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Tour-based and Supply Chain Modeling for Freight in Chicago

Prepared for:
Expert Panel Meeting

Prepared by:
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Colin Smith
Kaveh Shabani

September 19, 2013

Meeting Agenda

Introduction and Opening Remarks	Kermit Wies, CMAP	9:00 – 9:10

- Objectives of this peer exchange

Project Context	Colin Smith, RSG	9:10 – 9:30

- Review and summary of existing mesoscale model
- Project objectives

Proposed Model Design	John Gliebe & Kaveh Shabani, RSG	9:30 – 10:50

- Overview of proposed model design and changes to mesoscale model
- Discussion of key concepts:
  - Defining agent typologies
  - Agent-based computational economics
  - Illustration of procurement market game
  - Supply chain as an activity network
- Response Sensitivity and Forecasting

Break	All	10:50 – 11:00
Implementation and Testing Plan	John Gliebe, RSG	11:00– 11:15
Panel and Peer Q&A	Colin Smith, RSG facilitator	11:15 – 12:00

- Opportunity for panel members and other distinguished guests to ask questions and provide recommendations

Adjourn	All	12:00 p.m.

Introduction and Opening Remarks
Kermit Wies, CMAP

Project Context
Colin Smith, RSG

- Review and Summary of Existing Mesocale Model
- Project Objectives

FHWA BAA Research: Project Context

Identify a framework that can be adopted by MPOs in the U.S. for use in evaluating transportation investments and their impacts on freight mobility.

Current freight forecasting methods do not address complexities of freight demand.

- The lack of detail at the traffic analysis zone level
- The lack of information about the local pickup and delivery trips
- The need to estimate shifts in long-haul and short-haul demand resulting from regional investments
- The ability to capture trip-chaining that occurs
- The need to represent commodities produced and consumed by different industries

RSG developed the current CMAP mesoscale freight model during this project funded by FHWA. The work built on earlier work by UIC and Cambridge Systematics, and added in new model components estimated using datasets from around North America

Mesoscale Freight Model Steps

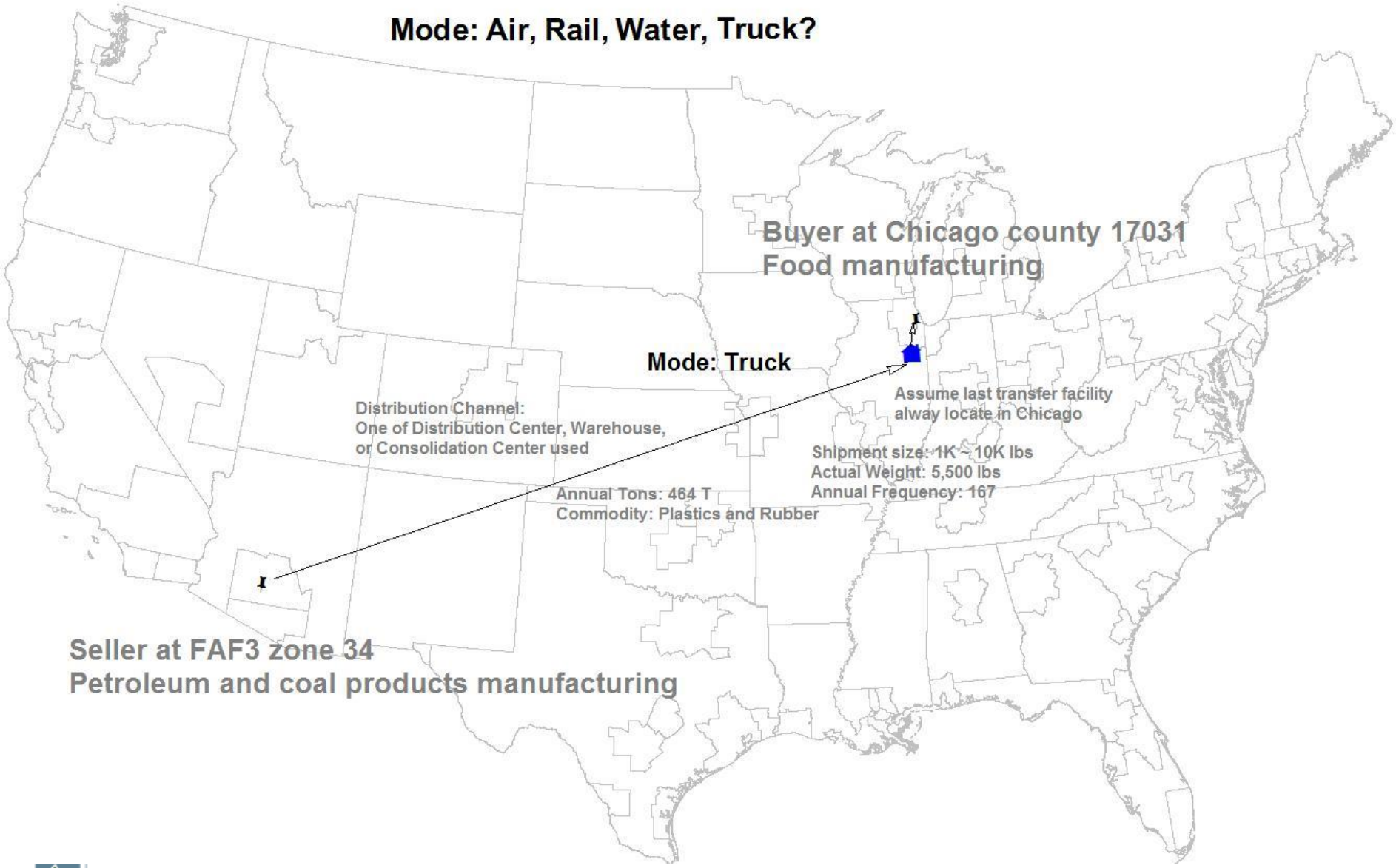
National Scale

- **Firm Synthesis** — Synthesizes a list of businesses in Chicago, the rest of the US, and an international sample
- **Supplier Selection** — Connects suppliers to buyers based on the commodities produced by the supplier and consumed by the buyer
- **Goods Demand** — Distributes commodity flows amongst the paired suppliers and buyers
- **Distribution Channel** — For each buyer/supplier pair, selects whether shipments are direct or involve intermediate handling (intermodal, distribution center)
- **Shipment Size** — For each buyer/supplier pair, converts an annual commodity flow to shipments by size and frequency
- **Mode and Transfers** — Identifies the mode for each leg of the trip from supplier to buyer and the transfer locations

Regional Scale

- **Truck Touring Model** — The local deliveries and picks up in the Chicago area are simulated using a truck touring model

Model Sequence: National Scale Models



Firm Synthesis

Firms are synthesized for the entire U.S. with a high level of industrial sector detail, and across several employment size categories

NAICS Groups	1-19	20-99	100-249	250-499	500-999	1,000-2,499	2,500-4,999	Over 5,000	Total
Agriculture	631,703	83,328	11,941	2,897	954	382	46	13	**731,264**
Mining\Construction	774,697	73,607	10,090	3,711	2,363	1,900	1,744	1,716	**869,828**
Manufacturing	228,381	74,451	18,942	6,170	2,384	828	143	49	**331,348**
Transportation\ Wholesale\Retail	1,518,135	214,956	34,082	7,305	1,536	393	71	34	**1,776,512**
Information\Finance\ Professional Services	2,094,868	186,140	32,431	10,141	4,336	1,737	295	97	**2,330,045**
Education\ Healthcare	731,344	110,504	20,120	4,523	2,168	1,748	435	157	**870,999**
Entertainment\ Recreation\Food	558,052	186,140	11,069	1,522	576	269	43	15	**757,686**
Other Services	694,640	45,377	3,409	548	163	40	12	3	**744,192**
Total	**7,231,820**	**974,503**	**142,084**	**36,817**	**14,480**	**7,297**	**2,789**	**2,084**	**8,411,874**

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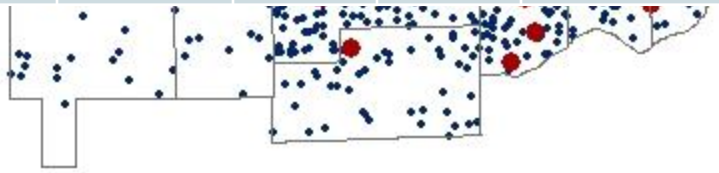

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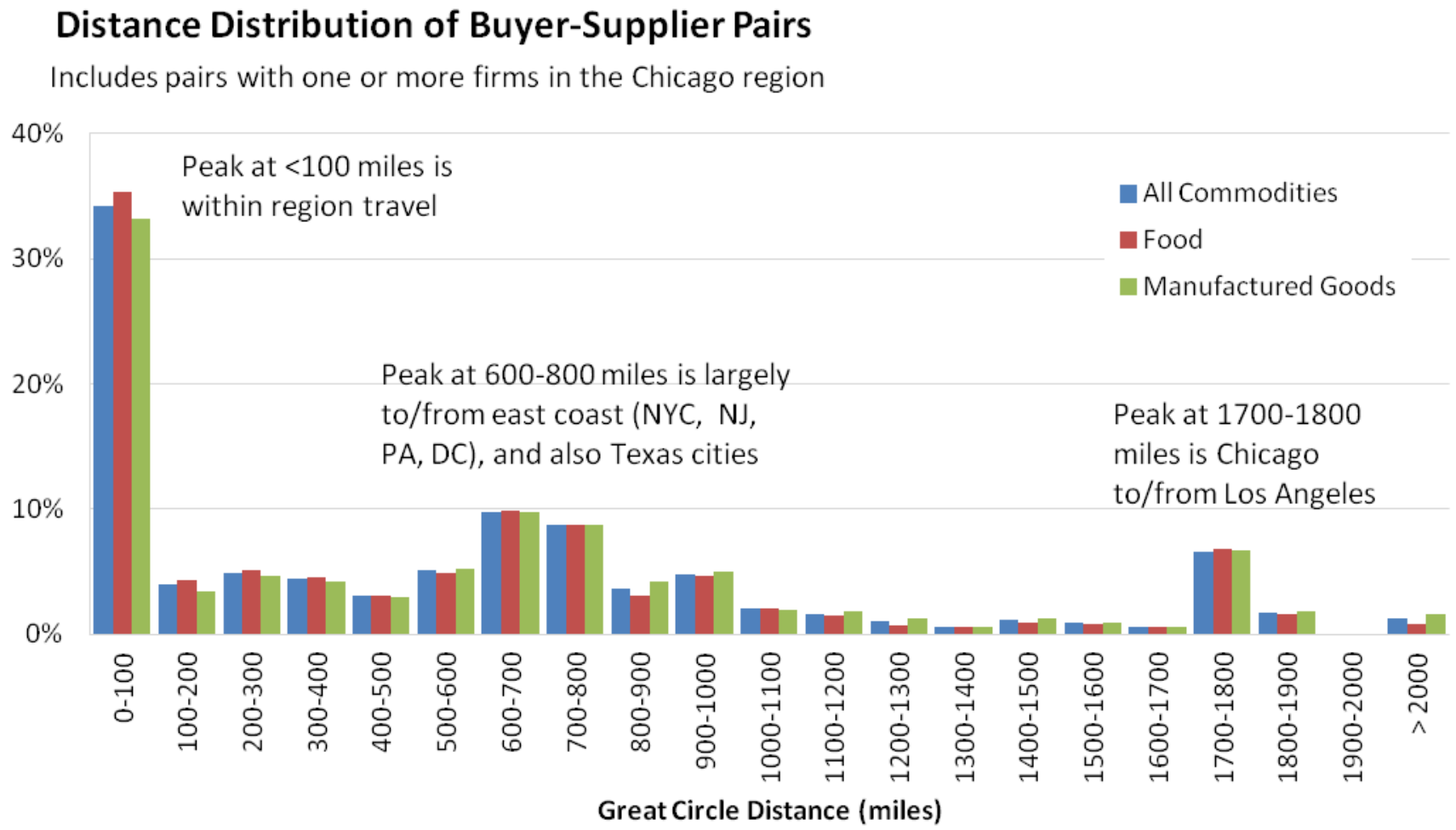
Supplier Selection

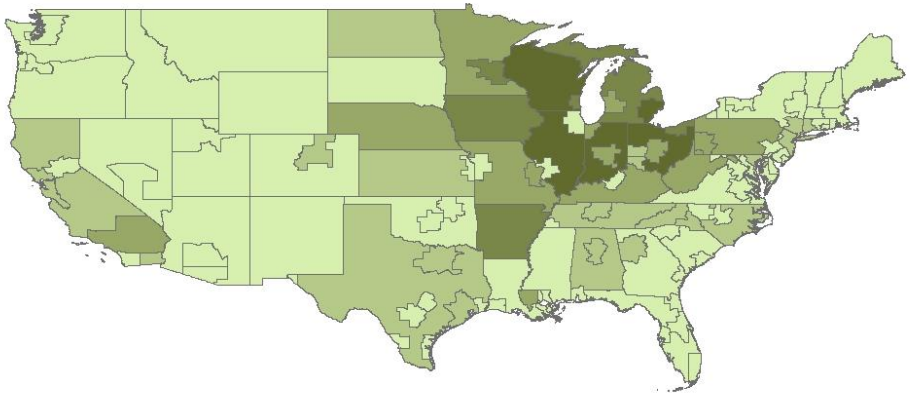
Buyers are paired with suppliers for each of the commodities that the buyer requires.



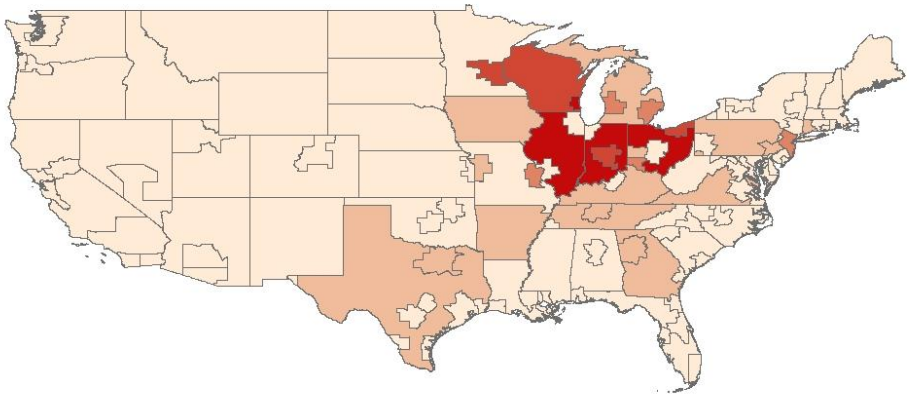
Goods Demand

Distributes commodity flows amongst the paired suppliers and buyers

- Based on employment at consuming firm
- Input/Output account data is used to estimate the value of each commodity used by each employee
- FAF commodity flow data is apportioned across the firm pairs
- Model therefore conserves the commodity flows, which are taken as fixed inputs



Manufactured good flows from Chicago

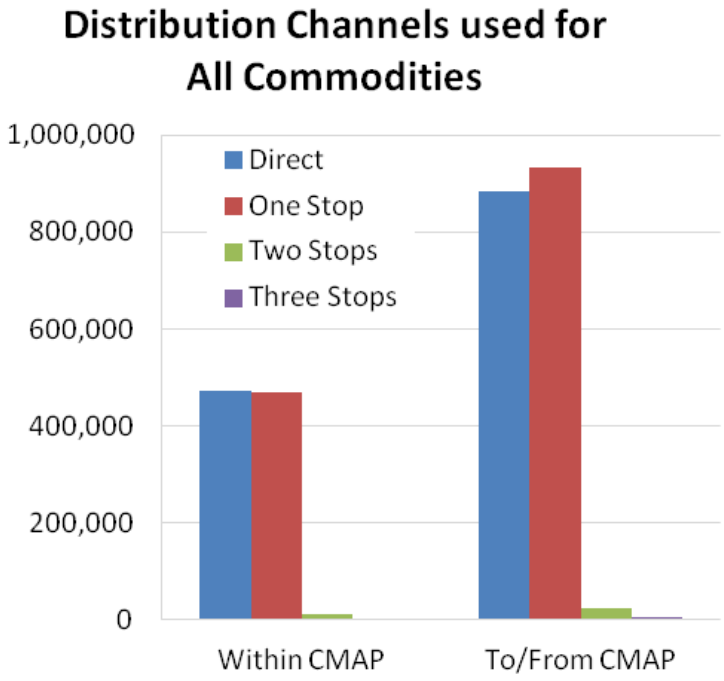


Manufactured good flows to Chicago

Distribution Channels

Multinomial Logit Model with 4 choices: direct shipment (no distribution center) and then 1-3 stops

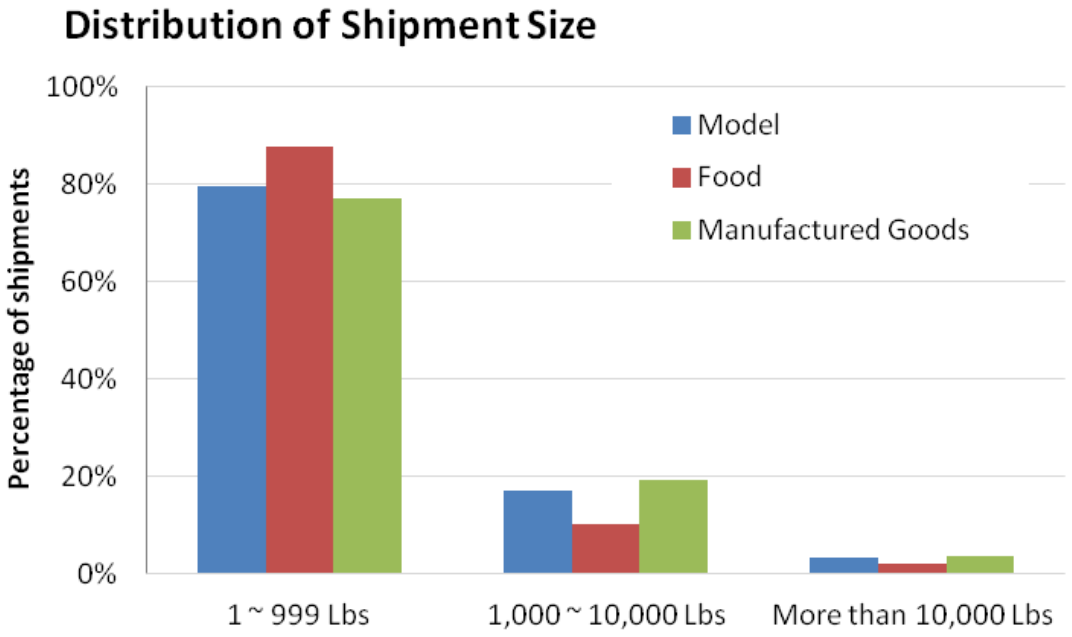
- Estimated using FAME shipment survey data collected by UIC (relatively small sample of data)
- Models estimated for food and manufactured goods (two commodity groups with largest samples in FAME data)
- Variables include firm size, supplier industry and buyer industry, distance
- Relatively even split for those commodities between direct shipments and via a distribution center (but likely not necessarily the case for other commodities)



