

Assessing Economic Productivity Impacts of Freight Transportation Investments

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The Role of Freight Transportation in Economic Competitiveness

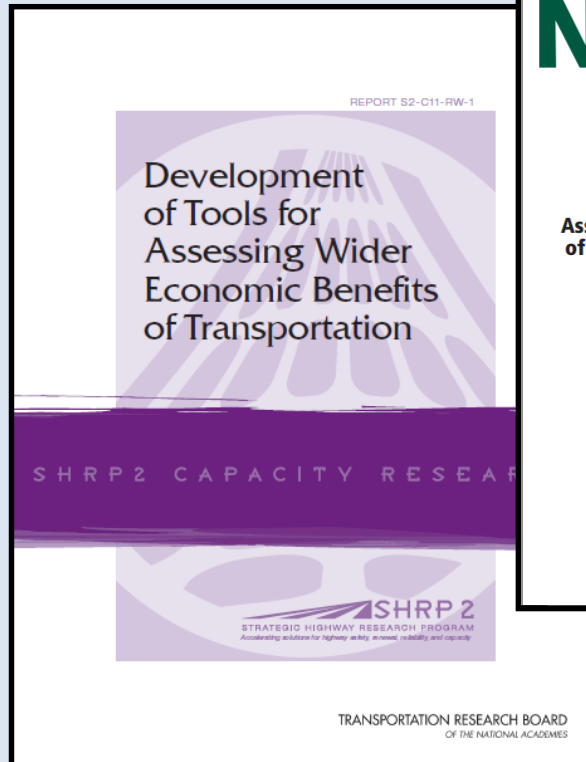
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Terminology

- **Economic Productivity** = Output \$ produced per Input \$
- **Cost Competitiveness** = Input \$ cost per Output \$
- **Economic (Development) Impact** = growth in economy
(from greater competitiveness through 3 mechanisms):
 - **Δ Productivity** → *More Income Generated
(per existing base of labor & capital)*
 - **Δ Export Sales** → *More Inflow of Income & Investment
(expanding business base, due to greater competitiveness)*
 - **Δ Import Substitution** → *Less Outflow of Income (to purchase
inputs, as local production becomes feasibility & competitiveness)*

→ *These are motivations for strategic investment*

Why Assess Productivity Impacts?

Increasing recognition of the role of freight in the economy

“improve the national freight network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development”

– *Map-21 Performance Goal*

“As manufacturers, our ability to move parts from suppliers to our factory—and finished goods from our factory to our customers—relies on the highways, railways, aviation and seaports of America. If we cannot move goods quickly and consistently, we cannot provide the advantage of efficiency to our customers, and we cannot be competitive.”

- *Susan Alt, Senior VP, Volvo*

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Why Assess Productivity Impacts?

- Address the disconnect between:

What we know,
from experience

&

What is captured in
traditional BCA

The importance of:

