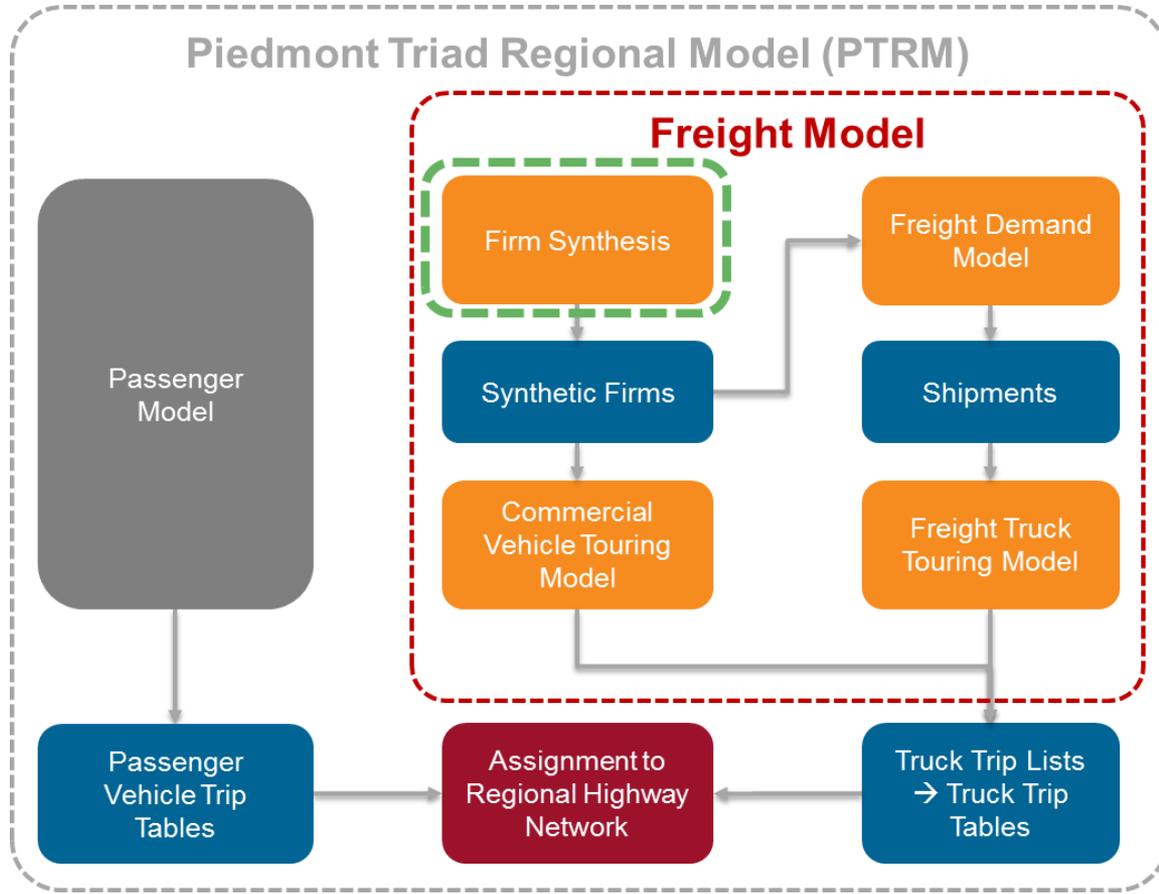
BusID	FAFZone	FIPS	TAZ	SCTG	NAICS6	NAICS4	NAICS3	NAICS2	NAICS6io	Industry10	Industry7	Industry5	Employees	esizecat
1	372	37081	283	3	111110	1111	111	11	1111A0	Agriculture	IND	Industrial	5	1-19
2	372	37081	58	2	111140	1111	111	11	1111B0	Agriculture	IND	Industrial	1	1-19
3	372	37081	339	2	111150	1111	111	11	1111B0	Agriculture	IND	Industrial	3	1-19
4	372	37067	2878	2	111150	1111	111	11	1111B0	Agriculture	IND	Industrial	2	1-19
5	372	37001	4053	3	111219	1112	111	11	111200	Agriculture	IND	Industrial	3	1-19