Shipment Size

Multinomial Logit Model with 3 choices: < 1000 lb, 1000-10,000lb, and more than 10,000 lb

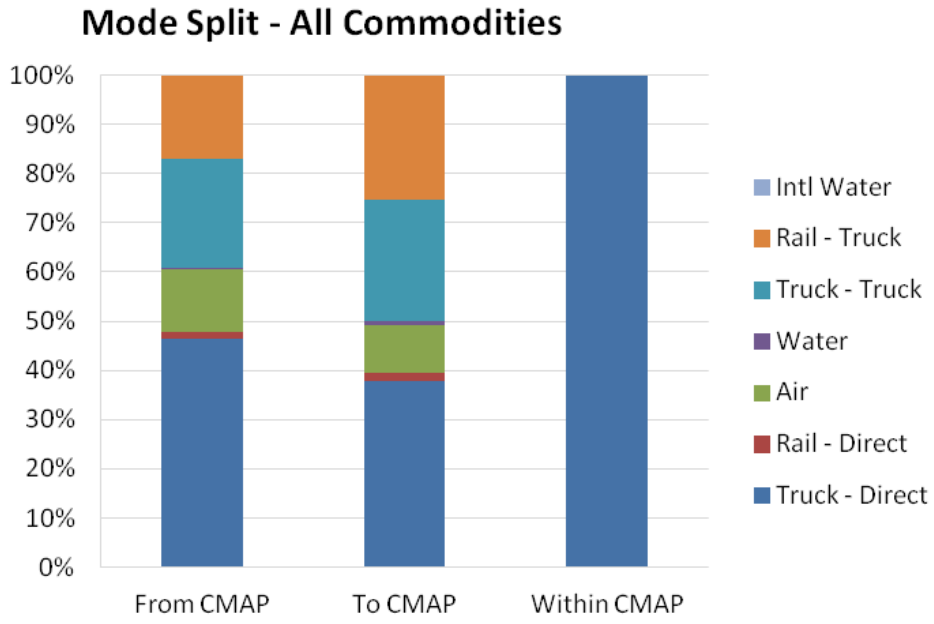
- Estimated using the Texas Commercial Vehicle Survey
- Small shipments (<1,000 lb) make up the largest proportion of shipments
- There is relatively little variation between the commodities: a slightly higher proportion of food shipments are small
- Actual shipment weights are drawn from the observed distribution within each category



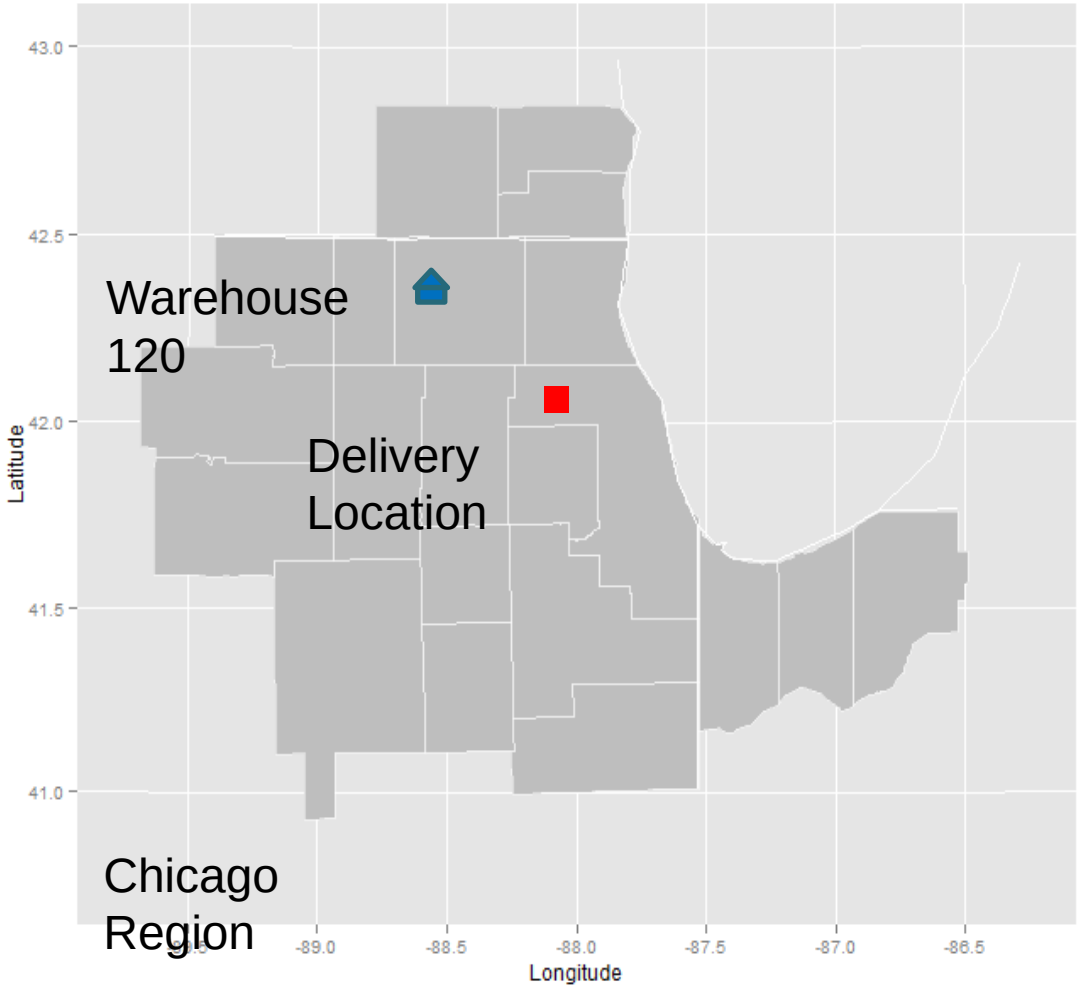
Mode and Path Choice

Mode choice model evaluates 54 alternatives by calculating the total logistics cost of transporting the shipment from supplier to buyer

- Logistics cost formulation will be described later in the meeting
- Alternatives include different modes: truck (FTL, LTL), rail (IMX, Carload), Water (River/Coastal, Deep Sea), Air
- Alternative paths include Chicago area airports, sea ports, rail yards, and truck facilities used for intermodal transfer



Convert to Daily Shipments and Select Warehouse



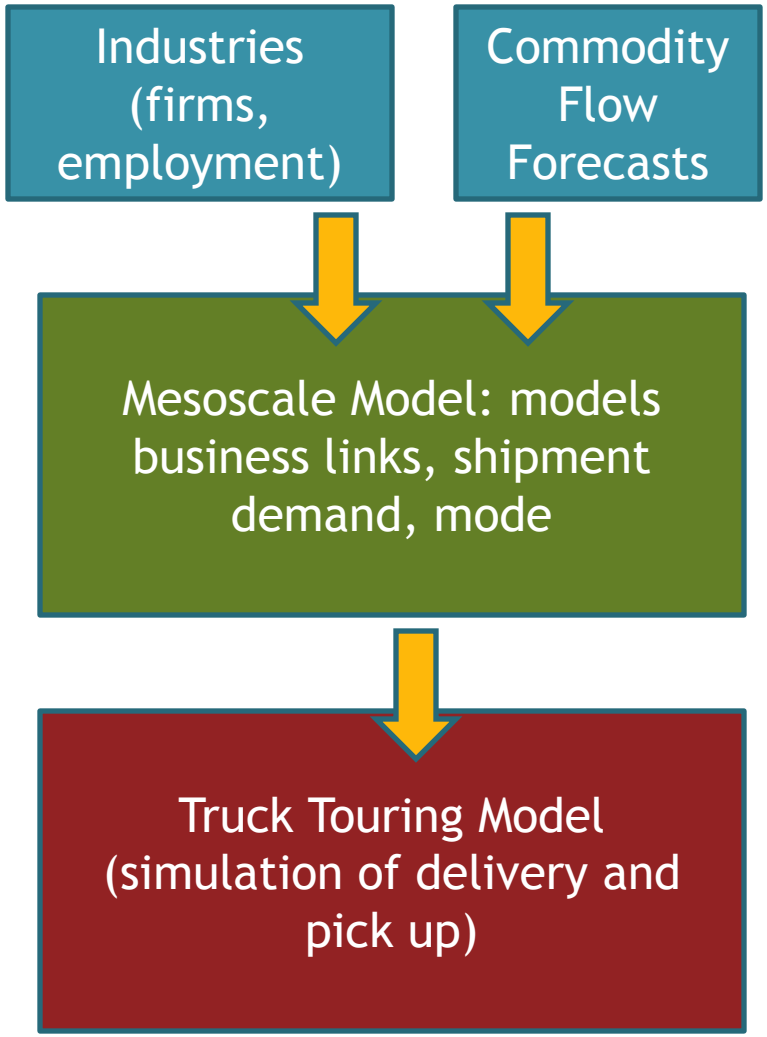
- Convert annual to daily shipments
- Identify warehouse/ distribution center locations from the synthesized business establishments
- Assign shipments to a warehouse/ distribution center

Application Development in R

- **Scripting Software**
  - R version 2.14
- **Runtime**
  - Total run time is 80-90 minutes
- **Hardware**
  - Manufacturer: HP Z200 Workstation
  - Processor: Intel Core i7 CPU 870 @ 2.93 GHz
  - Installed RAM: 12.0 GB
  - OS: Windows 7 Professional (64-bit)

Model Component	Run Time (minutes)	Notes
Firm synthesis	13	Synthesize 8 million firms and choose buyers (7.5 million) and suppliers firm types (1.4 million) for CMAP simulation
Supplier selection	24	Match supplier firm types for about 3 million firms
Supply chain and goods demand	19	Apportion FAF flows for 3 million buyer supplier pairs and locate 8 million firms to mesozones
Distribution channel	1.0	Predict distribution channels for 3 million buyer-supplier pairs using logit shares
Shipment size	1.5	Estimates annual shipment size and frequency
Mode-Path selection	20	Evaluation of annual logistics and transport costs for 54 mode-paths
Vehicle choice and tour pattern	1.5	Daily simulation for 300k deliveries\pick-ups from warehouses
Stop clustering and sequencing	1.5	Clusters and sequences stops on tours
Stop duration	0.2	Estimates stop duration
Time of day	1.5	Constructs tours from start time and stop duration

Project Objectives



Existing model system:

- National data describe the economic system that leads to the demand for freight movement
- Commodity Flow data from FAF is a fixed input
- As national and local scale there are implemented models that handle the simulation of shipments and truck delivery activity
- The model system is not responsive to macro level economic changes and contains a simple, rule based approach to forming trading relationships

Project Objectives

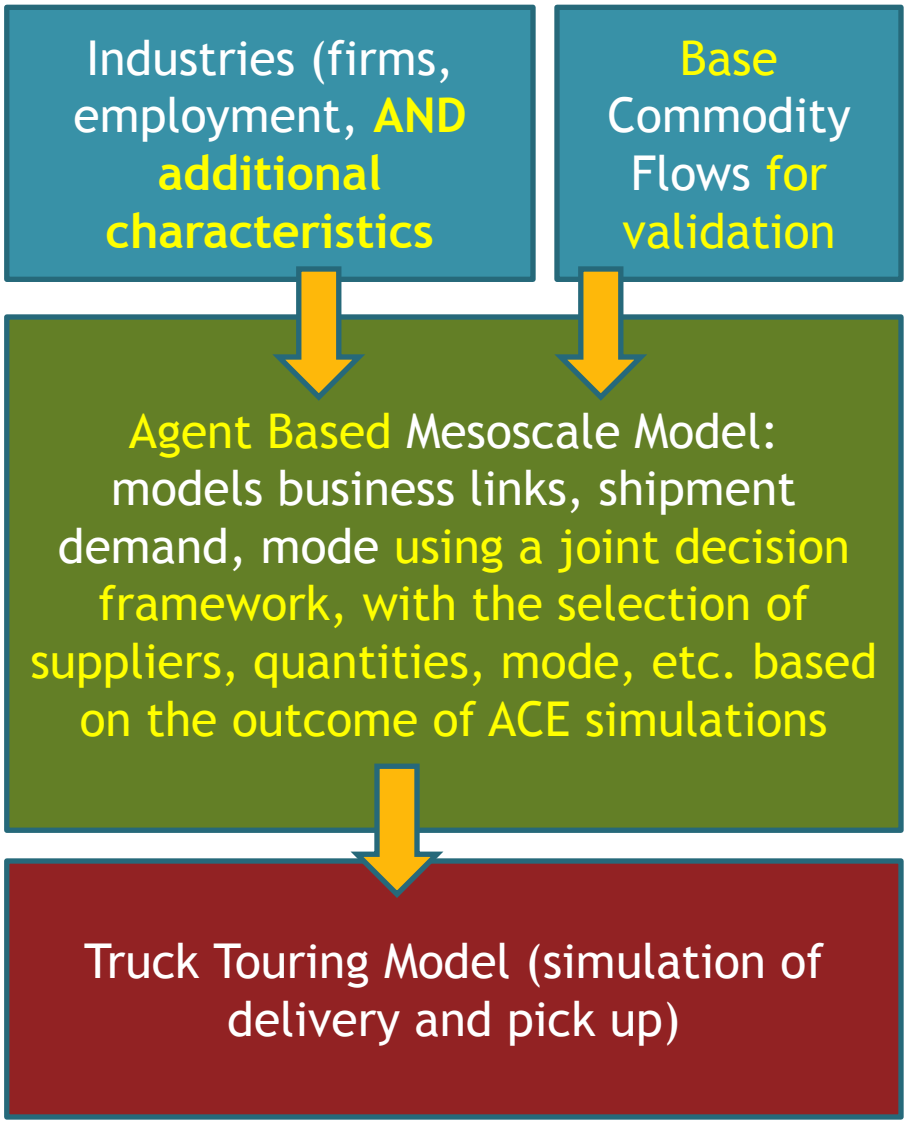
Proposed model system requirements:

Commodity flow forecasts that are responsive to:

- macroeconomic conditions
- large-scale infrastructure changes
- technological shifts in logistics and supply chain practices
- and other assumptions and scenario inputs

Key features design features:

- Endogenous commodity flow prediction
- Improved representation of foreign trade
- Response to price signals



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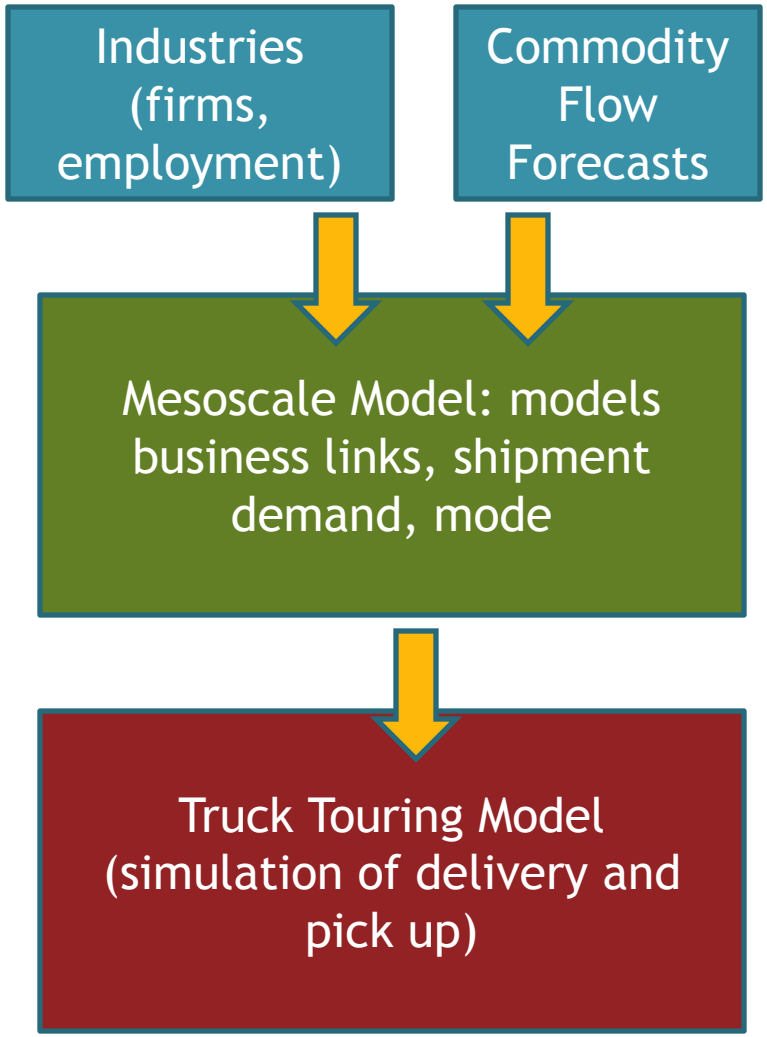
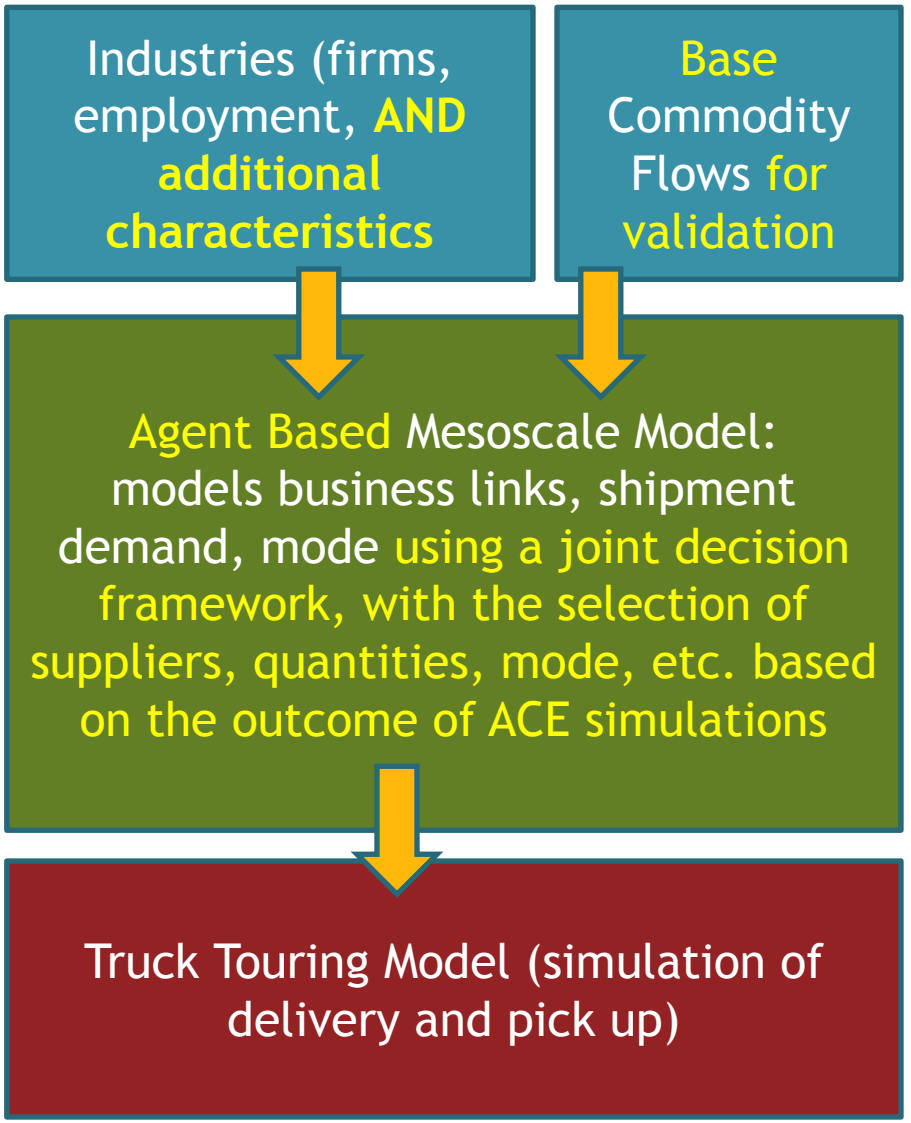
Project Objectives