- Intermodal gateways
- Supply-chain connections
- Reliability

... in supporting cost-effectiveness for businesses and economic development

- Travel time
- Operating costs
- Safety
- Environmental

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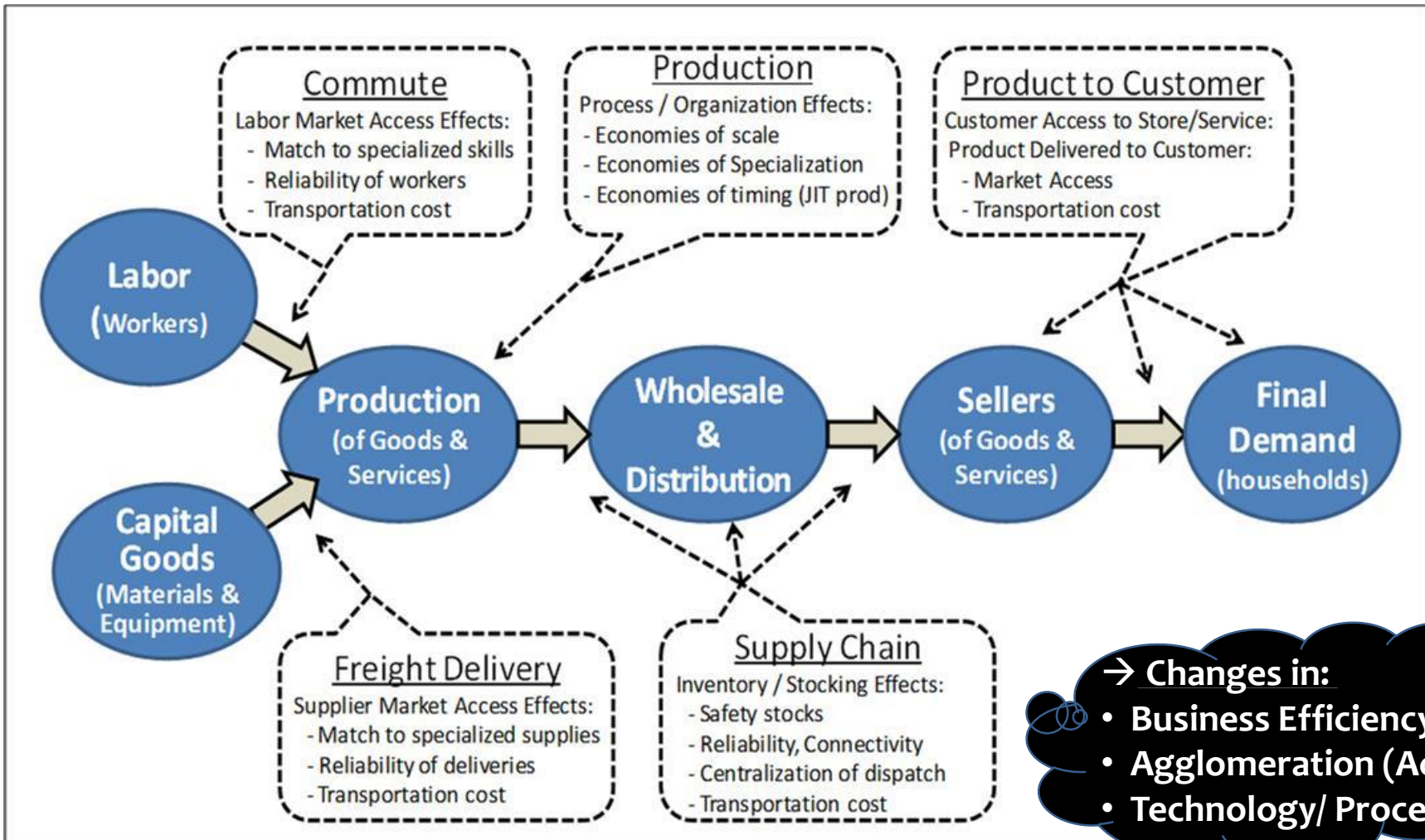
&

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**NCHRP Project 02-24: ASSESSING PRODUCTIVITY
IMPACTS OF TRANSPORTATION INVESTMENTS**

Transportation Effects on Productivity



→ Changes in:

- Business Efficiency (Cost)
- Agglomeration (Access)
- Technology/ Process

3 Key Impact Categories

Reliability

- Reduce buffer time required for on-time arrival
- Avoided costs: labor, inventory & fleet requirements
- Enable new supply-chain technologies

Market Access

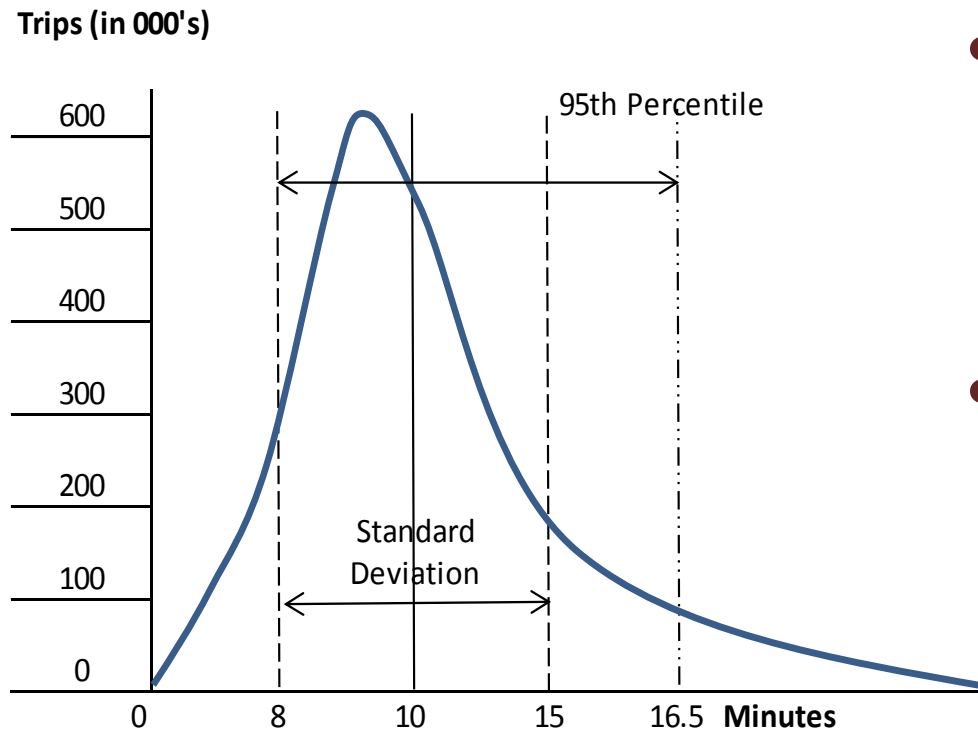
- Access to material input & customer markets
- Improved matching & economies of scale

