How Truck and Rail Compete in Commodity Movement in the U.S.?

Amir Samimi, Kouros Mohammadian, Kazuya Kawamura

University of Illinois at Chicago

The 3rd International Conference on Innovations in Travel Modeling of the Transportation Research Board

Tempe, Arizona, May 10-12, 2010

UIC

The University of Illinois at Chicago

Background

- A direct comparison of shipment costs was the primary method (Cunningham, 1982).
- Reliability, flexibility, safety, and some other non-cost factors entered the analysis when the random utility models emerged (Norojono and Young, 2003)
- Hensher and Figliozzi (2007) argued that new supply chain concepts are adopted by many companies, which subsequently influenced the shipping preferences and required fundamental revision in the models.

UIC

The University of Illinois at Chicago

Objectives

- To introduce a large-scale behavioral freight modeling framework with a focus on modal split.
- To utilize publicly available freight data in the U.S. for the framework.
- To conduct a survey and satisfy the data needs.
- To introduce a behavioral freight mode choice model.
- To run a microsimulation freight model for the U.S.

UIC

The University of Illinois at Chicago

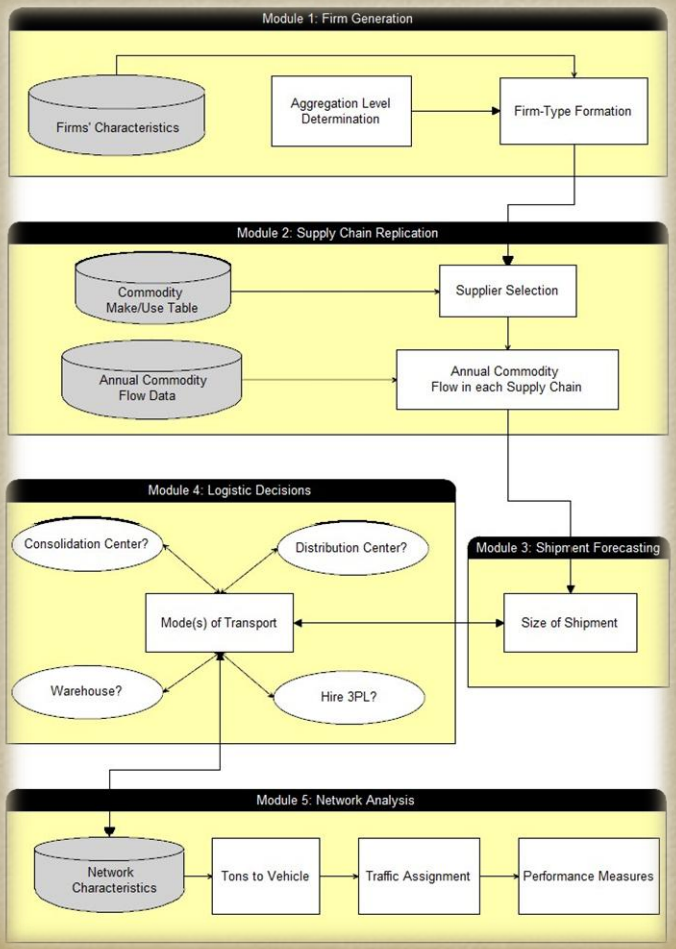
Technical challenges

- Rapid changes in the supply chain management strategies,
- Lack of an acceptable freight modeling framework,
- Freight data scarcity.