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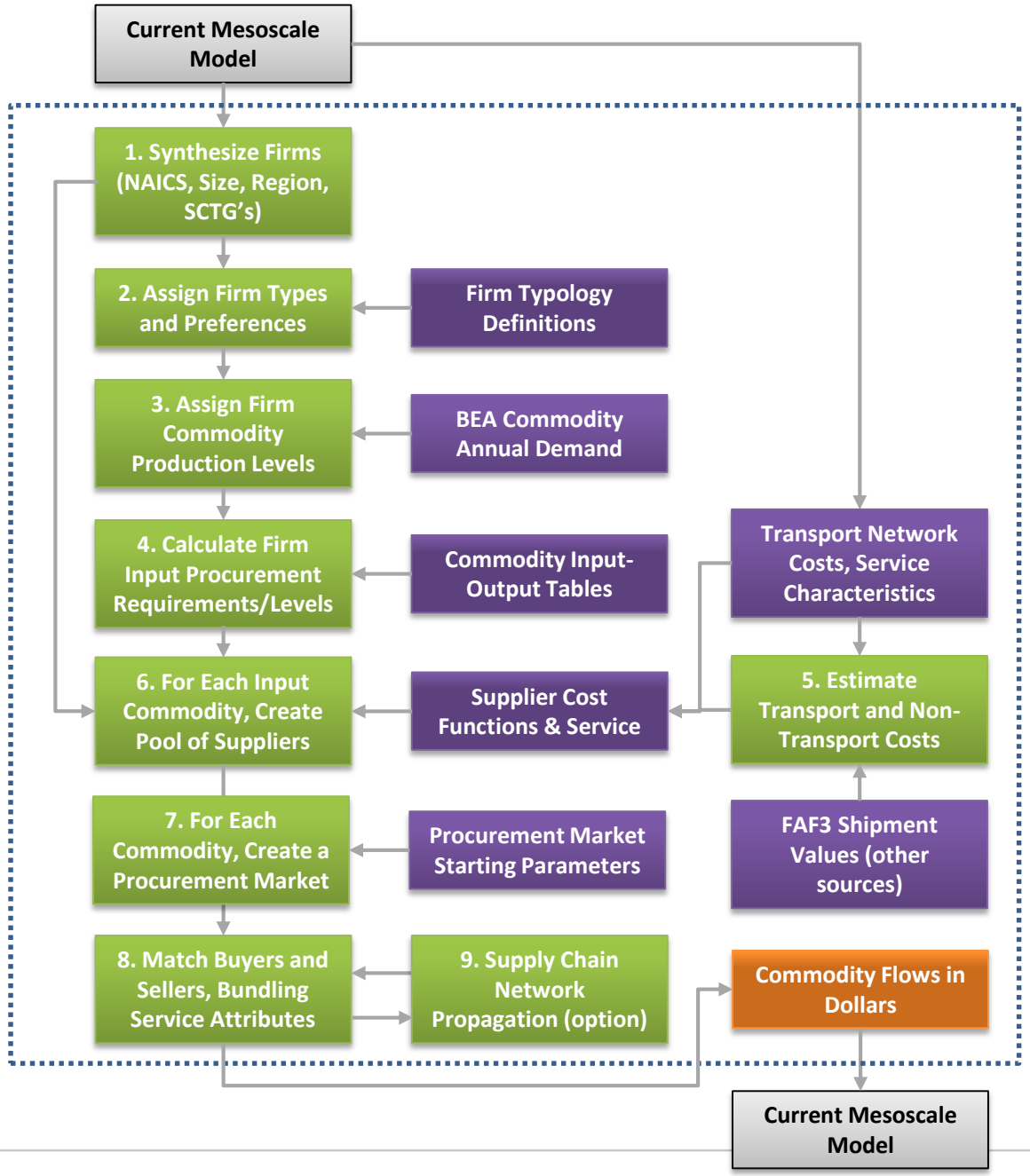
Proposed Design of Mesoscale Extension
John Gliebe and Kaveh Shabani, RSG

- **Overview of Proposed Model Design**
- **Key Concepts:**
  - Defining Agent Typologies
  - Agent-based Computational Economics
  - Illustration of Procurement Market Game
  - Supply Chain as Activity Network
  - Response Sensitivity and Forecasting

Model Design Overview and Integration



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1. Synthesize Firms

- Start with existing method of firm synthesis
- Within the CMAP region, firms are treated as establishments in that they are situated in a single location and function as establishments
- Outside of the CMAP region, "representative" firms will be created to represent a single industry, and region/country (FAF zone)
  - E.g., Wyoming Coal Producers
- Firm attributes
  - Industry Code (NAICS)
  - CPB Zone (County Business Patterns zone used during supplier selection)
  - FAF Zone (country/region)
  - CMAP modeling zone
  - Commodity Type(s) Produced (SCTG)
  - Size (number of employees)
  - Production capacity (commodity units produced per year)

2. Assign Firm Types and Preferences

- **Purpose to define firms' sourcing preferences (tradeoffs) for various combinations of source offerings ("attribute bundles")**
- **Commodity Service Offerings**
  - Unit cost / total cost
  - Average shipment time
  - Frequency of shipments / Average shipment size
  - Proximity of supplier
  - Perceived reliability of the supplier
  - Perceived quality of the supplier's commodity (assert for certain scenarios)
- **Firm Operational Types**
  - Efficiency vs. Responsiveness: Is commodity "innovative" or "functional"?
  - Geographic Proximity: Are there preferences for near-sourcing vs. far-sourcing?
  - Centralization Tendencies: Is commodity likely to utilize warehousing and distribution systems?
  - Vertical Integration Tendencies: Is commodity likely to be produced in-house?

3. Assign Firm Commodity Production Levels

- U. S. Bureau of Economic Analysis (BEA) data will be used to estimate the total dollar-value of output commodities based on firm size
- Account for production cost differences for non-U.S. countries
- For imports, BEA reports producer prices at U.S. port of entry in U.S. dollars

Commodity	Industry			Total Intermediate	Total Final Uses	Total Commodity Output
	Industry A	Industry B	Industry C			
Commodity A	50		10	60	25	85
Commodity B	40	60	20	120	-10	110
Commodity C	-	10	110	120	100	220
Total Intermediate	90	70	140	300	-	-
Total Value Added	40	20	40	-	115	-
Total Industry Output	130	90	180	-	-	400

4. Calculate Input Procurement Requirements

- **BEA Input-Output (I-O) tables**
  - "Use" tables after redefinitions to represent only *direct* inputs
  - Normalized becomes Direct Requirements table

	Commodities/Industries	11	21	22	23	31G	42
IOCode	Name	Agriculture,	Mining	Utilities	Constructio	Manufacturi	Wholesale
11	Agriculture, forestry, fishing, and hunting	0.1950	0.0000	0.0000	0.0011	0.0480	0.0001
21	Mining	0.0028	0.0816	0.1332	0.0084	0.1046	0.0002
22	Utilities	0.0154	0.0184	0.0003	0.0033	0.0140	0.0048
23	Construction	0.0045	0.0263	0.0107	0.0007	0.0031	0.0016
31G	Manufacturing	0.2005	0.1242	0.0081	0.2442	0.3524	0.0488
42	Wholesale trade	0.0475	0.0140	0.0010	0.0232	0.0448	0.0343
44RT	Retail trade	0.0018	0.0016	0.0000	0.0360	0.0016	0.0005
48TW	Transportation and warehousing	0.0216	0.0240	0.0342	0.0135	0.0232	0.0337
51	Information	0.0007	0.0020	0.0008	0.0061	0.0040	0.0077
FIRE	Finance, insurance, real estate, rental, and leasing	0.0782	0.0529	0.0067	0.0300	0.0189	0.0483
PROF	Professional and business services	0.0103	0.1061	0.0129	0.0812	0.0618	0.1155
6	Educational services, health care, and social assistance	0.0021	0.0000	0.0000	0.0000	0.0000	0.0004
7	Arts, entertainment, recreation, accommodation, and food servic	0.0010	0.0014	0.0029	0.0027	0.0031	0.0056
81	Other services, except government	0.0019	0.0019	0.0005	0.0130	0.0030	0.0082
G	Government	0.0003	0.0000	0.0001	0.0000	0.0005	0.0068
Used	Scrap, used and secondhand goods	0.0022	0.0001	0.0000	0.0007	0.0014	0.0000
Other	Noncomparable imports and rest-of-the-world adjustment	0.0002	0.0019	0.0005	0.0002	0.0047	0.0071
V001	Compensation of employees	0.1070	0.1506	0.1820	0.3723	0.1617	0.3476
V002	Taxes on production and imports, less subsidies	-0.0007	0.0725	0.1592	0.0076	0.0135	0.1409
V003	Gross operating surplus	0.3076	0.3206	0.4468	0.1558	0.1358	0.1881
	Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

(partial table shown)

Capturing Maximum Freight Flows by Value

Industries for which the number of "top" inputs shown in first column capture more than 95%of total inputs by value

*** 5111 and below are freight producing industries**

Number of Input Commodities	2002 Benchmark 4 digits NAICS All Codes	2002 Benchmark 4 digits NAICS Only up to 5111*	2002 Direct Req. 6 digits NAICS All Codes	2002 Direct Req. 6 digits NAICS Only up to 511
Top 5	0%	1%	0%	0%
Top 10	1%	7%	1%	6%
Top 20	7%	52%	3%	16%
Top 25	14%	85%	5%	36%
Top 30	24%	98%	-	-
Top 50	94%	100%	56%	97%

Source: BEA, Industry Economic Accounts

Capturing Maximum Freight Flows by Value

Industries (NAICS 2-digit) that capture more than 95% of inputs by value for different numbers of top inputs.

Industry	Top 5	Top 10	Top 20	Top 25	Top 50
Agr., Forest, Fish	5%	11%	32%	95%	100%
21	0%	9%	9%	45%	100%
22	0%	67%	100%	100%	100%
Construction	0%	0%	0%	0%	29%
31	0%	11%	46%	70%	100%
32	0%	7%	15%	36%	99%
33	0%	1%	3%	14%	98%
42	0%	0%	0%	0%	100%
48	0%	29%	43%	57%	100%
49	0%	0%	33%	67%	100%
51	0%	0%	0%	60%	100%

5. Estimate Transport and Non-Transport Costs

- **Transport and Logistics Costs**
  - Use skims from the multi-modal network model and unit costs created as part of the current mesoscale model to provide *transport and logistics costs*, composed of:
    - Ordering cost
    - Transport and handling cost
    - Damage cost
    - Inventory in-transit cost
    - Carrying cost
    - Safety stock cost

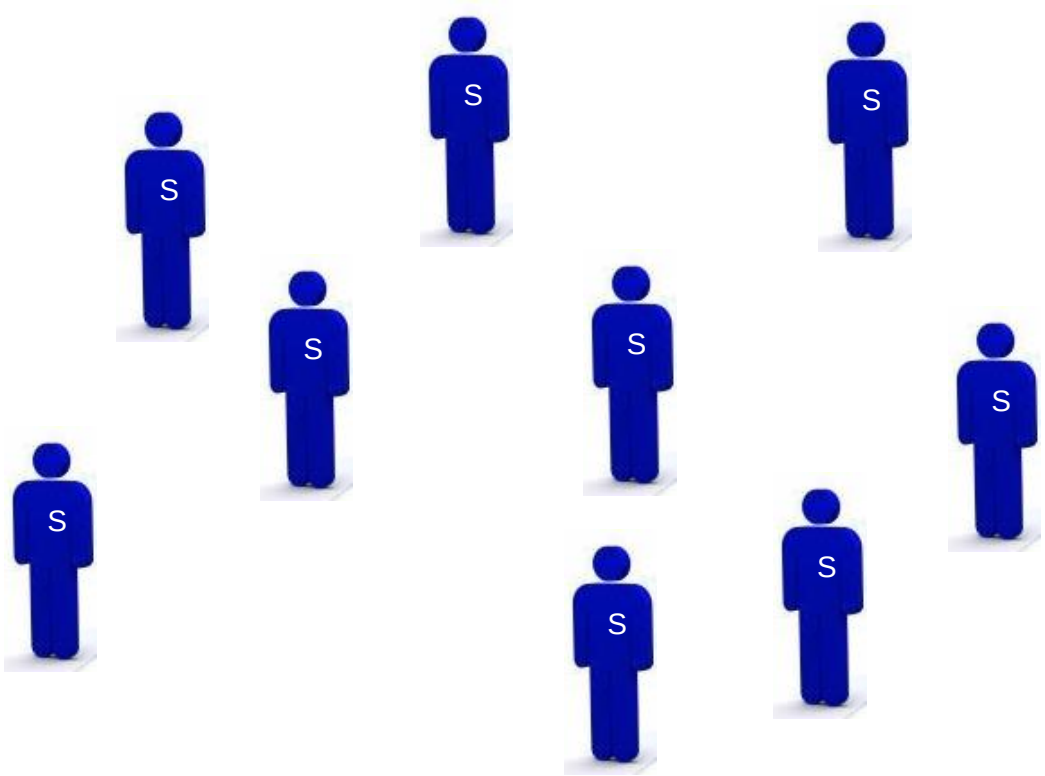
    (more on this later)

- **Total Costs**
  - Use FAF^3 estimates of total shipment values between FAF zones to provide a *total cost* figure

- **Non-Transport/Logistics Costs = Total Costs – Transport Costs**

6. Create Supplier Pools

- For each of the 43 SCTG commodity groups, synthetic firms in the simulation will be identified as producers of that commodity
- Agents will represent alternative bundles of service offerings by applying models to assign values based on the current mesoscale models for…
  - Shipment Size
  - Distribution Channel Usage
  - Mode-Path

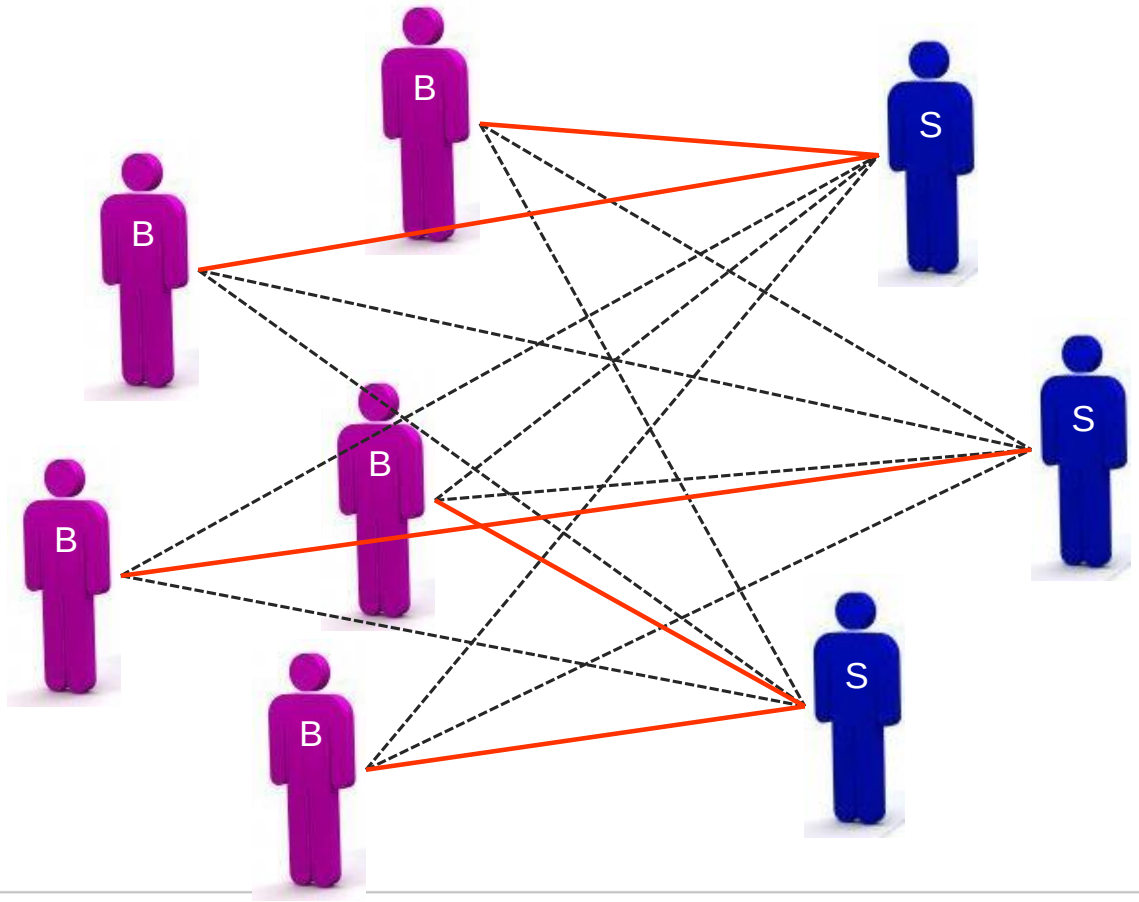


7. Create a Procurement Market Scenario

- Transport system cost parameters
- Regional, national economic growth assumptions by industry/commodity sector
- Technical coefficients representing the factors of production that transform inputs into outputs, as represented in the I-O tables
- Commodity-market-specific parameters representing assumptions about the typologies of buying and selling agents and their behavior
- Forecasting scenarios:
  - Baseline
  - Future Year “business-as-usual”
  - Alternative futures