Freight Demand Output
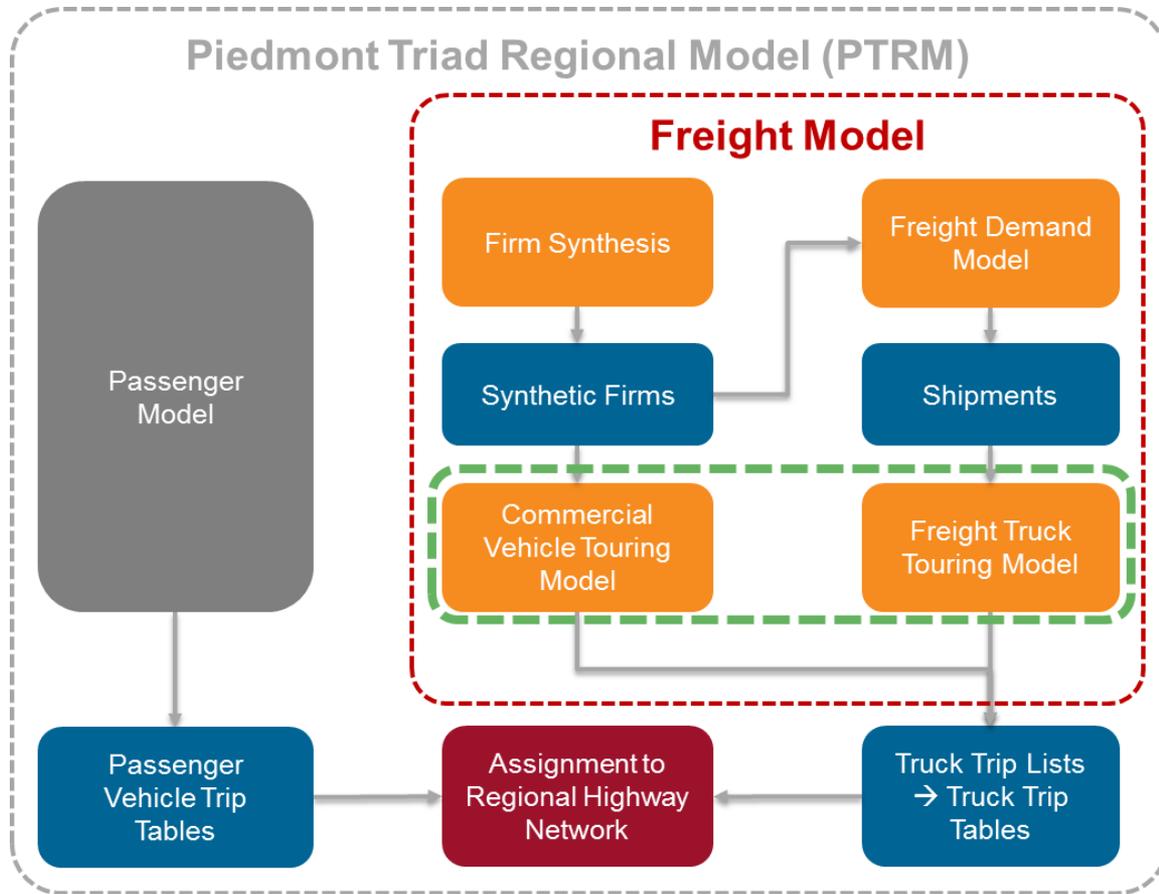
Annual shipment database for shipments to and from all freight shipping and receiving businesses in the region

Piedmont Triad Regional Model (PTRM)