UIC

The University of Illinois at Chicago

FRAMEWORK



FAME

FREIGHT

ACTIVITY

MICROSIMULATION

ESTIMATOR

UIC

The University of Illinois at Chicago

Firm Generation

INTRODUCTION

FRAMEWORK

DATA NEEDS

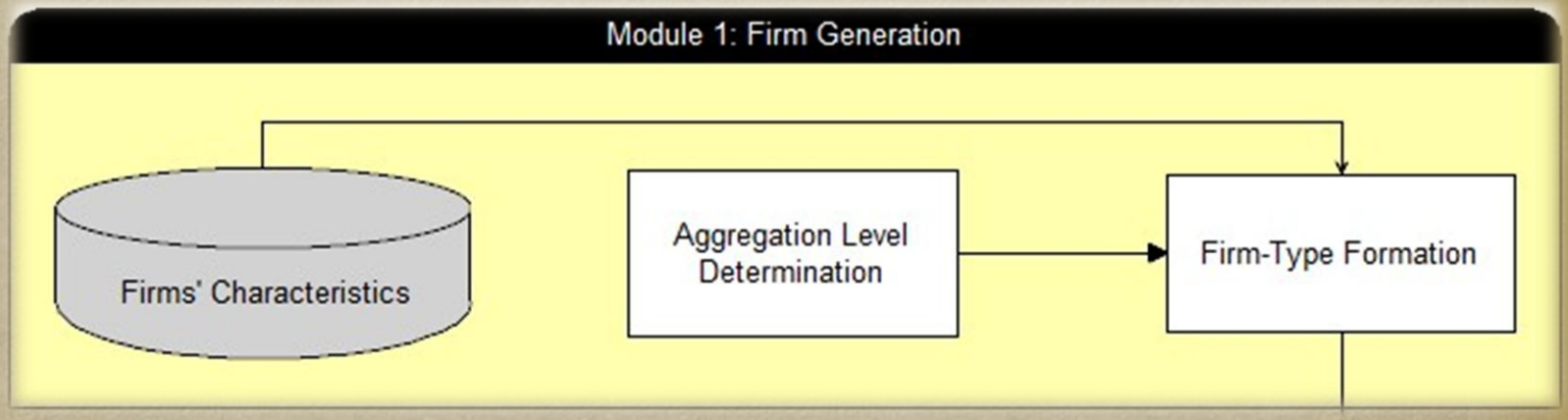
THE SURVEY

MODELS

SIMULATION

CONCLUSION

Q/A



UIC

The University of Illinois at Chicago

Supply Chain Replication

INTRODUCTION

FRAMEWORK

DATA NEEDS

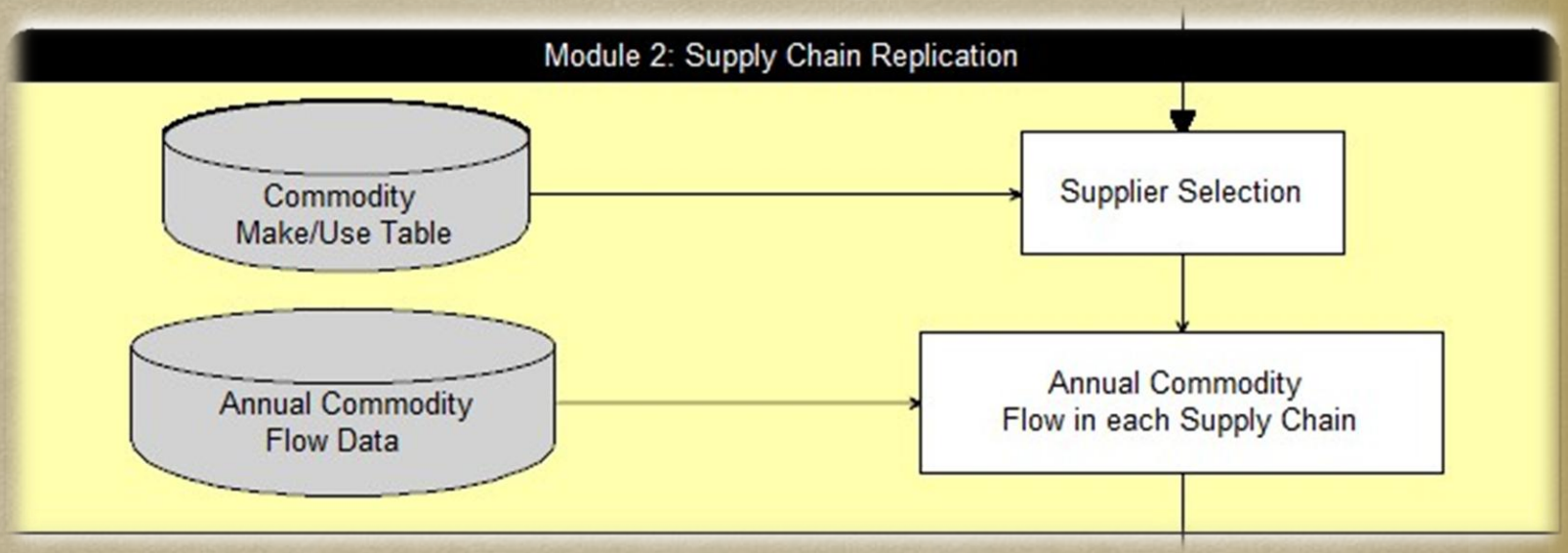
THE SURVEY

MODELS

SIMULATION

CONCLUSION

Q/A

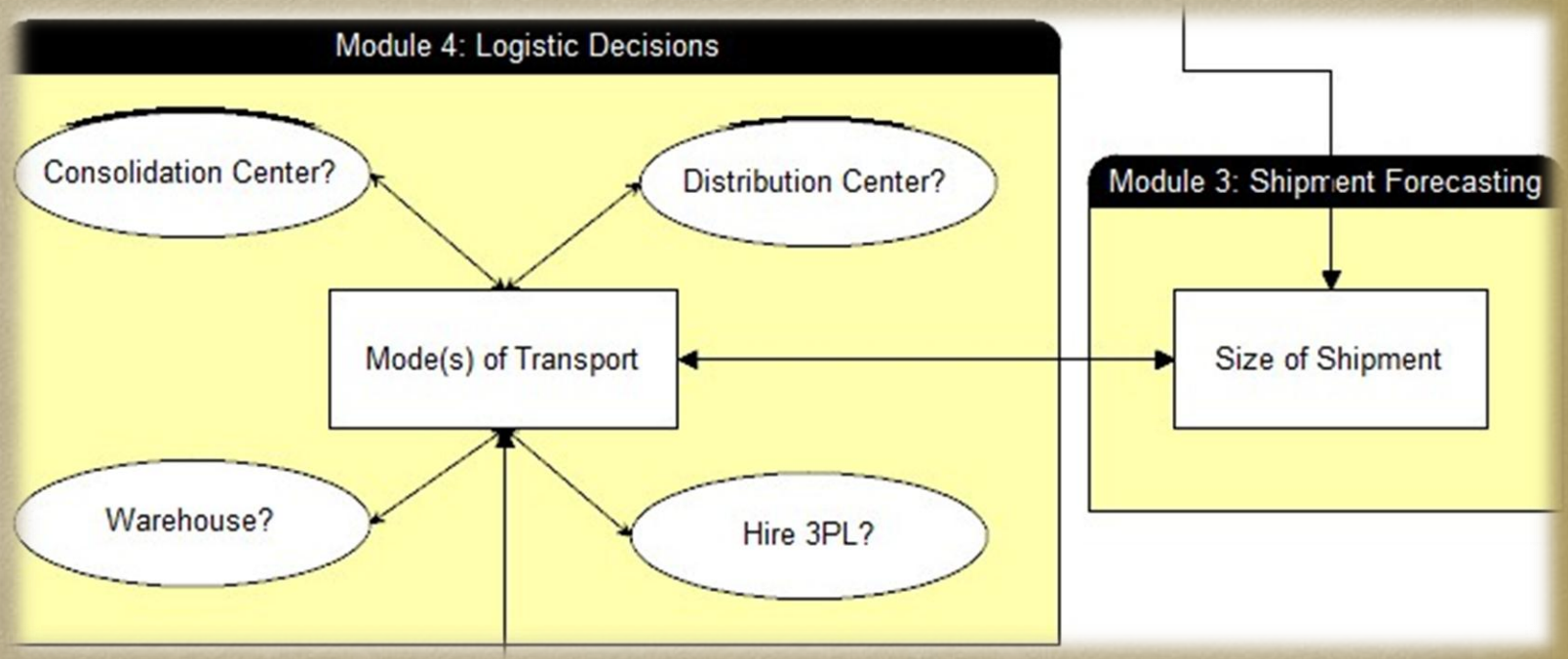


UIC

The University of Illinois at Chicago

Logistics Planning

INTRODUCTION
FRAMEWORK
DATA NEEDS
THE SURVEY
MODELS
SIMULATION
CONCLUSION
Q/A



UIC

The University of Illinois at Chicago

Network Analysis

INTRODUCTION

FRAMEWORK

DATA NEEDS