8. Match Buyers and Sellers, Bundling Service Attributes

- Create buyer agents with preferences for bundled cost-service attributes
- For each of the 43 commodity types under consideration, a procurement market model will be run
- The objective of this step is to find suppliers for every commodity input required by buyers



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9. Supply Chain Network Propagation (Option)

- **Track and allow the cost of inputs purchased by a firm affect the cost of its outputs and therefore the price it offers to other firms**
- **Example:**
  - Iron ore purchased by Firm "A" to make steel from an expensive supplier.
  - Steel maker must raise prices in bids to other firms that may need to purchase steel to make machinery.
  - Machinery manufacture must raise prices in bids to firms that buy their machinery for automotive manufacturing.
  - Auto maker's prices affected by steel costs and machinery costs!
- **Complex implementation would involved full feedback**
- **Simpler method would be to order 43 SCTG games in an order starting with raw materials and working progressively toward more refined commodities**

Key Concepts

AGENT TYPOLOGIES

Research Questions

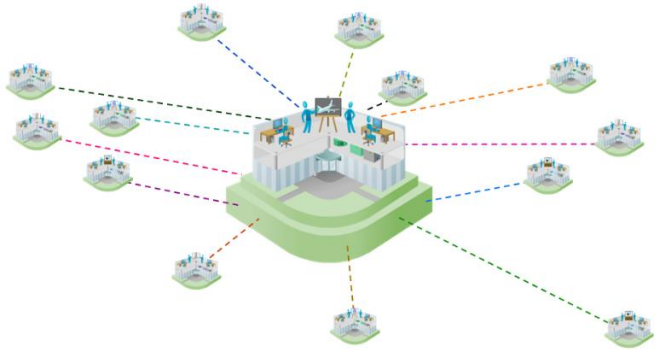
To assign firms to various behavioral preference categories

To formulate firms' response sets and preference structures

Set preference weights

Constraining choice-set

- Is commodity likely to be produced in-house ?
- Is commodity likely to utilize warehousing and distribution systems ?
- Is commodity "innovative" or "functional" ?



Firm Attributes and Typologies

- **Sourcing Culture**
  - Near-sourcing
  - Off-shoring
  - ✓ Supplier type
  - ✓ Product value
  - ✓ Demand uncertainty
- **Centralization**
  - Centralized
  - Decentralized
  - ✓ Firm size
  - ✓ Product variety
  - ✓ Demand uncertainty
- **Vertical Integration**
  - Downstream Suppliers
  - Upstream Suppliers
  - Upstream/Downstream
  - ✓ Firm size
  - ✓ Product criticality
  - ✓ Demand uncertainty

Literature Review

- A lot of factors influencing sourcing decisions in the literature
- There is not a generally accepted measure in the literature
- Vertical integration is a multidimensional concept
- Most of the factors are hard to measure
- Firm goals: high quality, low cost, on-time delivery, etc.

Possible Approaches in the Literature

Two general methods to categorize the firm type attributes:

Quantitative and Qualitative

Value-added / sales

The degree to which a firm produces its intermediate inputs through vertical integration

sensitive to industry structure differences

Firm or commodity attributes

- Firm size
- Demand uncertainty
- Product variety
- …

hard to measure attributes

Quantitative Approaches

Ratio of a firm's value added to its sales revenue

The more a firm makes rather than buys

The lower are its bought-in goods/services relative to its sales

The more vertically integrated it might be

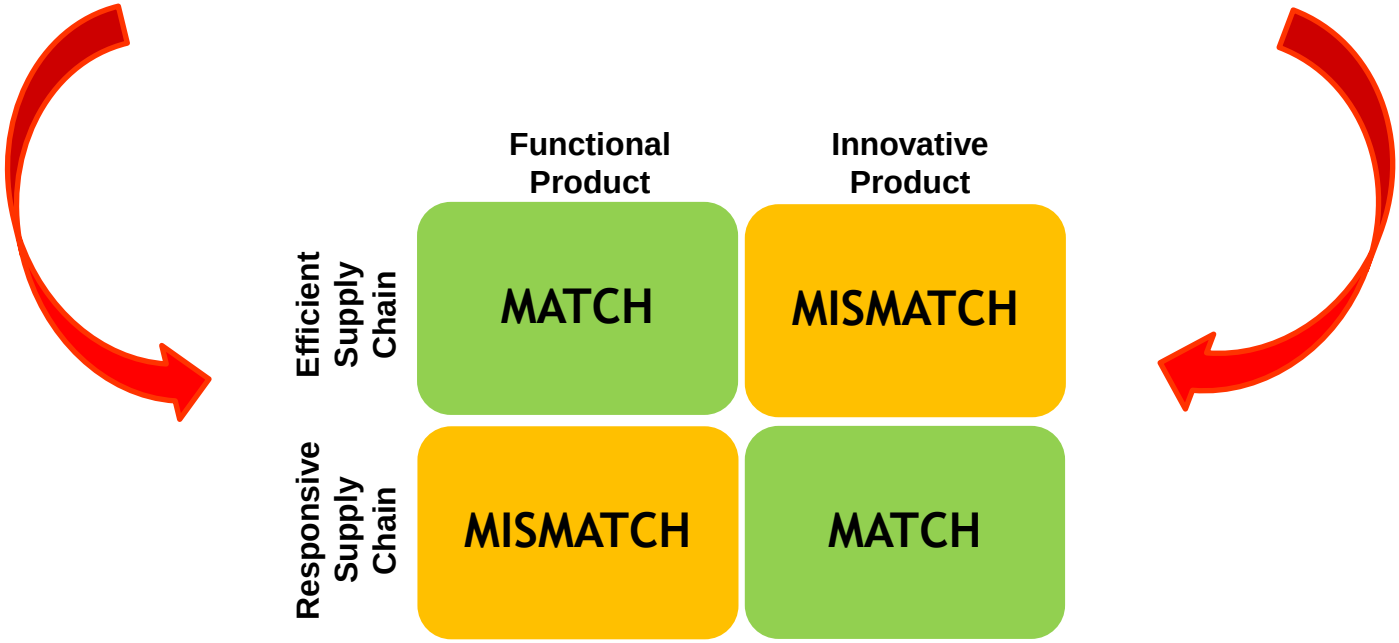
Example

Industry	2002 NAICS code	Value added by manufactures (million dollars)	Value of shipments (million dollars)	Vertical Integration (value added/value of shipments)
Petroleum/coal products	324	78,559	497,875	15.8%
Pharmaceuticals	3254	140,568	191,410	73.4%
Medical equipment and supplies	3391	60,232	84,560	71.2%
Computer and peripheral eqpm.	3341	25,974	52,530	49.4%
Dairy products	3115	28,396	84,580	33.6%

Product and Supply Chain Types

Classifying commodities based on demand patterns and characteristics

Functional Products	Innovative Products
Mature product	Early life cycle stage
Low product variety	High product variety
Predictable demand	Unpredictable demand
minimize inventory	Deploy significant buffer stocks
Greater reliance on low cost modes	Greater reliance on fast and reliable modes



Proposed Hybrid Approach

Example

CBPZONE	CBPZONEp	SCTG	makerID	userEmp	GCD	n6ioSUPP.	n6ioBUYER	Supplier Industry	Buyer Industry
1	17201	3	17201-1111A0_3-1	10	578.7	1111A0_3	1111A0_3	Agricultural Prod.	Agricultural Prod.
38	17031	26	17031-321100_26-1	1750	285.4	321100_26	337110_39	Wood Products	Furniture
107	17097	35	17097-334111_35-2	7,500	928.0	334111_35	334111_35	Electronics	Electronics

Buyer and supplier zones

Buyer and supplier zones

No. of

dista

Industry and commodity

Procurement Strategies

Functional Products	Innovative Products
Focus should be on minimizing total cost (transportation, inventory, etc.)	Focus should be on reducing lead times and on supply flexibility to be responsive to customers
Sourcing from low-cost countries, e.g., China and Taiwan is appropriate	Sourcing close to the market area is a better strategy
The difference between manufacturing and transportation costs plays the main role in sourcing decision	Short lead time may be achieved using air shipments

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Hybrid Approach Example

Example

No.	Firm Attribute	Pair 1	Pair 2	Pair 3	Weight
1	Commodity type produced	Func./Inno.	Functional	Innovative	0.05
2	Commodity type consumed	Func./Inno.	Func./Inno.	Innovative	0.05
3	Firm size (user no. of emps)	Low	Medium	High	0.05
4	Demand Uncertainty	Medium	Low	High	0.10
5	Technological Uncertainty	Low	Low	High	0.05
6	Supplier Uncertainty	Medium	Low	High	0.05
7	Product Value	Medium	Low	High	0.05
8	Quick Desired Response	Both	Cost	Customer	0.10
9	Supplier Market Competitiveness	Medium	Low	High	0.05
10	Asset specificity (AS, for suppliers)	0.82%	0.45%	17.4%	0.10
11	VI degree (method 1)	38.6%	29.8%	30.0%	0.10
12	VI degree (method 2)	11.0%	16.3%	23.6%	0.25
	Near-sourcing	-	-	+	If 4, 6 and 9 > 0.2
	Purchasing Centralization	+	-	+	If 2, 4, 6, 8 and 9 > 0
	VI Decision	-	-	+	if al l> 0.5

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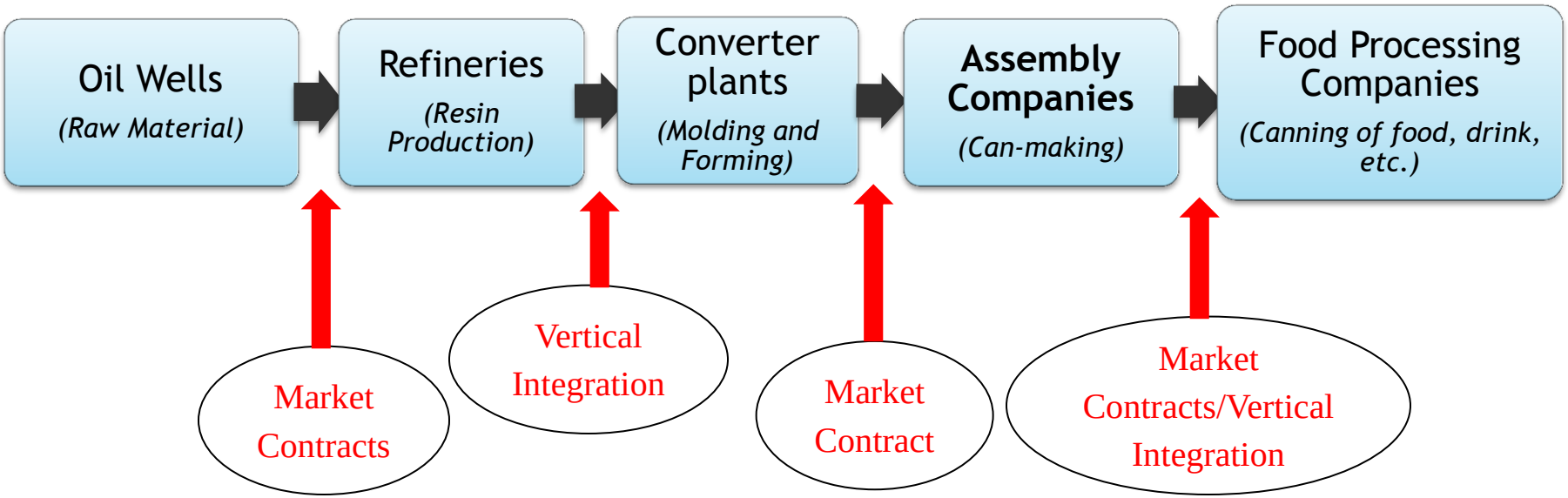
Summary

- Vertical integration as well as firm and industry behavior and strategies are dynamic processes and change through time
- Vertical integration may be full or partial
- Firms watch their competitors and use different strategies



Key Concepts

LOGISTICS COST EQUATION

Cost Function *(Current Mesoscale mode, improved equation)*

$$G_{mnql} = \beta_{0ql} + \beta_1 \times \left(\frac{Q}{q}\right) + T_{mnql} + \beta_2 \times j \times v \times Q + \beta_3 \times t_{mnl} \times v \times \frac{Q}{365} + (\beta_4 + \beta_5 \times v) \times \frac{q}{2} + \beta_5 \times v \times a \times \sqrt{(LT \times \sigma_Q{}^2) + (Q^2 + \sigma_{LT}{}^2)}$$

Ordering Cost | Transport and Handling Cost | Damage Cost | Inventory in-transit cost | Carrying Cost | Safety Stock Cost

Variable or Parameter	Description or Interpretation (of Parameters)	Source
G_{mnql}	Logistics cost (shipper m and receiver n with shipment size q and logistics chain l)	Calculated in the model
Q	Annual flow in tons	FAF
q	Shipment size in tons	Variable
β_{0ql}	Alternative-specific constant	Parameter to be estimated
β_1	Constant unit per order	Parameter to be estimated
T	Transport and intermediate handling costs	network skims, survey data
β_2	Discount rate	Parameter to be estimated
j	Fraction of shipment that is lost or damaged	Survey data or assumed value
v	Value of goods (per ton)	FAF data
β_3	Discount rate of goods in transit	Parameter to be estimated
t	Average transport time (days)	Lookup table (or skims), survey data
β_4	Storage costs per unit per year	Parameter to be estimated
β_5	Discount rate of goods in storage	Parameter to be estimated
a	Constant, set safety stock a fixed prob. of not running out of stock	Survey data or assumed value
LT	Expected lead time (time between ordering and replenishment)	Lookup table (or skims) , survey data
σ_Q	Standard deviation in annual flow (variability in demand)	Survey data, assumed value
σ_{LT}	Standard deviation of lead time	Lookup table (or skims), survey data

(source: Cambridge Systematics, 2011)

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Cost Calculation Example 1

Cost type	Rail	Truck	Air	Water
Transport	0.3	0.8		0.3
Inventory in-transit	0.0	0.0		0.0
Safety Stock	322.2	277.0		886.4
Ordering	7.5	7.5		7.5
Damage	0.0	0.0		0.0
Carrying	316.7	316.7		316.7
TOTAL COST ($)	646	602		1,210

SCTG=1, animals

from zone 76 to 205

c ($/ton)	*16.2*	*43.1*	-	*16.4*
t (hrs)	*12.0*	*6.0*	-	*163.0*
Q (tons)	*0.02*	*0.02*	*0.02*	*0.02*
GCD (mile)	*227.6*	*227.6*	*227.6*	*227.6*
Value ($)	*25.0*	*25.0*	*25.0*	*25.0*
v ($/ton)	*1,344.0*	*1,344.0*	*1,344.0*	*1,344.0*
B3	*0.1*	*0.1*	*0.1*	*0.1*
B5	*0.1*	*0.1*	*0.1*	*0.1*
a	*1.0*	*1.0*	*1.0*	*1.0*
LT+t	*22.0*	*16.0*	*10.0*	*173.0*
LT sd	*1.0*	*1.0*	*1.0*	*1.0*
Q sd	*1.0*	*1.0*	*1.0*	*1.0*
q	*250.0*	*250.0*	*250.0*	*250.0*
B1	*50.0*	*50.0*	*50.0*	*50.0*
j	*0.01*	*0.01*	*0.01*	*0.01*
B2	*0.1*	*0.1*	*0.1*	*0.1*
B4	*5,000.0*	*5,000.0*	*5,000.0*	*5,000.0*

Assumptions				
	LT	10.00	LowDiscRate	0.01
	LT sd	1.00	MedDiscRate	0.05
	Q sd	1.00	HighDiscRate	0.25
	B1	50		
	j	0.01		
	B4	5000		

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Cost Calculation Example 2

Cost type	Rail	Truck	Air	Water
Transport	589,237,492.8	1,520,648,574.9	-	-
Inventory in-transit	3,192.4	1,544.8	-	-
Safety Stock	360,210.9	360,210.9	-	-
Ordering	3,212,535,576.2	3,212,535,576.2	-	-
Damage	7,204.2	7,204.2	-	-
Carrying	437.51	437.5	-	-
TOTAL COST ($)	3,802,144,114	4,733,553,548	-	-

SCTG=15, Coal

from zone 273 to 131

c ($/ton)	*52.4*	*135.2*	-	-
t (hrs)	*38.8*	*18.8*	-	-
Q (tons)	*11,243,874.52*	*11,243,874.52*	*11,243,874.52*	*11,243,874.52*
GCD (mile)	*929.8*	*929.8*	*929.8*	*929.8*
Value ($)	*72,042,173.6*	*72,042,173.6*	*72,042,173.6*	*72,042,173.6*
v ($/ton)	*6.4*	*6.4*	*6.4*	*6.4*
B3	*0.0*	*0.0*	*0.0*	*0.0*
B5	*0.0*	*0.0*	*0.0*	*0.0*
a	*0.5*	*0.5*	*0.5*	*0.5*
LT+t	*48.8*	*28.8*	*10.0*	*10.0*
LT sd	*1.0*	*1.0*	*1.0*	*1.0*
Q sd	*1.0*	*1.0*	*1.0*	*1.0*
q	*350.0*	*350.0*	*350.0*	*350.0*
B1	*50.0*	*50.0*	*50.0*	*50.0*
j	*0.01*	*0.01*	*0.01*	*0.01*
B2	*0.0*	*0.0*	*0.0*	*0.0*
B4	*5,000.0*	*5,000.0*	*5,000.0*	*5,000.0*