Intermodal Connectivity

- Increment in access from longer-distance modes
- Rail, marine, air
- Connections extend beyond analysis region

Reliability: Buffer Time Cost

Buffer Time to ensure 95% on-time delivery



Source: SHRP2 C-11 Final Report

- The impact of congestion reduction on **reducing “non-recurring” incident delays**
- The value of improving predictability and **reducing “buffer-time”**

Incorporating Reliability into BCA

- Estimate changes in vehicle-hours of buffer time
 - Capacity expansion/tolling → Changing V/C ratios
 - Incident management systems → Reduction in the frequency/duration of incidents
- Apply per-hr cost factors
 - (Reliability Ratio) x (Value of Time)
 - Basic: Accounts for driver and vehicle operating costs
 - More advanced: quantify commodity-specific reliability/logistics costs

Commodity-Specific Information

❖ Truck Reliability Costs

- f (Buffer Time, Truck Volume, Occupancy, Driver Costs)

❖ Commodity Reliability Costs

- Capital Lock-Up Costs:

f (Buffer Hours, Commodity Value, Capital Costs)

- Perishability Costs:

f (Buffer Hours, Commodity Value, Perishability Factors)

- Supply Chain Costs:

f (Buffer Hours, Commodity Value, JIT Factors)

See: **Stephen Fitzroy, Derek Cutler, and Brian Alstadt**. New Methods for Assessing the Costs of Delay and Reliability on Major Highway Corridors: A Commodity-Focused/Industry Sector Approach for Addressing Freight Planning in MAP-21. (C3) MAP-21 and Disinvestment.

So What? Supporting Corridor-Level Commodity-Specific Analysis

Capital Lock-Up

Differentiate corridors carrying higher and lower-value goods

- E.g. Motor vehicle parts (\$8,732/ton) versus Ready-Mix Concrete (\$69/ton)

Perishability Costs

Identify corridors carrying commodities with high perishability

- E.g. Fresh fruits, vegetables, fish, and dairy products

Supply Chain Costs

Identify corridors carrying commodities whose disruption would impose costs on just-in-time supply chains

- E.g. Electronics, advanced machinery

Market Access

- Improved freight access to material inputs and customers
- Enables traditional time/cost savings, *and...*
- ...offers productivity improvements from economies of scale and improved matching between buyers and suppliers

Market Access

- Multiple measures of access:
 - Employment as a generic measure of economic activity
 - Breadth of the one-day delivery market – Employment within a 3-hour drive
 - “Effective density” – the sum of all employment in surrounding zones, weighted by an inverse function of impedance (e.g. travel time/cost)