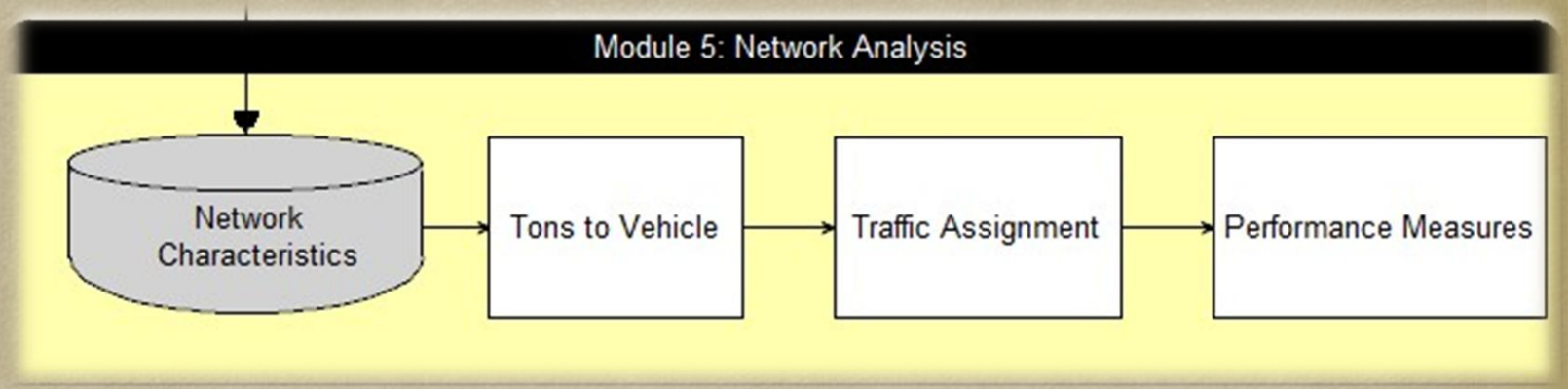
THE SURVEY

MODELS

SIMULATION

CONCLUSION

Q/A



UIC

The University of Illinois at Chicago

DATA NEEDS

Four types of data are required for FAME:

- Information on Business Establishments,
- Aggregate Freight Movements,
- Information on Individual Shipments,
- Specifications of the Transportation Networks.

UIC

The University of Illinois at Chicago

UIC SURVEY

- A person with comprehensive knowledge of the firm's supply chain and transportation activities was asked for this online survey.
- Around 9.3% of those clicked on the survey link.
- 316 establishments participated in the survey providing information on 881 shipments across the country.
- PART I: Establishment Information.
- PART II: Shipment Information.
- PART III: Contact Information.

UIC

The University of Illinois at Chicago

Biasness

Value and weight share of each mode:

Mode	Dollar Value		Weight		Shipments
	CFS	UIC	CFS	UIC	UIC
Truck	68%	67%	60%	49%	69%
Rail	3%	4%	10%	12%	5%
Water	1%	8%	4%	8%	5%
Air, air & truck	5%	9%	0%	1%	11%
Intermodal	15%	12%	7%	30%	11%
Pipeline & unknown	9%	-	20%	-	-

UIC

The University of Illinois at Chicago

MODELS

Models that are used in FAME:

- Supplier selection,
- Shipment size,
- Mode Choice.

UIC

The University of Illinois at Chicago

Supplier Selection

A Bi-Level Supplier Selection Model:

- List all the candidate suppliers,
  - ✓ FAF industry to commodity crosswalk,
  - ✓ Make and use tables in the 2002 Benchmark Input-Output Account.
- Suitability assessment?
  - ✓ A fuzzy rule-based system.