Assumptions

LT	10.00	LowDiscRate	0.01
LT sd	1.00	MedDiscRate	0.05
Q sd	1.00	HighDiscRate	0.25
B1	50		
j	0.01		
B4	5000		

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Cost Calculation Example 3

Cost type	Rail	Truck	Air	Water
Transport	-	2,134.4	58,773.0	-
Inventory in-transit	-	429.6	1,285.2	-
Safety Stock	-	611,051.1	631,805.5	600,358.9
Ordering	-	3,640.8	3,640.8	3,640.8
Damage	-	101.7	101.7	101.7
Carrying	-	2,433.0	2,433.0	2,433.0
TOTAL COST ($)	-	613,615	691,863	

SCTG=35, Electronics

from zone 2 to 199

c ($/ton)		106.6	2,935.1	-
t (hrs)	-	14.8	44.3	-
Q (tons)	20.0	20.0	20.0	20.0
GCD (mile)	622.0	622.0	- 622.0	622.0
Value ($)	1,016,806.0	1,016,806.0	1,016,806.0	1,016,806.0
v ($/ton)	50,779.0	50,779.0	50,779.0	50,779.0
B3	0.3	0.3	0.3	0.3
B5	0.3	0.3	0.3	0.3
a	2.3	2.3	2.3	2.3
LT+t	10.0	24.8	54.3	10.0
LT sd	1.0	1.0	1.0	1.0
Q sd	1.0	1.0	1.0	1.0
q	550.0	550.0	550.0	550.0
B1	50.0	50.0	50.0	50.0
j	0.01	0.01	0.01	0.01
B2	0.0	0.0	0.0	0.0
B4	5,000.0	5,000.0	5,000.0	5,000.0

Assumptions

LT	10.00	LowDiscRate	0.01
LT sd	1.00	MedDiscRate	0.05
Q sd	1.00	HighDiscRate	0.25
B1	50		
j	0.01		
B4	5000		

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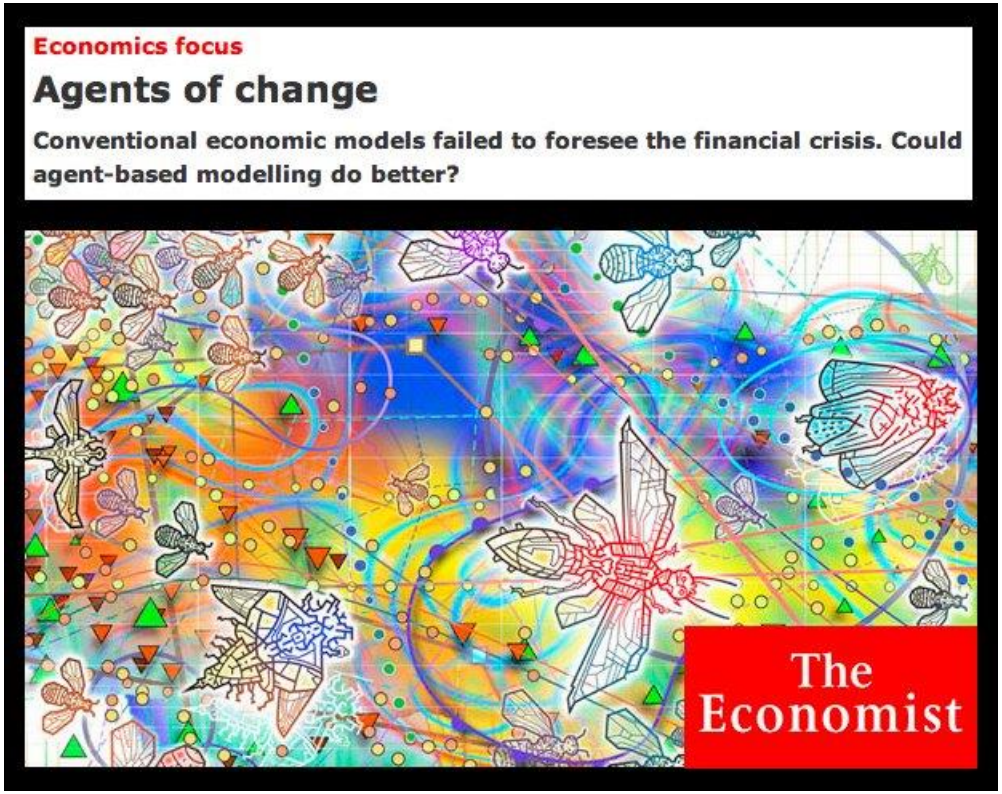
Graphic Source: Argonne National Labs
http://www.scidacreview.org/0802/html/abms.html

Key Concepts

AGENT BASED COMPUTATIONAL ECONOMICS (ACE)

What is agent-based computational economics?

- "Bottom up" approach in which individual agents are simulated in a virtual world in which they make decisions, ***interact*** with and react to each other, and patterns ***emerge*** from the collective actions of many agents
- Research characterized by rigorous study of economic systems through computational experiments
- Methodological kinship with complex systems studies in social and natural sciences
  - Electric power trading
  - Social choice and voting
  - Racial segregation in housing
  - School choice
  - Habitat destruction
  - Honeybee swarms



Source of graphic: http://computationallegalstudies.com/2010/07/27/agents-of-change-agent-based-models-and-methods-the-economist/

ACE: Answering questions about complex systems

- **Why have certain global regularities emerged and persisted despite the absence of centralized planning and control, while other global outcomes have not been observed?**
  - How are trends in supply-chain and logistics practices, such as insourcing, outsourcing, and near-sourcing influenced by privately held values and beliefs regarding various forms of uncertainty, asset specificity, and commodity attributes?
  - How much is simply imitation?
- **What types of micro-level dynamics of individual traders lead to the collective patterns market behavior that we observe?**
  - Which agents in the supply chain network have the greatest influence on other agents (commodities, industries)?
  - Are there ties between agent/industries that may be important to assessing regional competitiveness and the likely trends in future freight flows?
- **How can good economic (infrastructure) policies be designed to achieve their intended effect?**
  - Road pricing, traffic flow management, trade tariffs, port capacity expansions

Key Concepts

PROCUREMENT MARKET GAME (PMG)

Background

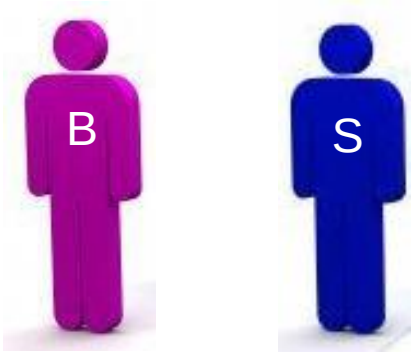
- **Research literature in supply chain sourcing decisions focuses on auction mechanisms that can be used to optimize outcomes**
  - E-procurement systems require efficient, robust algorithms (algorithmic game theory)
  - Common objectives are to induce suppliers to bid at true cost, avoid collusion, and other forms of strategic lying
    - Example: "2nd Price Sealed Bid" (Vickery 1961)
- **Appropriateness of auction mechanisms for Mesoscale Freight Model**
  - Industry and commodity-specific
  - Not necessarily applicable to smaller and less technologically advanced firms
  - Typically designed for optimization
  - Won't necessarily capture idiosyncratic behavior of agent preferences, habits and beliefs
- **ACE approaches offer a more general, flexible framework**
- **PMG inspired by Trade Network Game (TNG)**
  - (Tesfatsion, McFadzean – Iowa State U.)
  - Agents are buyers, sellers and dealers (buy or sell)
  - 2 x 2 Payoff matrix – "cooperate" or "defect" labeling (e.g., Prisoners Dilemma)
  - Evolutionary programming framework (genetic algorithm)
  - Multiple rounds of pairwise trades
  - Agent expectations are updated after each round based on outcomes of all trading games
  - Market properties emerge through iterative play

PMG Implementation in Mesoscale Freight Model

- **Play 43 PMGs – one for each SCTG commodity market**
- **Used to define/assign sourcing relationships and, ultimately, commodity flows between producers and suppliers**
  - An established tie results in the procurement of a commodity at a certain dollar-valued quantity
- **Procurement decision encompasses joint choice of…**
  - Supplier
  - Shipment sizes
  - Distribution center usage
  - Mode choice
- **Different from TNG, PMG will need to:**
  - Incorporate domain-specific information about firms, including their attributes related to their typology and preferences, and data-driven commodity costs and supplier service characteristics
  - Payoffs will need to be asymmetric (i.e., differentiating various agent types) and have domain-specific meaning (i.e., differentiating various market/commodity types)
  - Selling agents will be capacity constrained by their production output levels

Initializing Agents

Buyer Attributes
- NAICS
- Size (# employees)
- FAF Zone
- Output commodity
- Input commodity
- Input commodity requirements ($ annual purchase) demand



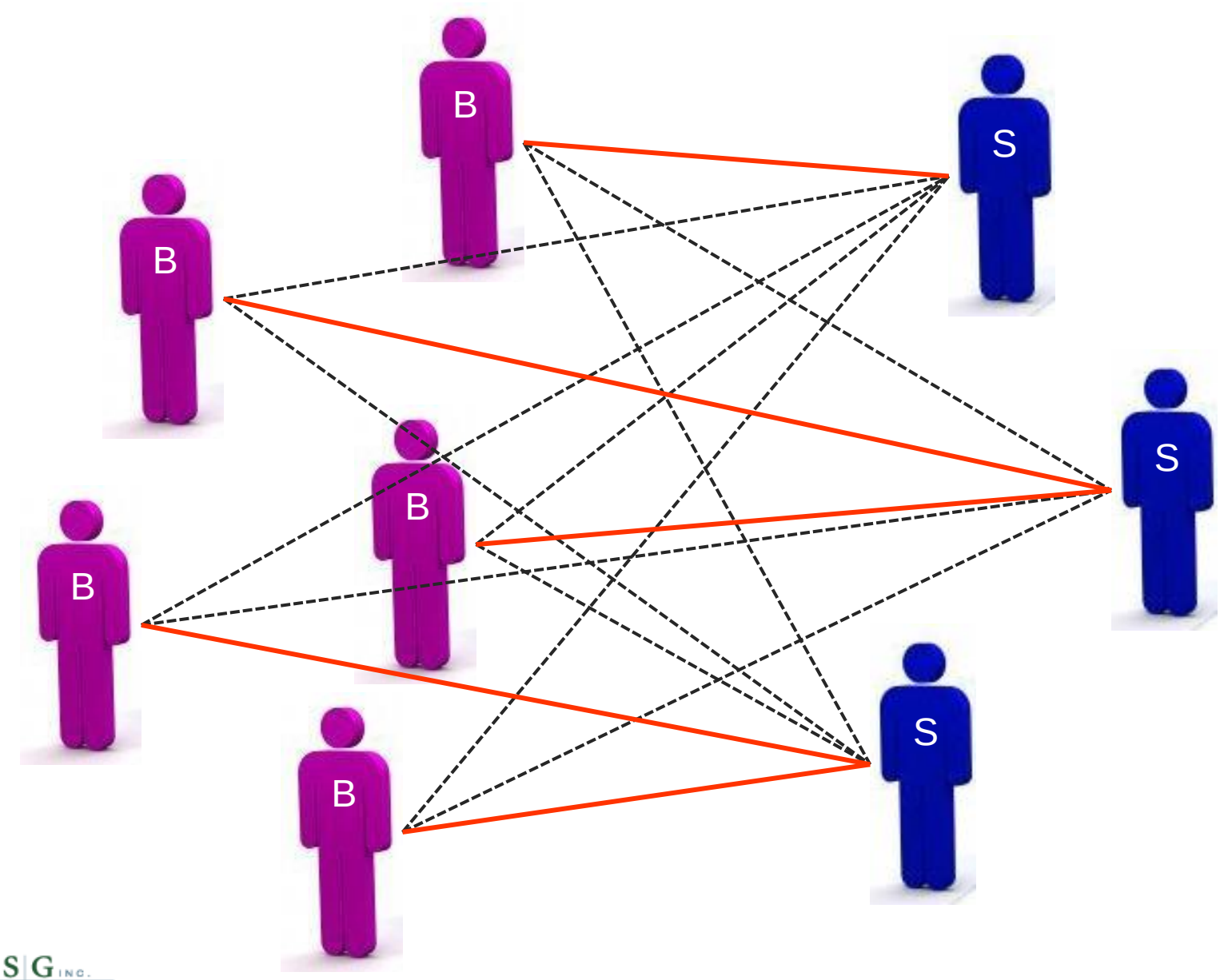
Seller Attributes
- NAICS
- Size (# employees)
- FAF Zone
- Output commodity
- Production level ($ annual output) capacity

Payoff Matrix (example)		
Decision	***Yes***	***No***
Yes	3 / 2	0 / 2
No	-1 / 0	1 / 1

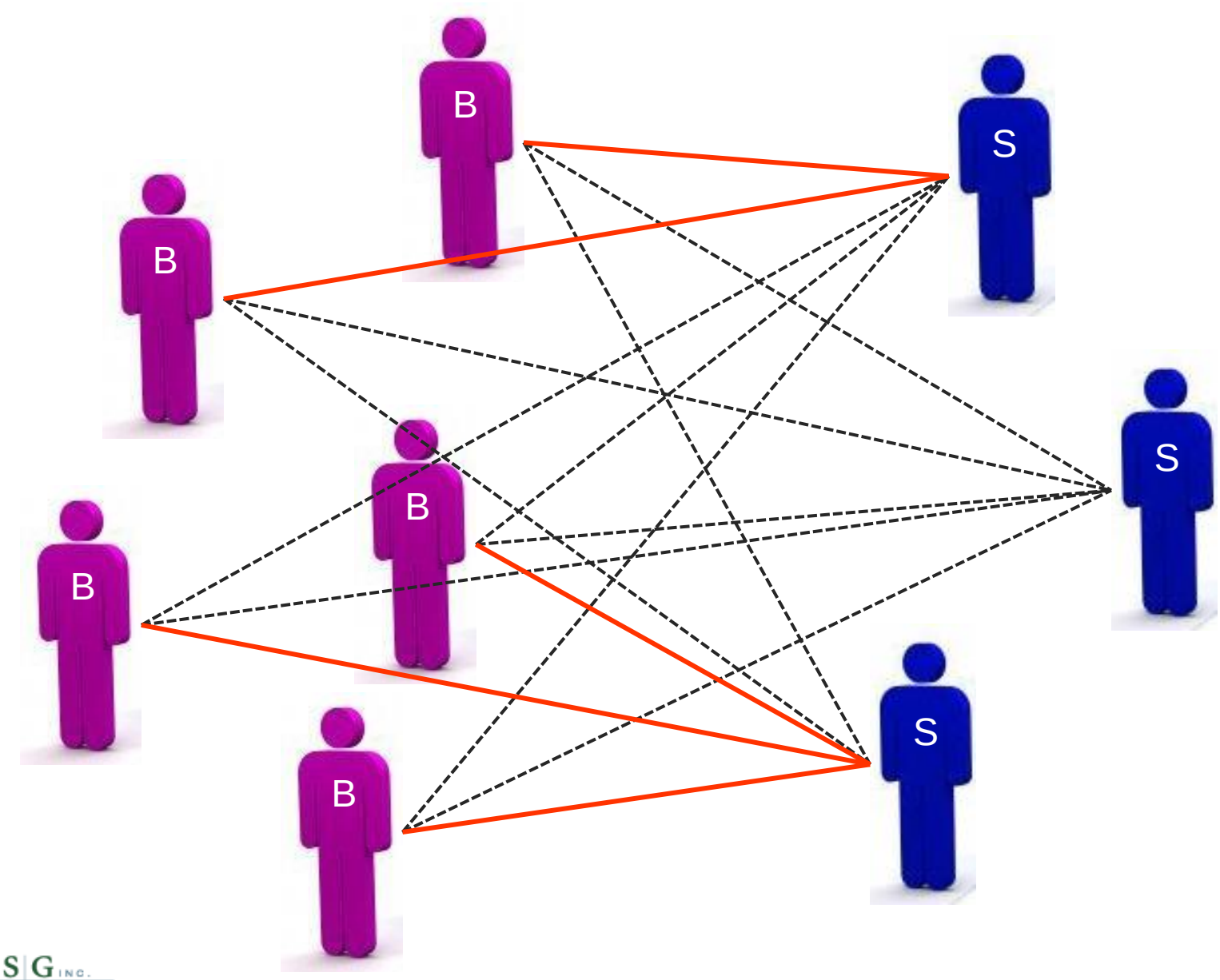
Buyer Preferences
- Efficient vs. Responsive
- Near-source vs. Far-source
- Centralized Distribution
- Vertical Integration

Seller Cost-Service Bundle
- Shipment sizes
- Average shipping times
- Distribution centers
- Mode
- Cost