Freight Model
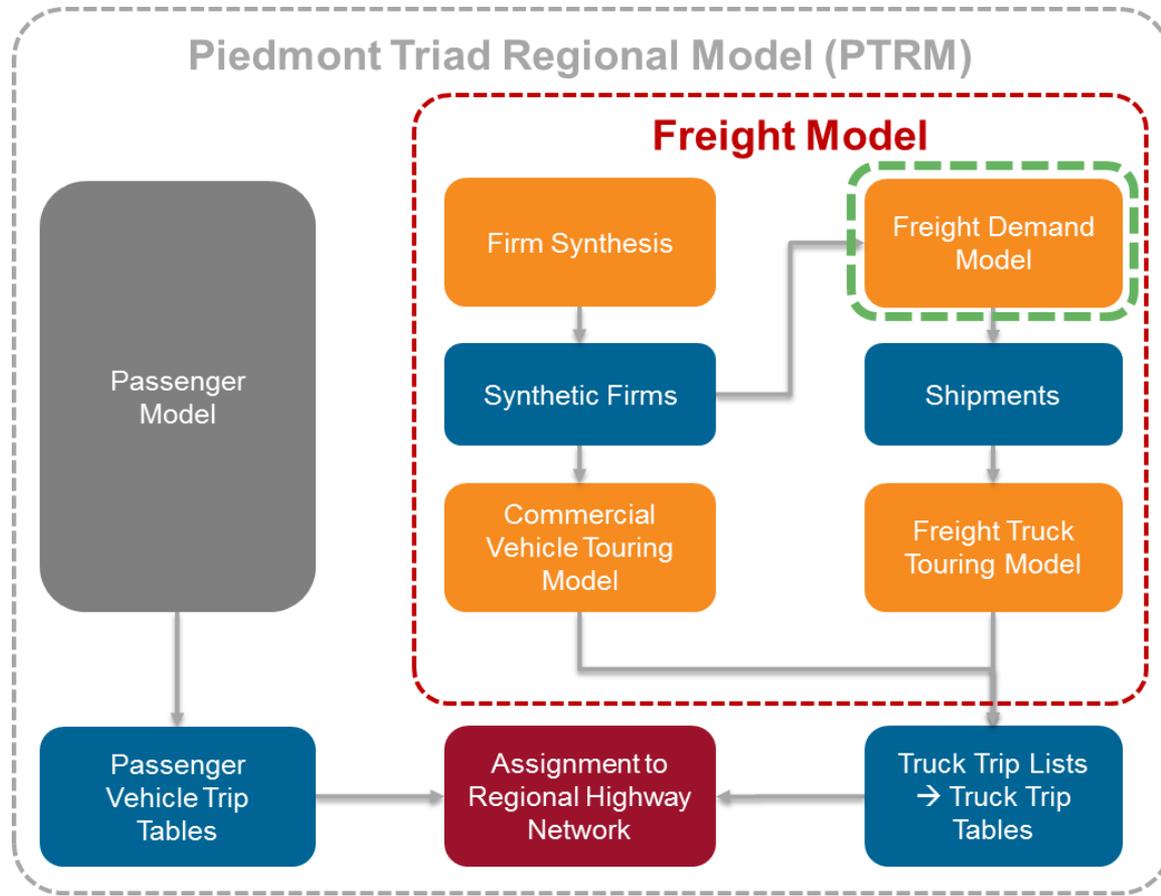
| BusID.Seller	BusID.Buyer	TAZ.Port	SCTG	Movement.Type	ShipmentSize	NumShipments	Channel	DistID
103	35978	NA	1	II	Less than 50 lbs	53	Direct	NA
115	5411	NA	1	II	Less than 50 lbs	4	Direct	NA
97	35335	NA	1	II	50 - 99 lbs	421	Direct	NA
97	33532	NA	1	II	50 - 99 lbs	110	Direct	NA
104	26363	NA	1	II	50 - 99 lbs	4	Direct	NA

Touring Model Output

- Freight truck touring: tour and trip roster database for all freight truck movements to, from, and within the region

- Commercial vehicle touring: same for all commercial vehicle movements within the region


Piedmont Triad Regional Model (PTRM)

Freight Model

Firm Synthesis	Freight Demand Model
Synthetic Firms	Shipments
Commercial Vehicle Touring Model	Freight Truck Touring Model

Passenger Model

Passenger Vehicle Trip Tables → Assignment to Regional Highway Network ← Truck Trip Lists → Truck Trip Tables