UIC

The University of Illinois at Chicago

Shipment Size

- Distribution of the size of the shipments by commodity type and by shipping distance was obtained from the CFS 2002,
- 9 categories for distance: 50 miles, 50-99, 100-249, 250-499, 500-749, 750-999, 1000-1499, 1500-2000, >2000.
- 3 categories for size: <1000 lbs., 10000-50000, 50000<.
- 43 categories for commodity: 2Digit-SCTG

Shipment Size

Initialization:

- For a given commodity and distance, define the following matrix:

$$\begin{array}{c} \\ \text{supplier } i \text{ to buyer } j \\ \\ \text{Total} \end{array} \begin{array}{c} \begin{array}{ccc} \textit{Small} & \textit{Average} & \textit{Large} \end{array} \\ \begin{bmatrix} \vdots & \cdots & \\ \vdots & x^{A}{}_{ij} & \vdots \\ \vdots & \cdots & \\ \sqrt{} & \sqrt{} & \sqrt{} \end{bmatrix} \end{array} \begin{array}{c} \textit{Total} \\ \begin{bmatrix} \sqrt{} \\ \sqrt{} \\ \sqrt{} \end{bmatrix} \end{array}$$

- Initialize in a way that larger supplier and buyers tend to ship their commodity in larger shipments.

Shipment Size

- Iterative Proportional Fitting (IPF),
- Determining factors in shipment size:
  - ✓ Establishment size of the supplier,
  - ✓ Establishment size of the buyer,
  - ✓ Shipping distance,
  - ✓ Commodity type.

UIC

The University of Illinois at Chicago

Mode Choice

Variable	Definition	Mean	Standard deviation
MODE	1: truck / 0: rail or any combination of that with truck	0.924843	0.263919
GCD	Great circle distance (miles)	616.563	640.328
WEIGHT	Weight of the shipment (lbs)	23457.6	28959
IMPEDANCE	= EXP (H_IMP/R_IMP)	6.1866	3.33839
H_IMP	Highway impedance	897.702	4589.48
R_IMP	Rail impedance	1176.16	9082.08
CONTAINERIZED	1: if the shipment is containerized / 0: otherwise	0.02296	0.149947
COMMODITY	1: if the commodity is agricultural, chemical, pharmaceutical, gravel, natural sands, cement, machinery, metal, mixed freight, miscellaneous, or prepared foodstuffs / 0: otherwise.	0.655532	0.475691

UIC

The University of Illinois at Chicago

Mode Choice

Item		Value	t-ratio	VIF
Coefficient	CONSTANT	4.832713742	8.170	-
	GCD	-.1042385818E-02	-4.856	2.0786606
	WEIGHT	-.2543805528E-04	-5.075	1.0296476
	IMPEDANCE	-.9889771944E-01	-1.978	2.0211493
	CONTAINERIZED	-1.271052643	-2.612	1.0550726
	COMMODITY	-.9403044651	-2.985	1.0463709
Fit Measures	Log likelihood	-58.56742	-	-
	Model Chi-squared	138.4382	-	-
	Akaike I.C.	0.26959	-	-
	Pseudo R-squared	0.54168	-	-
	Correctly Predicted (%)	95.615866	-	-
	Correctly Predicted (%) – rail	58.33333	-	-