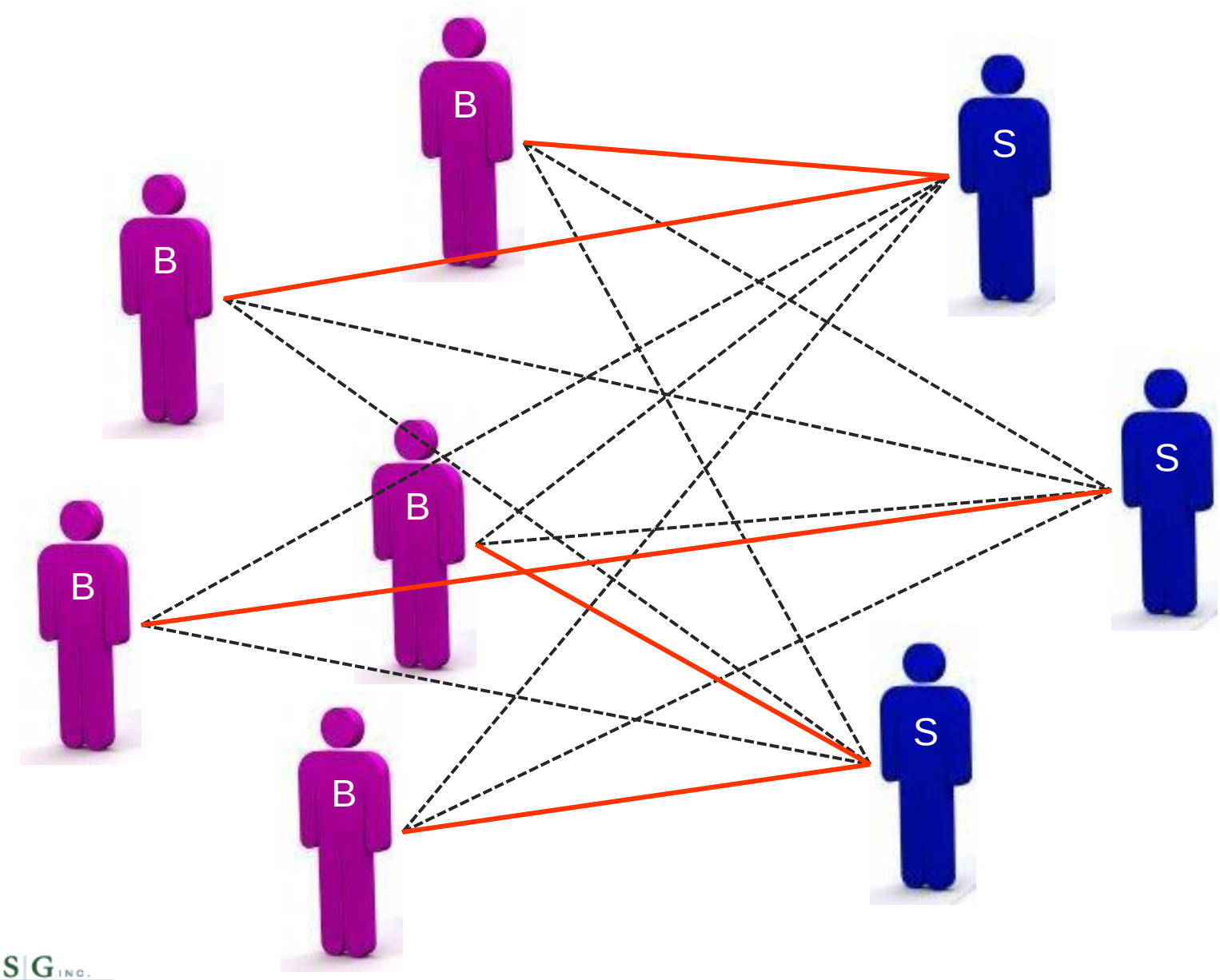
Round 1



Round 2



Round 3



Example PMG: Trade Scenario "A"

- Large buyer "L" and a small buyer "S" who are both in the packaged foods industry, commodity code, CC=1
- Each buyer needs to purchase a quantity of an input commodity, seafood, commodity code, CC=2. Both buyers are in the geographic zone, GZ=1

First Buyer

	CC	GZ	Size	Cost Wght.	Time Wght.	Order Size
Buyer "L"	1	1	L	-0.2	-0.8	20

	CC	GZ	Unit Cost	Ship Time	Utility	Order Cost
Seller "F"	2	3	$ 0.95	7	-5.79	$ 19.00
Seller "D"	2	2	$ 2.00	3	-2.80	$ 40.00
Seller "L"	2	1	$ 3.00	1	-1.40	$ 60.00

Second Buyer

	CC	GZ	Size	Cost Wght.	Time Wght.	Order Size
Buyer "S"	1	1	S	-0.4	-0.6	5

	CC	GZ	Unit Cost	Ship Time	Utility	Order Cost
Seller "F"	2	3	$ 0.95	7	-4.58	$ 4.75
Seller "D"	2	2	$ 2.00	3	-2.60	$ 10.00
Seller "L"	2	1	$ 3.00	1	-1.80	$ 15.00

Opportunity Cost Constant (Failed Trade):	-7.0

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Pairwise Trade L-F

- Large Buyer and Foreign Seller

Should Buyer "L" and Seller "F" form a trading alliance? (Assuming mutual exclusivity)

(Sourcing decision for purchase of Commodity Code #2 "Meat/Seafood")

Expected Payoffs to Buyer		
Yes	-5.79	<--Utility of Transaction
No	-2.10	<--Expected Utility if another supplier must be chosen (assuming even odds among remaining sellers and zero risk of no trade)[1]

Payoffs to Seller			
Yes	$	19.00	<--Revenue of Transaction
No	$	1.58	<--Expected Revenue of holding out for another (more lucrative) buyer (assuming 1/3 chance of success competing against two other sellers)[1]

Outcome:	***Buyer says "no" (holding out for a better contract); Seller says "yes"***
	We don't know the actual payoffs, yet! (pending outcomes of other pairwise trading games)
[1]	**Update expected probabilities over repeated trading games**

Pairwise Trade S-D

- Small Buyer and Domestic Seller

Should Buyer "S" and Seller "D" form a trading alliance? (Assuming mutual exclusivity)

(Sourcing decision for purchase of Commodity Code #2 "Meat/Seafood")

Expected Payoffs to Buyer		
Yes	-2.60	<--Utility of Transaction
No	-3.19	<--Expected Utility if another supplier must be chosen (assuming even odds among remaining sellers)[1]

Payoffs to Seller		
Yes	$ 10.00	<--Revenue of Transaction
No	$ 13.33	<--Expected Revenue of holding out for another (more lucrative) buyer (assuming 1/3 chance of success competing against two other sellers)[1]

Outcome:	***Buyer says "yes"; Seller says "no" (holding out for a better contract)***	
	We don't know the actual payoffs, yet! (pending outcomes of other pairwise trading games)	

Pairwise Trade L-L

- Large Buyer and Local Seller

Should Buyer "L" and Seller "L" form a trading alliance? (Assuming mutual exclusivity)

(Sourcing decision for purchase of Commodity Code #2 "Meat/Seafood")

Expected Payoffs to Buyer			
Yes		-1.40	<--Utility of Transaction
No		-4.30	<--Expected Utility if another supplier must be chosen (assuming even odds among remaining sellers)[1]
Expected Payoffs to Seller			
Yes	$	60.00	<--Revenue of Transaction
No	$	5.00	<--Expected Revenue of holding out for another (more lucrative) buyer (assuming 1/3 chance of success competing against two other sellers)[1]
Outcome:	***Buyer says "yes"; Seller says "yes"***		
	We don't know the actual payoffs, yet! (pending outcomes of other pairwise trading games)		

Scenario A Resolution

- And so on… All pairwise combinations (2 x 3 = 6) are calculated and expected payoffs for each game are updated based on these pairwise outcomes

Actual Payoffs for Round 1						
Pairwise Games:	**L-F**	**S-D**	**L-D**	**S-L**	**S-F**	**L-L**
Buyer--Yes	-5.79	-7.0	-2.80	-7.0	-7.0	-1.40
Buyer--No	-1.40	-7.0	-1.40	-7.0	-7.0	-2.80
Seller--Yes	$ -	$ 10.00	$ -	$ 15.00	$ -	$ 60.00
Seller--No	$ -	$ -	$ -	$ 60.00	$ -	$ 15.00

- Only partnership formed was between Buyer L ("large") and Seller L ("local").
- Under an assumption of mutual exclusivity, an initially favorable L-D match was superseded by L-L (slightly better for the buyer)
- Buyer S ("small") was outbid after holding out for the preferred provider ("local").
- Buyer S was rejected by all of the sellers, who were holding out for Seller L ("large").
- During the second round, buyers and sellers would update their beliefs about the probability of a successful trade, which should result in a second alliance forming between Buyer S and Seller D ("domestic").
- Seller F ("foreign") is priced out of this market for fish, but could become competitive in a different scenario if cost structures or preferences were to change.

Example PMG: Trade Scenario "B"

- In this scenario, the Foreign Seller "F" invests in an air freight service to Chicago that allows shipments to arrive in 2 days, which more than doubles unit costs, although they were already quite low
- This changes the utilities that both buyers with respect to Seller "F"

First Buyer

	CC	GZ	Size	Cost Wght.	Time Wght.	Order Size
Buyer "L"	1	1	L	-0.2	-0.8	20

	CC	GZ	Unit Cost	Ship Time	Utility	Order Cost
Seller "F"	2	3	$ 2.10	2	-2.02	$ 42.00
Seller "D"	2	2	$ 2.00	3	-2.80	$ 40.00
Seller "L"	2	1	$ 3.00	1	-1.40	$ 60.00

Second Buyer

	CC	GZ	Size	Cost Wght.	Time Wght.	Order Size
Buyer "S"	1	1	S	-0.4	-0.6	5

	CC	GZ	Unit Cost	Ship Time	Utility	Order Cost
Seller "F"	2	3	$ 2.10	2	-2.04	$ 10.50
Seller "D"	2	2	$ 2.00	3	-2.60	$ 10.00
Seller "L"	2	1	$ 3.00	1	-1.80	$ 15.00

Opportunity Cost Constant (Failed Trade):	-7.0

Pairwise Trade L-F

- Large Buyer and Foreign Seller

Should Buyer "L" and Seller "F" form a trading alliance? (Assuming mutual exclusivity)

(Sourcing decision for purchase of Commodity Code #2 "Meat/Seafood")

Expected Payoffs to Buyer		
Yes	-2.02	<--Utility of Transaction
No	-2.10	<--Expected Utility if another supplier must be chosen (assuming even odds among remaining sellers and zero risk of no trade)[1]

Payoffs to Seller		
Yes	$ 42.00	<--Revenue of Transaction
No	$ 3.50	<--Expected Revenue of holding out for another (more lucrative) buyer (assuming 1/3 chance of success competing against two other sellers)[1]

Outcome:	***Buyer says "yes" ; Seller says "yes"***
	We don't know the actual payoffs, yet! (pending outcomes of other pairwise trading games)

Pairwise Trade S-F

- Small Buyer and Foreign Seller

Should Buyer "S" and Seller "F" form a trading alliance? (Assuming mutual exclusivity)

(Sourcing decision for purchase of Commodity Code #2 "Meat/Seafood")

Expected Payoffs to Buyer			
Yes		-2.04	<--Utility of Transaction
No		-2.20	<--Expected Utility if another supplier must be chosen (assuming even odds among remaining sellers)[1]
Payoffs to Seller			
Yes	$	10.50	<--Revenue of Transaction
No	$	14.00	<--Expected Revenue of holding out for another (more lucrative) buyer (assuming 1/3 chance of success competing against two other sellers)[1]
Outcome:	***Buyer says "yes"; Seller says "no" (holding out for a better contract)***		
	We don't know the actual payoffs, yet! (pending outcomes of other pairwise trading games)		

Pairwise Trade L-L

- Large Buyer and Local Seller

Should Buyer "L" and Seller "L" form a trading alliance? (Assuming mutual exclusivity)

(Sourcing decision for purchase of Commodity Code #2 "Meat/Seafood")

Expected Payoffs to Buyer		
Yes	-1.40	<--Utility of Transaction
No	-4.30	<--Expected Utility if another supplier must be chosen (assuming even odds among remaining sellers)[1]

Expected Payoffs to Seller		
Yes	$ 60.00	<--Revenue of Transaction
No	$ 5.00	<--Expected Revenue of holding out for another (more lucrative) buyer (assuming 1/3 chance of success competing against two other sellers)[1]

Outcome:	***Buyer says "yes"; Seller says "yes"***
	We don't know the actual payoffs, yet! (pending outcomes of other pairwise trading games)

Scenario B Resolution

- And so on… All pairwise combinations (2 x 3 = 6) are calculated and expected payoffs for each game are updated based on these pairwise outcomes

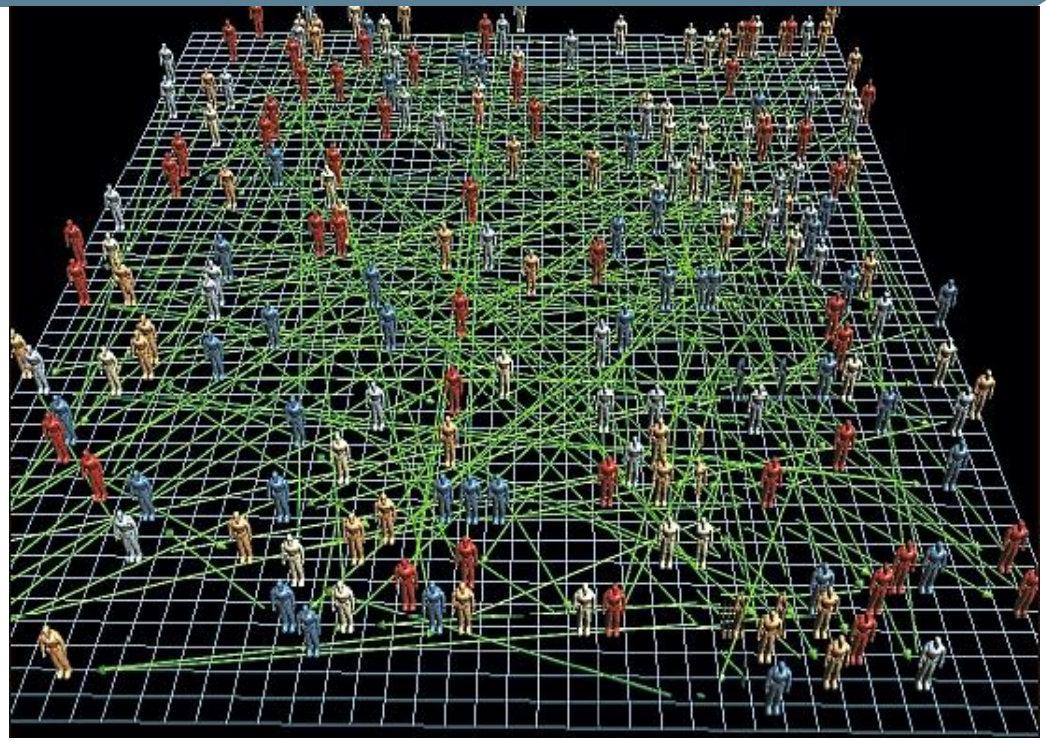
Actual Payoffs for Round 1						
Pairwise Games:	**L-F**	**S-D**	**L-D**	**S-L**	**S-F**	**L-L**
Buyer--Yes	-5.79	-7.0	-2.80	-7.0	-7.0	-1.40
Buyer--No	-1.40	-7.0	-1.40	-7.0	-7.0	-2.80
Seller--Yes	$ -	$ 10.00	$ -	$ 15.00	$ -	$ 60.00
Seller--No	$ -	$ -	$ -	$ 60.00	$ -	$ 15.00

- Only partnership formed was between Buyer L ("large") and Seller L ("local"), who outbid Seller F (foreign).
- Buyer S (“small”) was rejected by all of the sellers, who were holding out for Seller L ("large").
- Whereas in the first scenario, the foreign seller was priced out of the market, in this scenario, the presence of the foreign seller is enough to induce both buyers to reject the notion of trading with the domestic seller because of higher expected value for waiting.
- During the next round, buyers and sellers would update their beliefs about the probability of a successful trade, which should result in a second alliance forming between Buyer S and Seller F ("foreign").
- Seller D (“domestic”) will be priced out of the market by the now competitive foreign Seller F, whose investment in air freight is starting to pay off.

Expectations of PMG

- Replicating what actually goes on in a procurement market is challenging
- Different payoff matrices may be defined to capture different styles and assumptions on the bilateral trade, resulting in different emergent behavior
- We may create 3-5 general types of games to represent commodity markets of similar types
- Buyers will outnumber sellers in the majority of markets
- Pair-feasibility criteria will be developed
- Stopping criteria to be determined, but providing suppliers to fulfill every buyer's input needs will be minimum—convergent solutions preferred
- Sellers will have "fuzzy" capacity constraints
- Cost structure assumptions and parameters, and utility preference weights will be highly influential, thus a large part of the development time
- FAF^3 flows will be used for benchmarking and calibration

Image by Argonne National Labs. Repast simulation. http://computationallegalstudies.com/2010/07/27/agents-of-change-agent-based-models-and-methods-the-economist/



Key Concepts

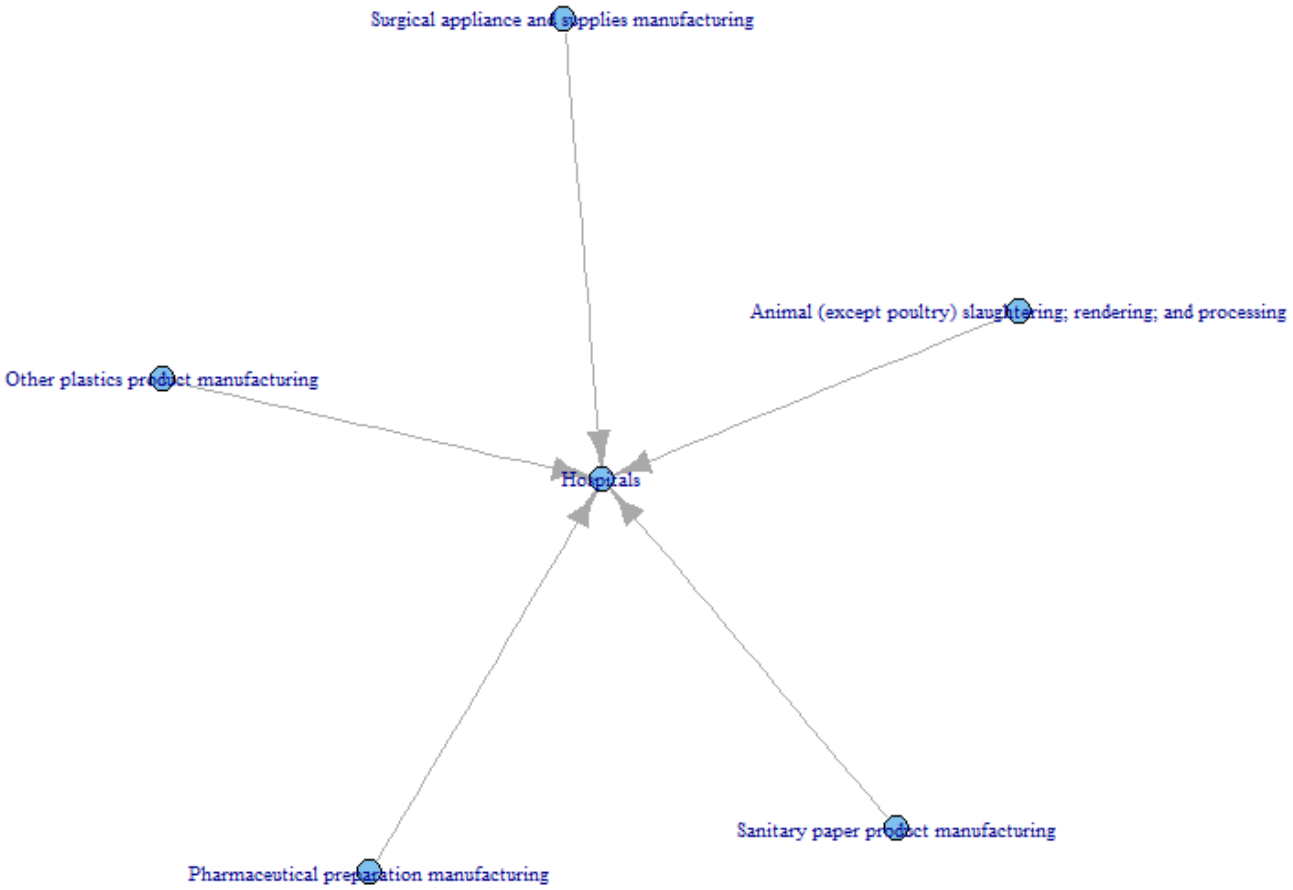
SUPPLY CHAIN AS ACTIVITY NETWORK

What is an Activity Network?