Intermodal Connectivity

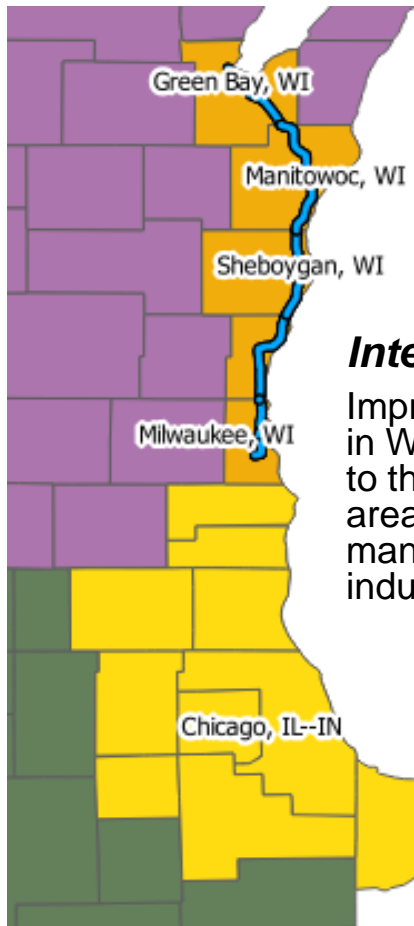
- A special case of market access
 - *Intermodal (rail, air, marine) terminals provide access to broader customer markets, depending on ground access, connecting services (volume, destinations, frequency & speed), and connection dwell time.*



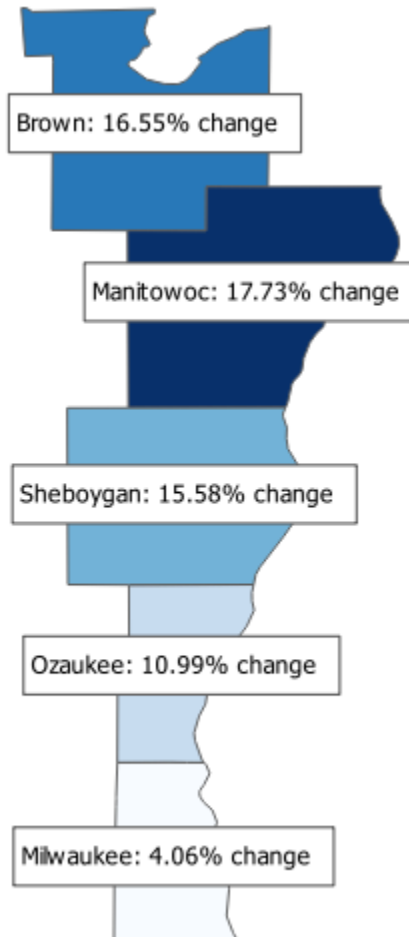
(cities within 2 hours total travel time from downtown Boston, based on driving a car or flying to destinations that have hourly or more frequent air service during business hours)

Elasticity Response to Improved Access

Elasticity: % change in productivity due to a % change in access



Interstate 43
Improved access in Wisconsin and to the Chicago area for local manufacturing industries



- 1) Calculate % change in Effective Density from transportation improvement
- 2) Multiply by appropriate elasticity (in this example: manufacturing access for buyer-supplier connections)

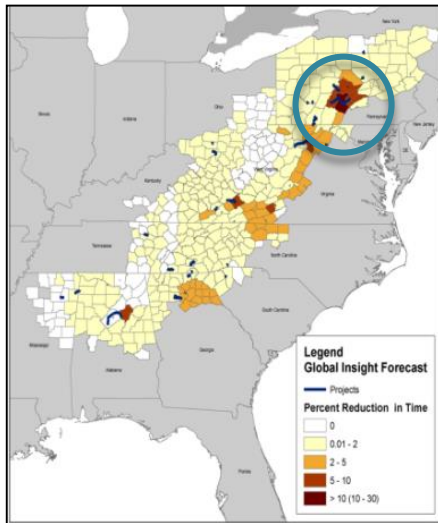
E.g. Brown County:
(16.55% change in access)
x (0.04 elasticity) =
0.66% change in productivity

Geography & Types of Access

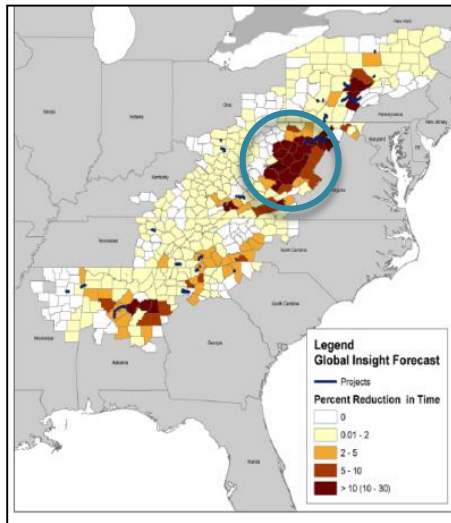
- Access is the joint result of transportation performance and the geographic distribution of economic activities