UIC

The University of Illinois at Chicago

SIMULATION

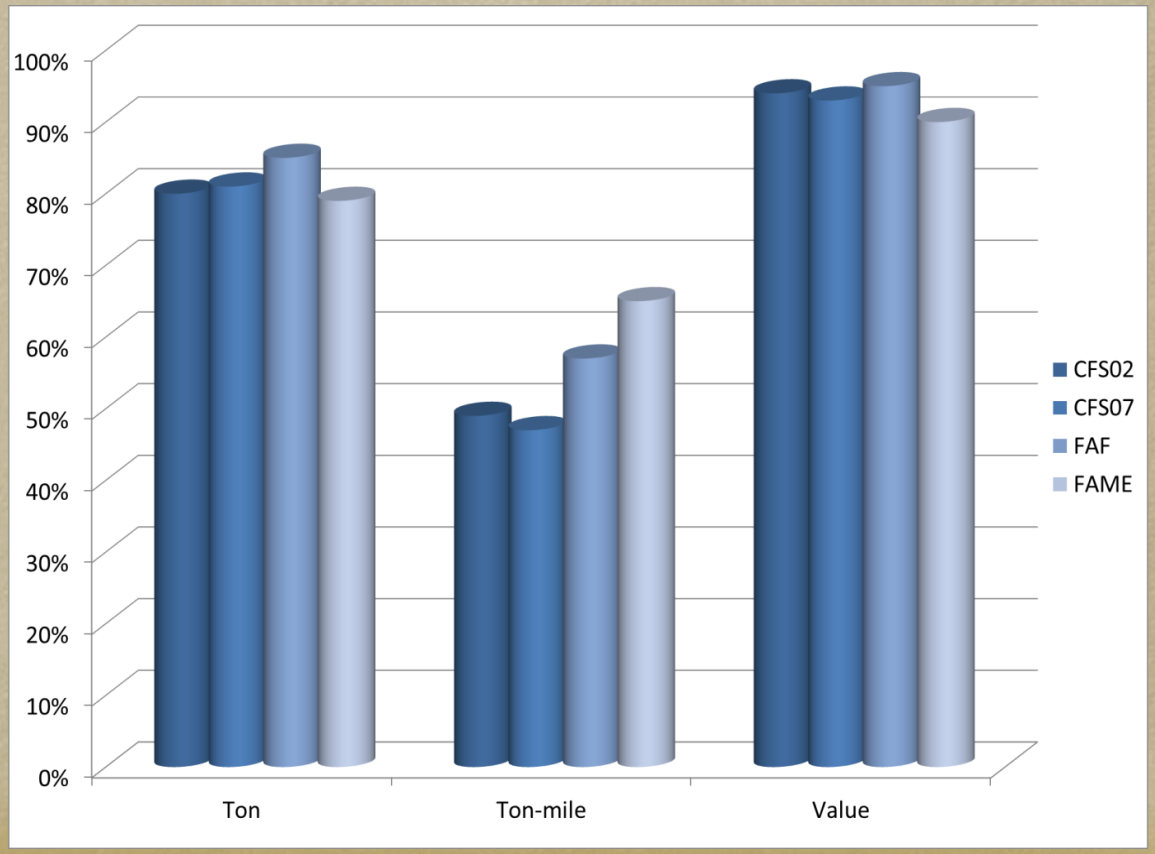
- A total of 46,243 firm-types were generated,
- In all the domestic FAF zones,
- Based on County Business Patterns (CBP) 2002,
- For each firm-type:
  - ✓ Location (FAF),
  - ✓ Industry (NAICS),
  - ✓ Size (8 clusters),
  - ✓ Number of actual firms

UIC

The University of Illinois at Chicago

SIMULATION

Modal Split Validation:



UIC

The University of Illinois at Chicago

CONCLUSION

Research Contribution:

- FAME is heavily based on public freight data in the U.S. and therefore data collection costs are substantially low.
- It is one of the early efforts in freight demand modeling that has a separate component for supply chain configuration.
- It has an open structure and could accept other components that may be available later.

UIC
The University of Illinois at Chicago

CONCLUSION

Research Contribution:

- Almost all the industry classes are covered in FAME.
- FAME has a unique geographic coverage and to the best of the author's knowledge, it is the first comprehensive nationwide freight microsimulation in the U.S.

UIC

The University of Illinois at Chicago

CONCLUSION

Future Works:

- Obtain more information on supplier selection preferences, and expand the second module,
- Develop a robust model to estimate the probability of a shipment being containerized,
- Consider international shipments as well,
- Implement econometrics models or logistic cost minimization approaches for shipment size,
- Network analysis.

UIC

The University of Illinois at Chicago

Q/A

INTRODUCTION
FRAMEWORK
DATA NEEDS
THE SURVEY
MODELS
SIMULATION
CONCLUSION
Q/A