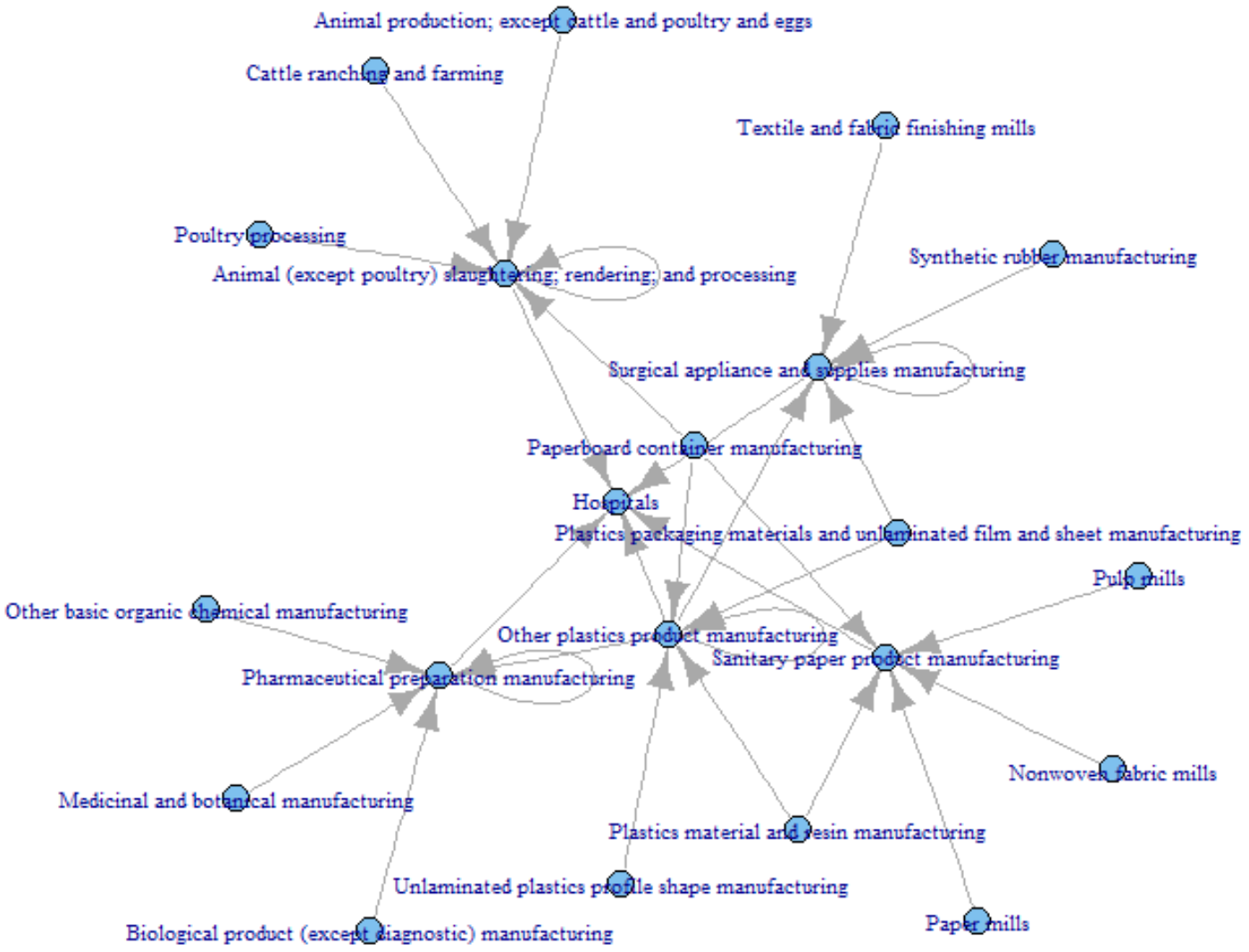
- Similar to social networks
- Goal directed toward a particular outcome (e.g., production)
- Nodes—actors/agents
- Links—ties between agents
- Flows—measure strength of ties
- Other Applications of Activity Networks
  - Criminology (drug/arms trafficking, terrorist cells, gangs)
  - Epidemiology (disease transmission)
  - Production processes (management science)
- Useful for studying network properties and relationships
  - Measures of centrality (prestige) for particular industries/firms/agents
  - Clustering, cohesion among groups of nodes (interdependency)
  - Weak links and gaps in the network
- Implementation for Mesoscale model extension
  - Agents represent firms/establishments
  - Links dimensioned by buyer-seller ties—strength proportional to flow values
  - Network propagation—allow prices charged by a supplier to be influenced by outcome of prior input sourcing decisions

Example: "Hospitals" (producer perspective)

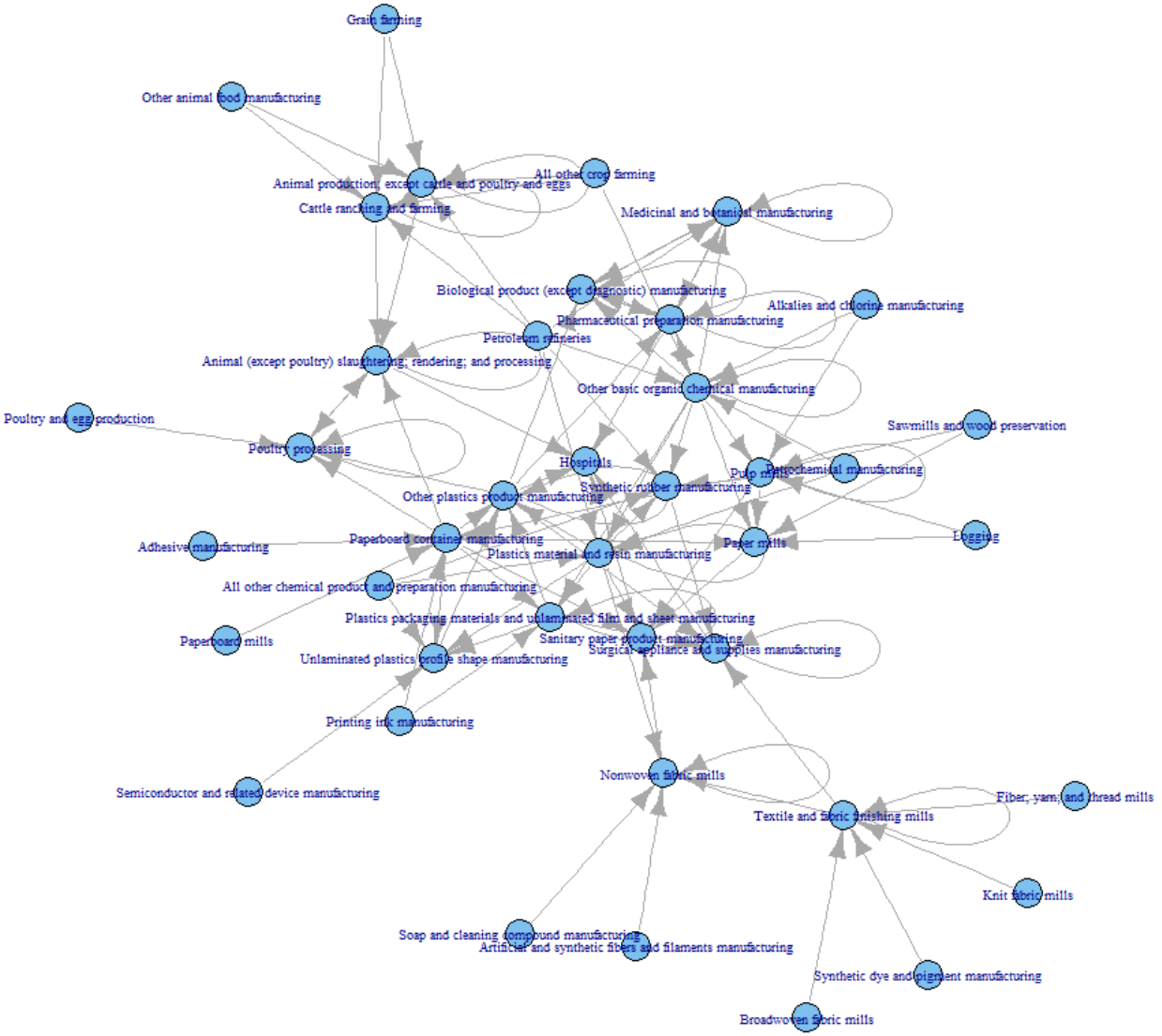
- 6-digit NAICS (U.S. BEA I-O Accounts)
- Top 5 input industries: 1st order direct relationships



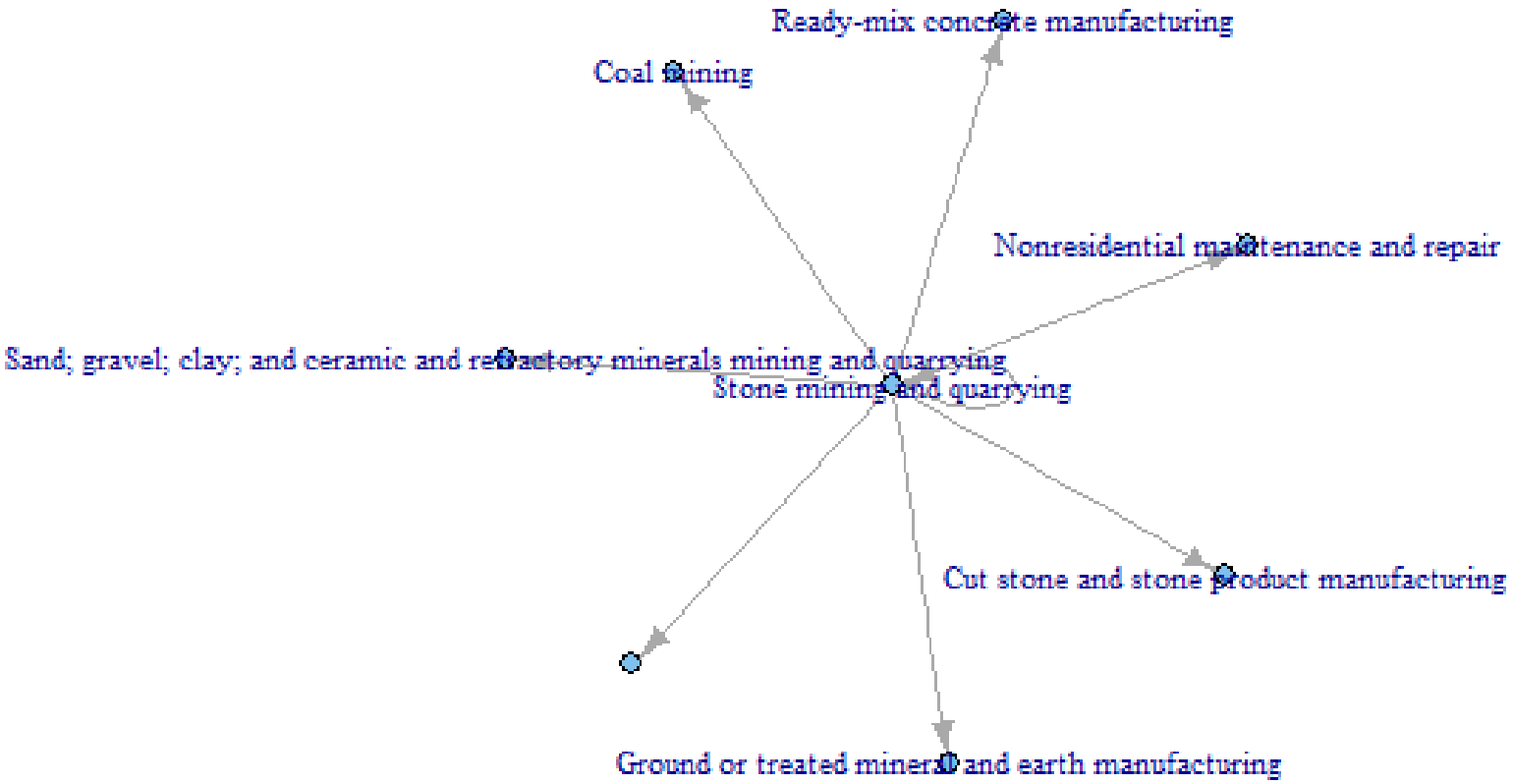
Hospital Production Inputs – 1st, 2nd order ties



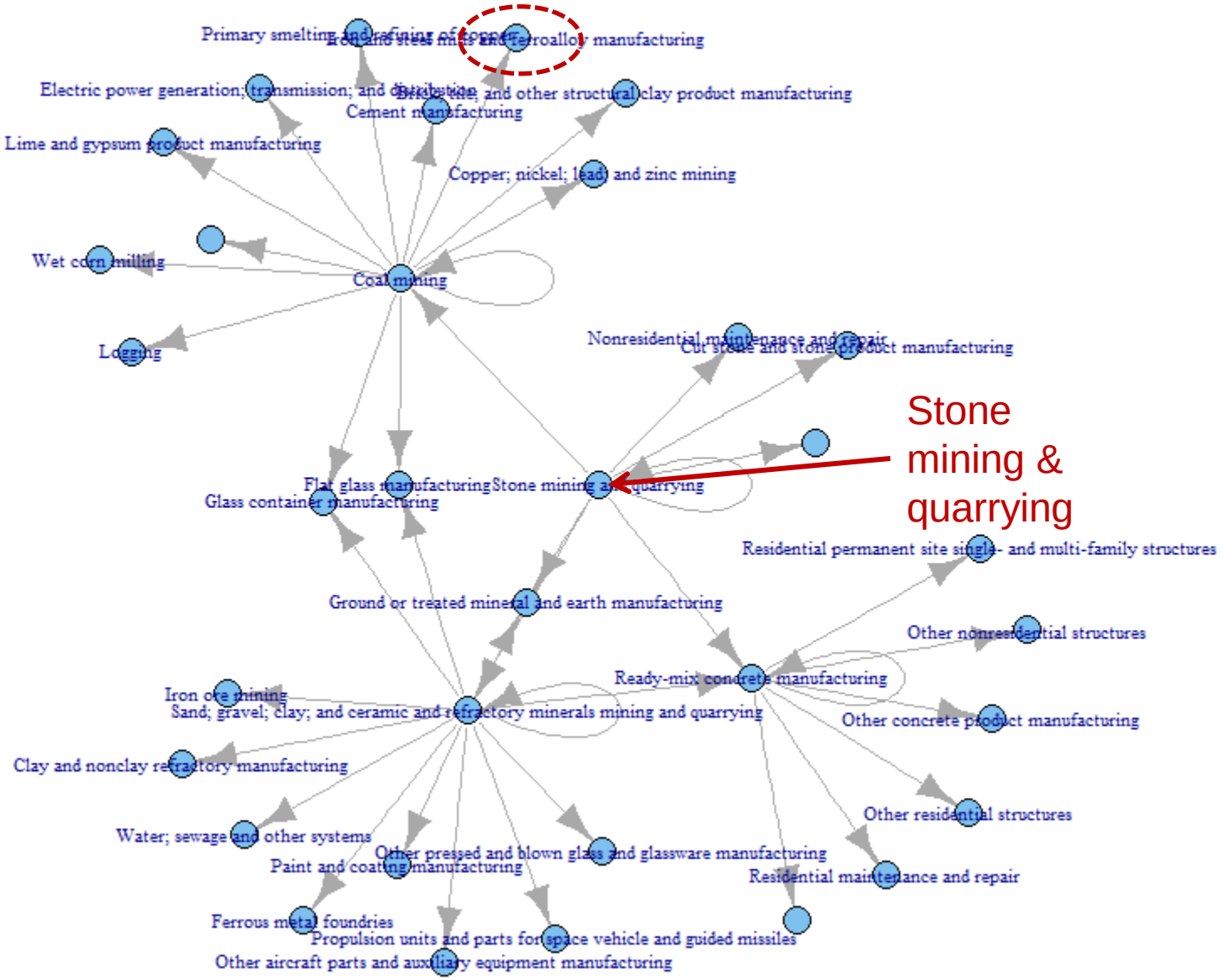
Hospital Production Inputs – 1st, 2nd, 3rd order ties