Completing the Appalachian Development Highway System: Areas with Change in Accessibility (by type)

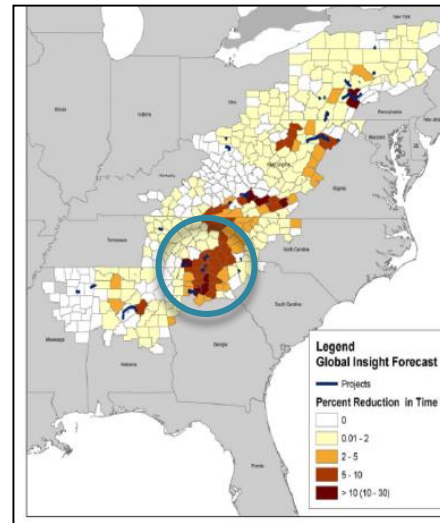
International Airport



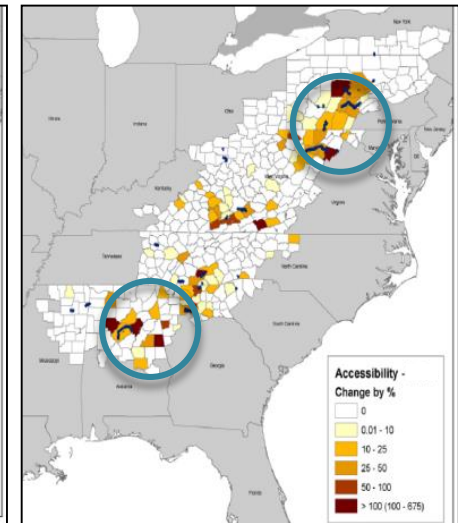
Intermodal Rail



International Port



Same Day Delivery



Source: *Economic Impact Study of Completing the Appalachian Development Highway System*. 2008.

Industry Sensitivity

- Industry sensitivity to access varies by type

		Sensitivity to Access Measure (1-10 scale)			
		40-min Market	3-hr Delivery Market	Commercial Airport	Rail Intermodal
NAICS	Sector				
Resource	212-213 Mining	3	0	4	5
	311 Food	3	0	0	0
Resource Based-Mfg	312 Beverage	10	0	0	3
	313 Textile Mills	5	5	2	3
	314 Textile	5	10	0	0
	315 Apparel	5	5	0	0
	316 Leather	5	3	2	5
	321 Wood	0	5	0	5
	322 Paper	0	5	0	5
Durables Mfg	323 Printing	10	0	7	0
	324 Petroleum	6	0	0	0
	325 Chemical	5	3	4	3
	326 Plastics	8	10	0	3
	327 Nonmetal Mineral	5	5	2	0
	331 Primary Metal	3	5	4	0
	332 Fabricated Metal	10	5	2	0
	333 Machinery Mfg	0	5	2	0
	334 Computer	3	5	2	3
	335 Elec Appliances	0	10	3	0
	336 Transport Equip	5	5	3	3
Trade & Distrib	337 Furniture	5	10	3	0
	339 Miscellaneous Mfg	5	5	5	0
	420 Wholesale Trade	10	0	3	0
	441-454 Retail Trade	8	3	3	5
	481-487 Transportation	5	0	3	0
	491-493 Del & Warehousing	10	0	2	3
	511 Publishing	10	0	0	0
Tech/ Services	512 Movie & Sound	10	3	9	0
	513 Broadcasting	10	0	5	0
	514 Internet & DP	8	3	5	0
	521-531 Finance, Insurance	10	0	3	0
	541-551 Prof. Scien Tech	10	3	10	0

For example:

Resource industries are sensitive to rail access;

Manufactured goods require one-day truck delivery markets;

And technical/service industries tend to rely more on labor market and airport access

Source: Alstadt, Weisbrod, and Cutler. The Relationship of Transportation Access and Connectivity to Local Economic Outcomes: A Statistical Analysis. Economic Development Research Group, published in Transportation Research Record, No 2297, 2012.