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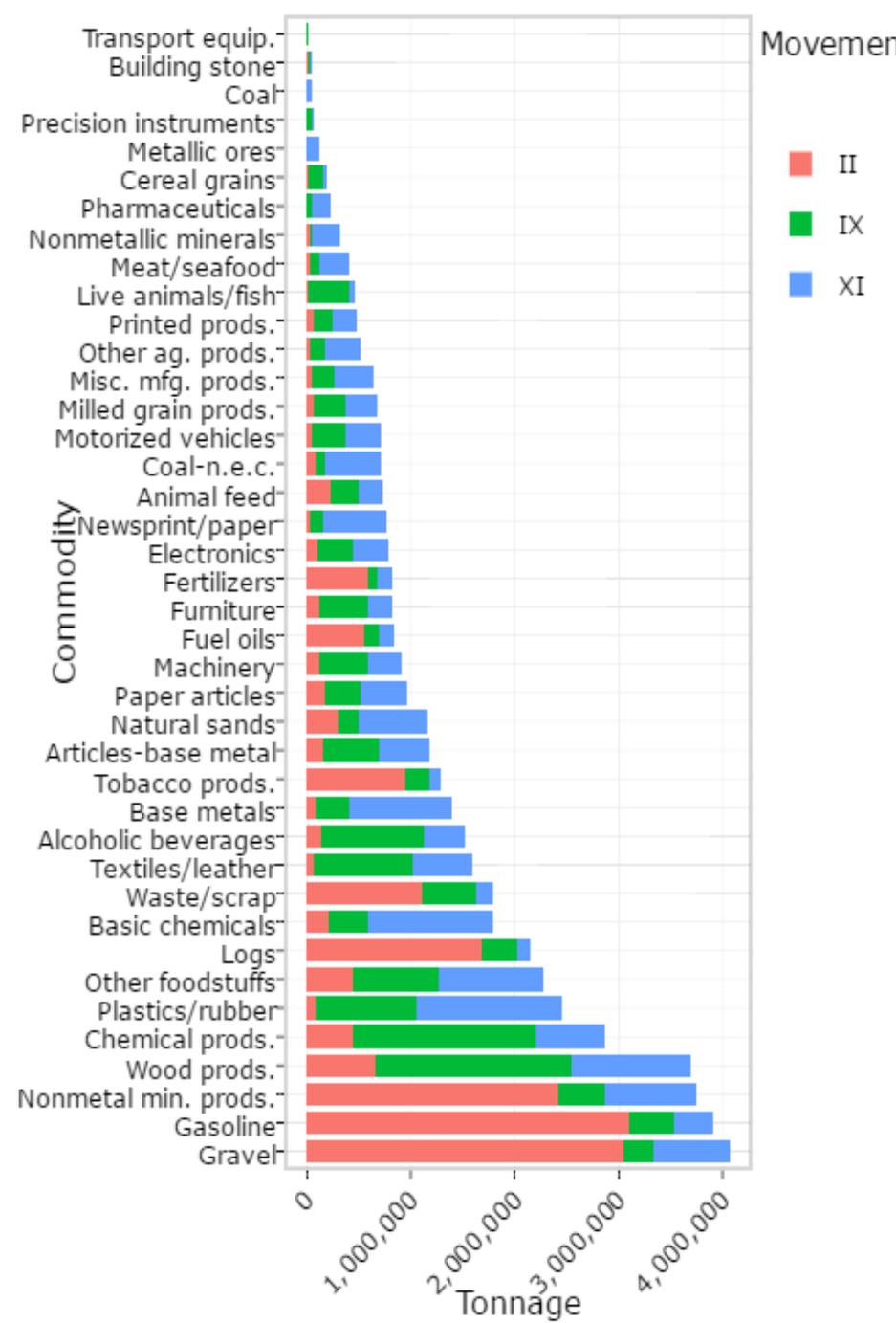# How can these outputs by visualized?