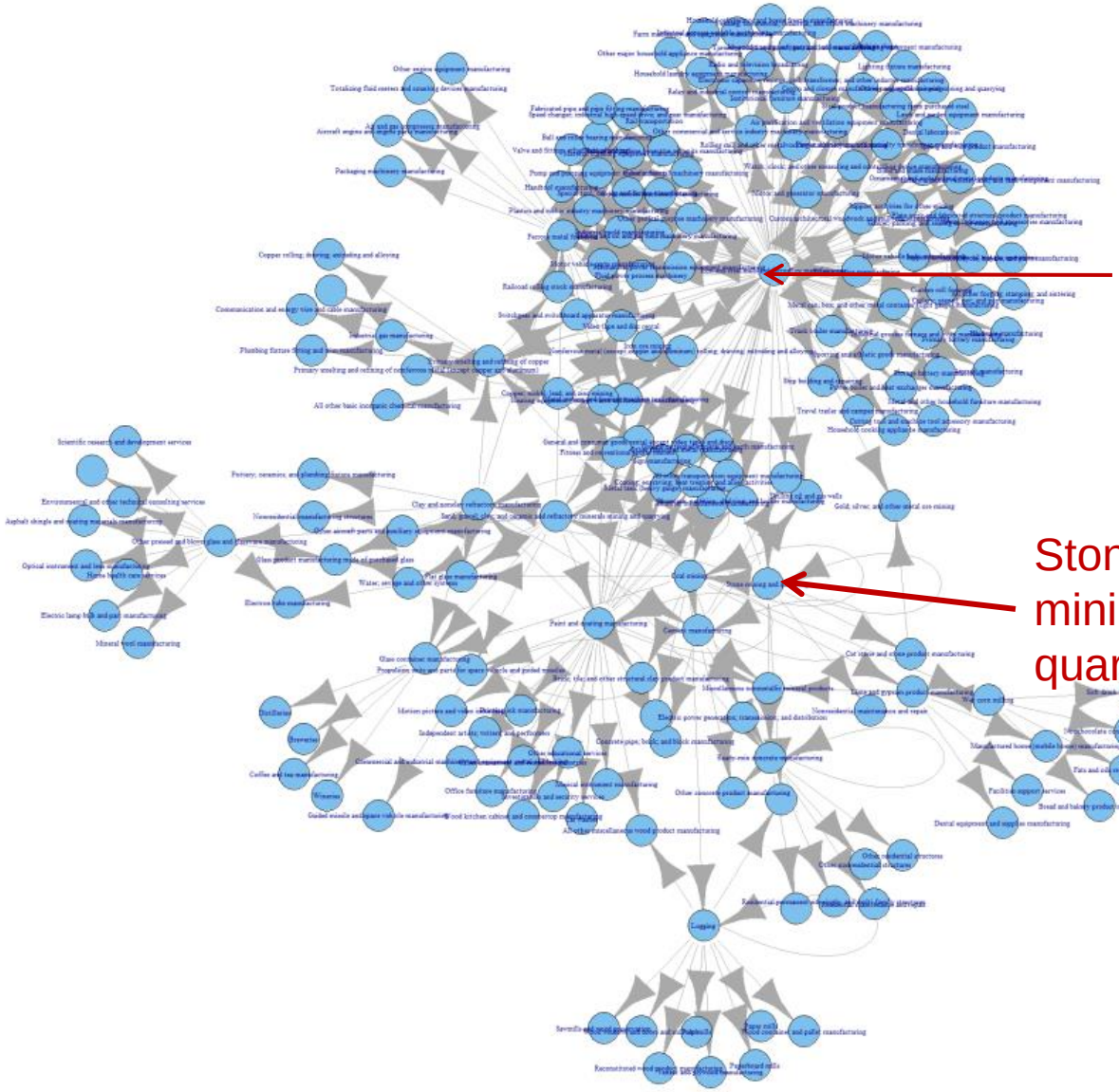
“Stone mining/quarrying” (supplier perspective)



“Stone mining/quarrying” (1st, 2nd order ties)



“Stone mining/quarrying” (1st, 2nd, 3rd order ties)



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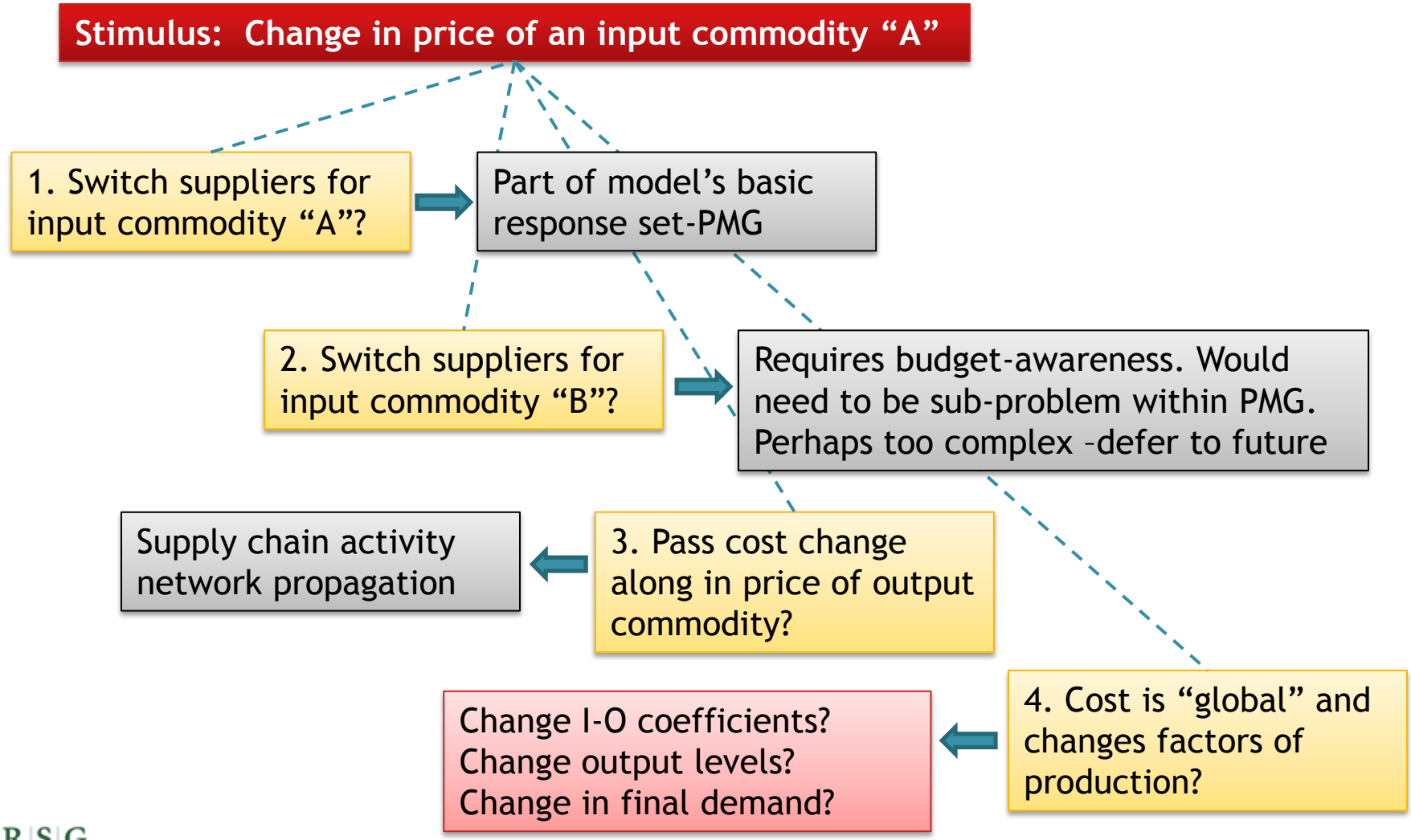
Response Sensitivity and Forecasting
John Gliebe, RSG

Levels of Response Sensitivity

- Different levels of response sensitivity can be incorporated in the model design (not mutually exclusive)

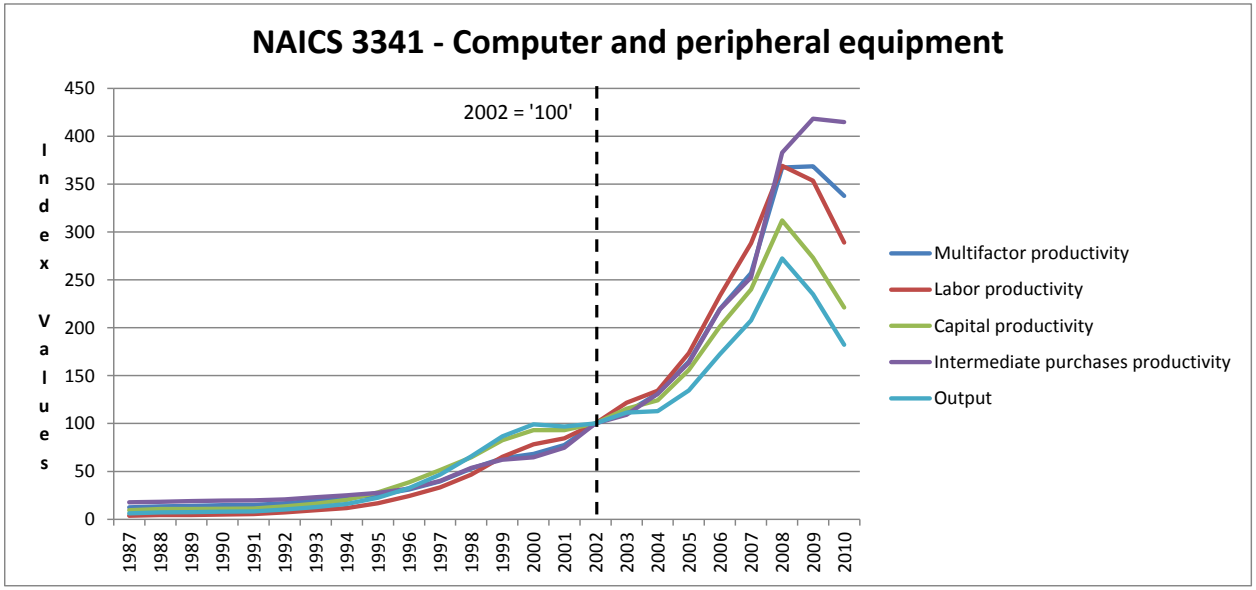


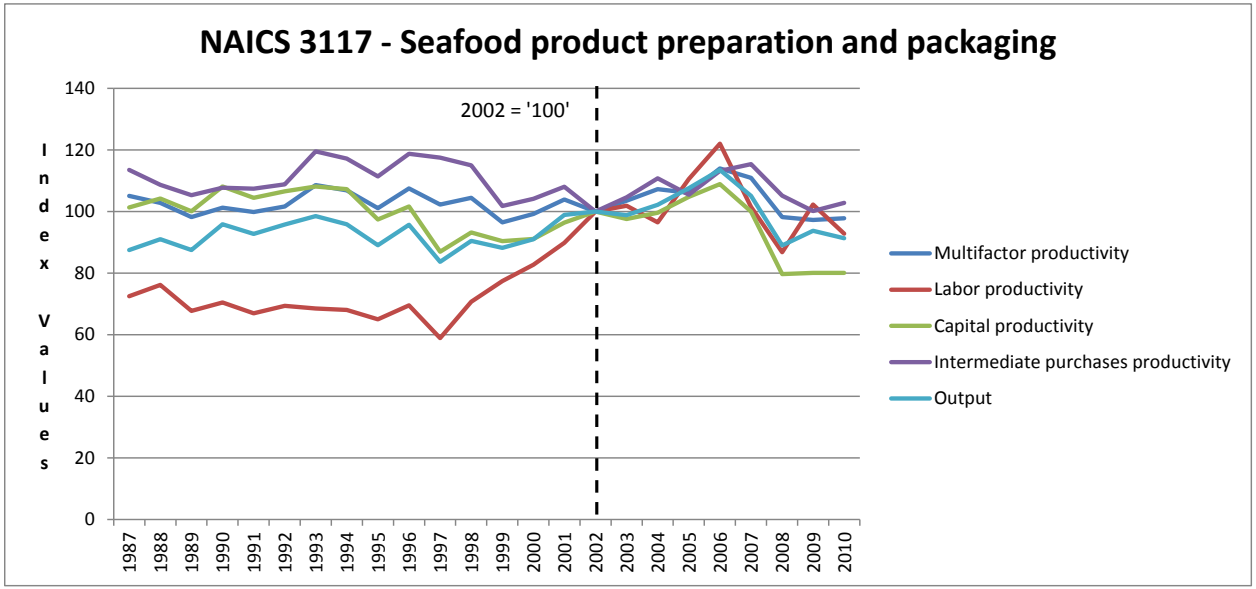
Changes in "Computer and Electronic Products"

Rank	Commodity	2002 (M$)	2011 (M$)	Change (M$)	% Change	% of total inputs	% of total inputs
1	Computer and electronic products	78,107	39,881	-38,226	-49%	49%	48%
2	Wholesale trade	25,737	13,846	-11,891	-46%	16%	17%
3	Fabricated metal products	9,783	5,020	-4,763	-49%	6%	6%
4	Publishing industries (includes software)	9,219	5,509	-3,710	-40%	6%	7%
5	Chemical products	6,681	3,720	-2,961	-44%	4%	4%
6	Primary metals	5,836	5,587	-249	-4%	4%	7%
7	Plastics and rubber products	5,442	1,590	-3,852	-71%	3%	2%
8	Electrical eq., appl., & components	4,357	2,832	-1,525	-35%	3%	3%
9	Utilities	2,928	1,012	-1,916	-65%	2%	1%
10	Truck transportation	1,864	1,045	-819	-44%	1%	1%
	Sum of Top 10	140,954	80,042			94%	96%
Total Intermediate Inputs		218,835	121,089	-97,746	-45%		
Compensation of employees		112,861	121,311	8,450	7%		
Taxes on prod. and imports, less subsidies		4,695	5,496	801	17%		
Gross operating surplus		5,972	86,731	80,759	1352%		
Total value added		123,528	213,538	90,010	73%		
Total industry output		342,364	334,628	-7,736	-2%		

- The total input used decreased by about $100 million from 2002 to 2011
- Gross operating surplus increased enormously
- Total industry output remained relatively unchanged
- More productive using less input value to produce the same level of total output
- Freight perspective: U.S. producers in this industry were shipping about the same amount of product in 2011 as in 2002, but were receiving about half the 2002 level of inputs

Multi-factor Productivity (U.S. BEA Index)





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Capturing Global Trends and Future Year Forecasts

- As a baseline measure, trends in input-output productivity should be derived from the Multifactor productivity index tables when making projections for more distant future years
- Other assumptions regarding future conditions be **asserted** as conditional statements in the future forecast input parameters
  - Deviations from the technical coefficients that describe the mix of input commodities used to produce a particular output commodity
  - Assumptions regarding the total demand for a particular commodity

Break

- 10-minute break

Implementation and Testing Plan
John Gliebe, RSG

Work Plan: Tasks 1 & 2-Stage 1

TASK 1: Model Design (Complete Oct. 2013)

Update model design document based on expert panel recommendations

* *Deliverable: Final model design technical report*

TASK 2: Develop Mesoscale Model Extension (Oct. 2013 - August 2014)

Stage 1	**Basics: Modification of Existing Code Base** (Oct. 2013 - Dec. 2013)
1.1	Create agents to cover entire geographic market and industry scope
1.2	Update agent cost components:
1.2.1	Derive complete travel time and cost skims by mode
1.2.2	Derive non-transport production costs by region
1.2.3	Assert agent types from literature
1.3	Modify R code to provide inputs to procurement market game (PMG)
1.4	Modify TNG C++ code to PMG requirements:
1.4.1	Agent attributes
1.4.2	Assymetric payoffs and cost/utility mapping
1.4.3	Genetic algorithm/belief updating to accommodate multiple agent types

Work Plan: Task 2-Stage 2

Stage 2	**Incremental Development** (Jan. 2014 - April 2014)
2.1	Develop PMG for one commodity market
2.1.1	Test PMG performance with cost only
2.1.1.1	Assume costs for suppliers do not change as a result of their input commodity choices
2.1.1.2	Assert utility preference weights based on literature
2.1.1.3	Leave out mode choice and shipment size dimensions
2.1.1.4	Assume primary mode chosen based on least-cost path
2.1.2	Test PMG performance with cost and shipment time variables
2.2	*Parallel Track A* : Test adding dimensionality to PMG
2.2.1	Multiple mode service options (add selling agents)
2.2.2	Shipment size and frequency service options (add selling agents)
2.3	*Parallel Track B* : Test adding other commodity markets
2.3.1	Determine 95% input commodity flow coverage by value for each output commodity
2.3.2	Simulate using "cost only" model from 2.1.1
2.3.3	Compare with FAF3 flow coverage, adjust parameters
2.3.4	Determine reasonable supplier/agent availability restrictions

Work Plan: Task 2-Stages 3 & 4

Stage 3	**Integrated Testing and Refinement** (May 2014 - June 2014)
3.1	Combine "best" model dimensions from Stage 2, combining Track A and Track B results
3.2	Test multiple supplier attribute variables
3.3	Test multiple commodity markets
3.4	Fine tune parameters

Stage 4	**Activity Network Implementation: Choice Outcome Propagation** (July. 2014 - Aug 2014)
4.1	Assume costs for suppliers change as a result of their input commodity choices
4.1.1	Develop ordering of commodity markets for PMG, starting with raw inputs
4.1.2	Develop function to update seller agent costs as a function of their input purchases
4.2	Tests dynamics with "best" model from Stage 3
4.3	Assess feasibility and behavioral implications

* *Deliverable: Prototype mesoscale model with extension components implemented*

Work Plan: Tasks 3 & 4

TASK 3: Sensitivity Testing (July 2013 - March 2015)

Subtask 1	**Create Scenarios with CMAP** (July 2014 - Sept. 2014)
1.1	Impacts of full implementation of Chicago's CREATE program
1.2	Impacts of implementation of Midwest Intermodal Hub in Iowa
1.3	Impacts of expansion of Port of Prince Rupert, BC
1.4	Impacts of reduction/increase in U.S. Trade with China

Subtask 2	**Run Scenarios, Analyze Results** (Aug. 2014 - March 2015)
2.1	Impacts of full implementation of Chicago's CREATE program
2.2	Impacts of implementation of Midwest Intermodal Hub in Iowa
2.3	Impacts of expansion of Port of Prince Rupert, BC
2.4	Impacts of reduction/increase in U.S. Trade with China

* *Deliverables: Technical report describing sensitivity test setup, results, lessons learned*
Final updated model code

TASK 4: Documentation and Training (April 2015 - June 2015)

Subtask 1	**Prepare Documentation** (April 2015 - May 2015)
1.1	Documentation of Model Theory, Algorithms and Parameter Development
1.2	User's Guide to Software, Data Preparation, Running the Model

Subtask 2	**User Training** (June 2015)
2.1	On-site training for CMAP staff

* *Deliverables: Documentation of model theory, algorithms and parameter development*
User's guide to software, data preparation, running the model
On-site training and training materials

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Panel Questions and Answers
Colin Smith, RSG, Moderator

Thank you!

Special thanks to our expert panel

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