Refinements: Supply Chain

- We have the opportunity to differentiate even more, based on our knowledge of supply-chain relationships
- E.g. study productivity response (elasticity) to improved access to material inputs required by a particular industry:

Access to inputs for industry x, in zone k

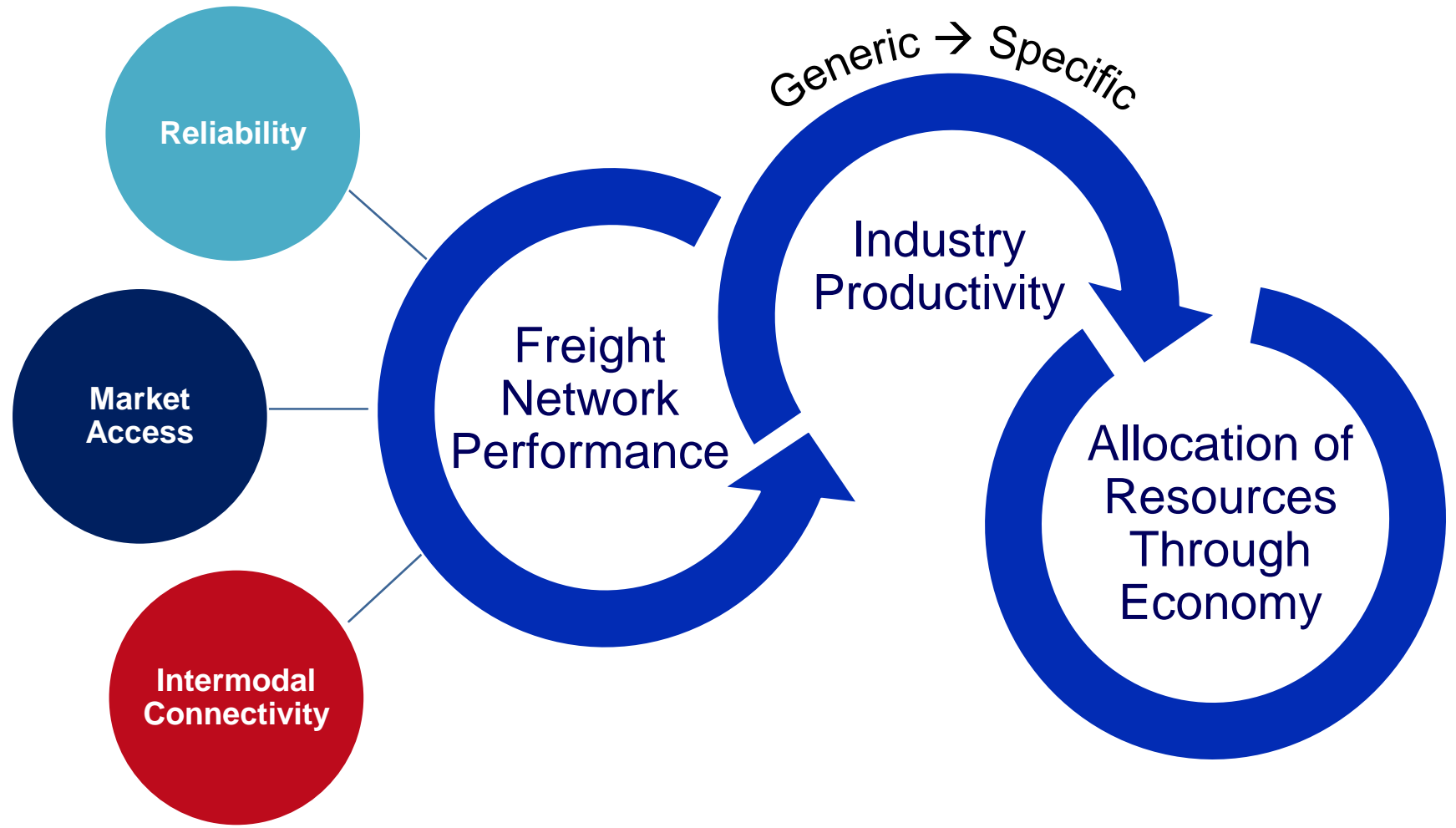
$$AI_{kx} = \sum_c \left(\sum_m \left(\frac{E_{cm} P_{xm}}{P_{xM}} \right) d_{ck}^{-\alpha} \right)$$

Discounted by a function of the travel time/cost required to access the input

Sum overall all zones c and all supplier industries m

Employment (activity) in each supplier industry, weighted by how important that supplier industry is to the target industry

Indicator proposed in: Drucker, Joshua and Edward Feser. Regional industrial structure and agglomeration economies: An analysis of productivity in three manufacturing industries. 2012. Regional Science and Urban Economics.



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Thank you!