Output dashboard, built at end of each scenario run, provides access to summary charts and maps of outputs from each of the four main freight model components
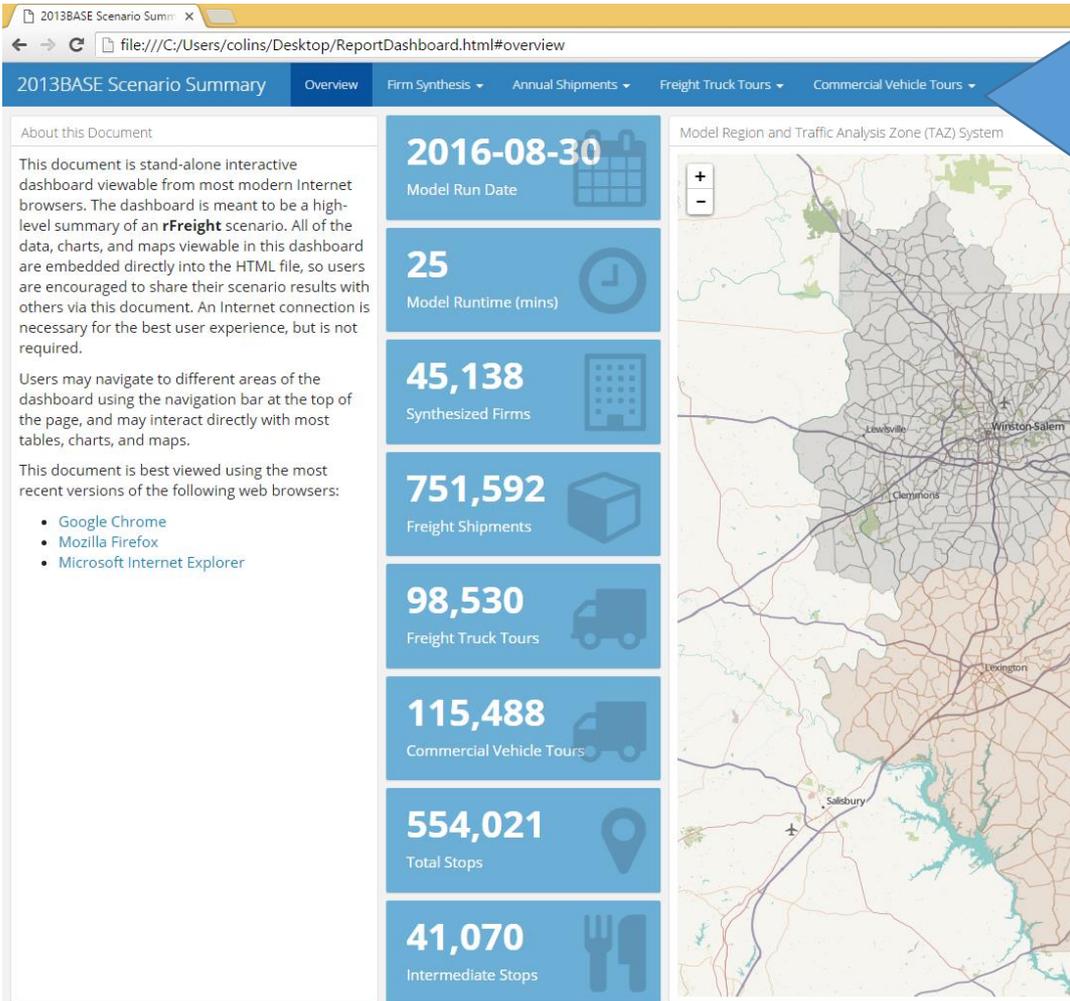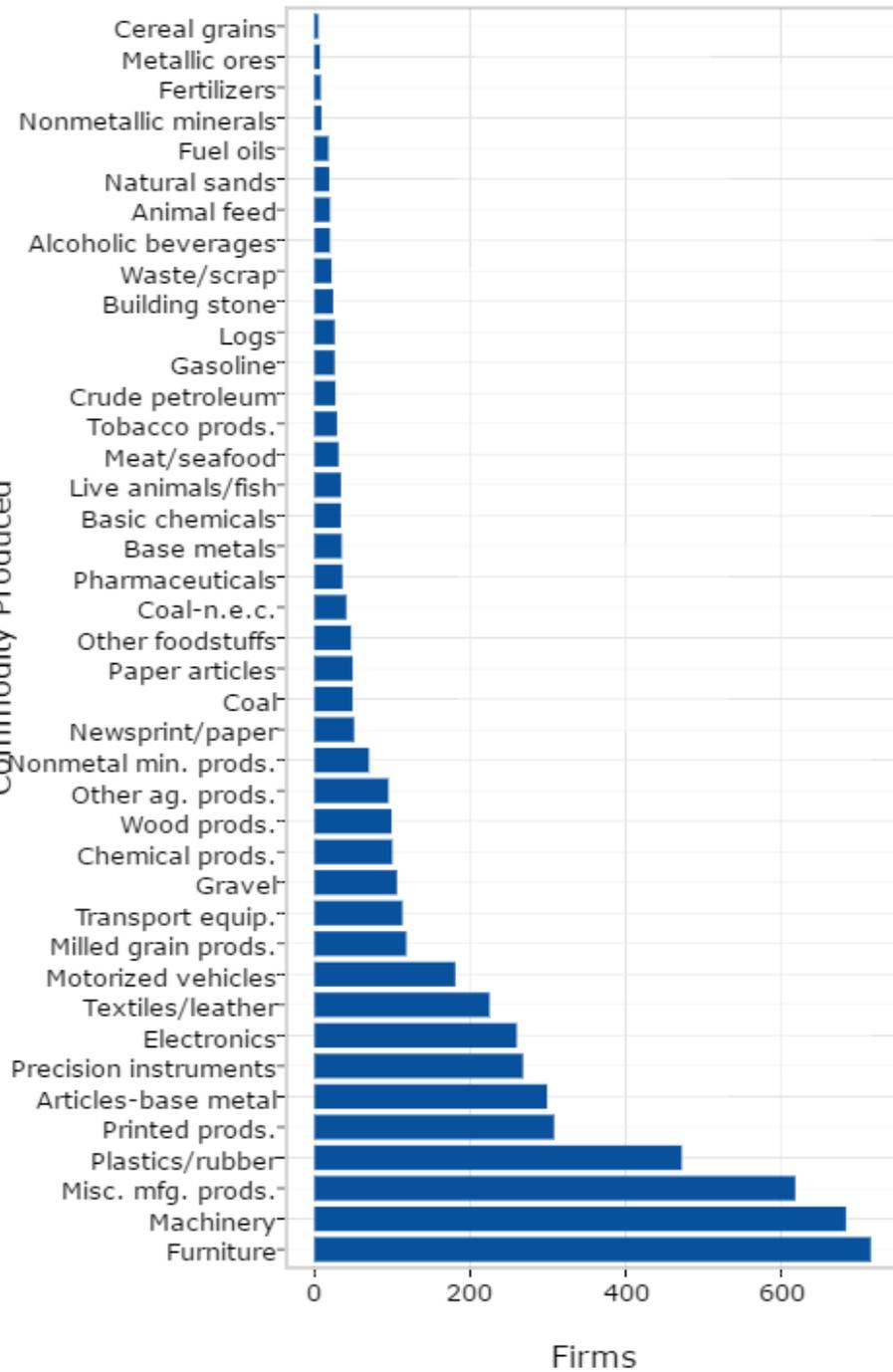
Tour Length by Vehicle for Freight Trucks
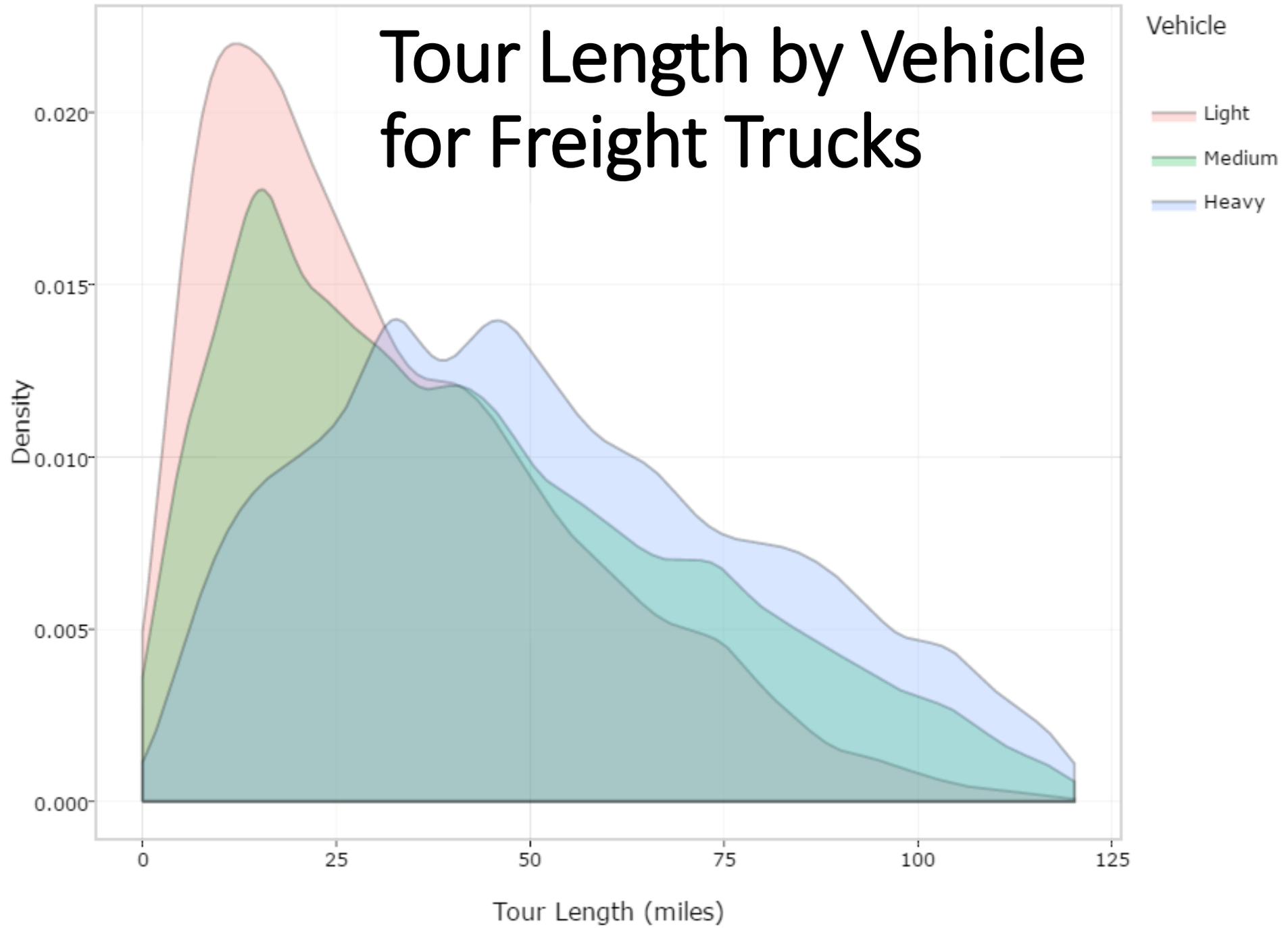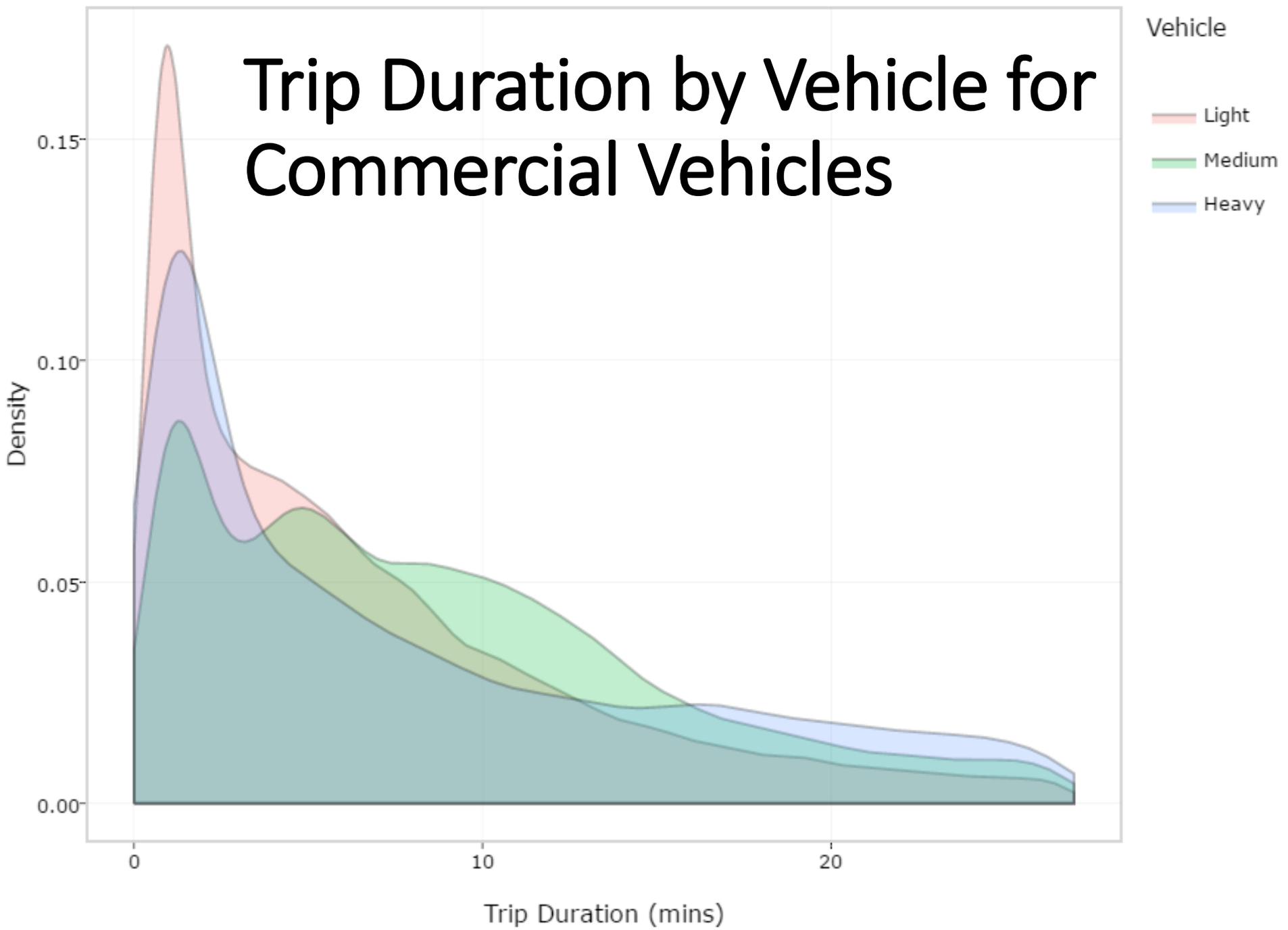
Trip Duration by Vehicle for Commercial Vehicles

What can we do with it ?

- Some examples of analysis we can now do that the old model couldn't:
  - Commodity/shipment movement changes under different SE growth scenarios
  - Analysis of impacts of new freight intensive development
  - Analysis of impacts of new freight node (e.g., distribution center) development
  - Impacts of regional or large scale modal investments that impact freight mode choice to and from the region

Summary

- Completed model development, validation, and sensitivity testing for the phase 2 freight model

- The freight model offers a significant step up for the PTRM's ability to answer freight planning questions

- The freight model includes new tools to support output visualization and scenario analysis

- The recommendations for phase 2 (to be presented later) include new data collection, model enhancements, and additional training