

Multi-Modal Freight Transportation: Regional Data Development and Analysis

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In New Jersey, as well as in all other states and regions of the country, information on freight movements has lagged significantly in terms of both availability and quality of data compared with information available about personal trips. Freight movement information is critical for comprehensive transportation planning. Commodity flow data and related analytical and modeling tools are needed for intelligent decision-making, which determines the state's expenditure of capital improvement funds. They are necessary inputs in the

state's evaluation of its position in the regional, national and global economy, and in designing the actions that will improve the its economic competitiveness.

In cooperation with NJDOT's recognition of the need for regional freight information, NCTIP undertook the following goals:

- Integrate two databases of commodity flows by standard transportation commodity code (STCC) and mode of transport between New Jersey counties and selected U.S. and foreign destinations.

- Develop a model for assigning commodity origin-destination (O-D) trip tables over the regional multi-modal transportation network.
- Use the model for various transportation analyses (e.g., estimating through truck traffic, exclusive freight facilities, toll changes, mode shifts).

This article focuses on the first goal of the project, development of descriptions of commodity flows in and out of New Jersey. This research generated a product using the NJDOT freight database that was made available to planners throughout the northern portion of the state and the New York/New Jersey Metropolitan region.

Research Project

The goal of NJDOT Freight Information Management System (NJFIMS) is to provide a powerful and effective tool to manage the commodity flow data in New Jersey. With the accumulation of the commodity flow data year by year, it becomes imperative to create an integrated freight movement database management system that supports the user in various aspects, including the commodity flow summary report, corridor analysis, multimodal planning, and other strategic issues in New Jersey.

The main objective for this portion of the research project was to develop descriptions of commodity flows in and out of New Jersey and to organize the data in user-friendly reports and databases. In addition,

it was important to interface the existing databases and analytical tools within an executive management information system (MIS) capable of providing analytical answers to a myriad of critical planning questions. Finally, a hypertext capability for the executive MIS was developed. The MIS is available for use on the Internet at <http://freight.njit.edu>.

It was envisioned that via the data review interfaces, the MIS would enable users to drill down the database to obtain specified information about the commodity flows for a single pair or multiple pairs of origin and destination counties. Following are examples of the search queries that the system could handle:

- What is the amount of commodity flows from Bergen, NJ to Bronx, NY in 1993, summarized by Standard Transportation Commodity Code (STCC) and Transportation Mode?
- What is the aggregate amount of commodity flows from Atlantic, Bergen, and Camden to Atlantic, Essex, Hudson and Hunterdon in 1982, summarized by STCC and Transportation Mode?
- What is the change in commodity flows between 1993 and 1982 databases from the Delaware Valley counties to Cape May, NJ?

Comparative Analysis of the Data

The research project was to use the most recent data available to generate reports for each of the 21 counties New Jersey showing commodity flows broken down by STCC and mode of transport. At the outset of this project it was established that two separate databases containing information on com-

modity flows were in use at NJDOT: the Reebie Associates' TRANSEARCH for 1982 and DRI/McGraw-Hill's (DRI) database containing 1993 flows. In the source databases, flows were given on a county-to-county scale, and between each county and points outside the state. The NJFIMS was developed using both sources of data so that the DRI database could be compared to the TRANSEARCH database.

The DRI database contains commodity flows among 21 NJ counties as well as those between NJ counties, 19 external adjacent areas and eight distant domestic areas. The data selected allow users to examine commodity flows based on various data sources and transportation modes.

Another comprehensive source of data is the Commodity Flow Survey (CFS), undertaken through a partnership between the Bureau of the Census, U.S. Department of Commerce, and the Bureau of Transportation Statistics, U.S. Department of Transportation. This survey, conducted as part of the Economic Census, produces data on the movement of goods in the United States. It provides information on commodities shipped, their value, weight, and mode of transportation, as well as the origin and destination of shipments of manufacturing, mining, wholesale, and selected retail establishments.

This section presents a comparison analysis of the 1993 CFS results (issued October 1996) and the DRI database, concentrating on New Jersey State commodity flow data validation. It identifies the discrepancies in the two data sources, in terms of magnitude of tonnage moved, five most shipped commodities, transportation modal shares

and most likely destinations.

More recent CFS data was issued in December 1999, well after the research was underway. However, the commodities shown in the 1997 CFS report were not classified using the STCC coding system, but rather used the Standard Classification of Transported Goods (SCTG) coding system. Because of the different approaches used by these two systems in classifying commodities (the STCC links them to an industry structure while the SCTG does not), a direct comparison by commodity of the DRI database with the 1997 CFS is difficult, if not impossible, to do. Because of the different approaches, this research focused on verifying that DRI 1993 data were comparable in tonnage and ranking to the 1993 CFS data, which used the STCC system.

It is important to keep in mind that the two databases are only preliminary estimates. In addition, the 1993 CFS does not include most crude oil shipments and DRI does not include overnight mail services.

1. Overall Tonnage Estimate

The total tonnage from all origins to all destinations in the U.S., as shown in Table 1, was estimated as 7679.9 million tons by the DRI database, while the CFS database estimated 9688.5 million tons of total USA shipments. There is a difference of 2008.6 million tons between those two estimates.

However, at the state levels, also shown in Table 1, the overall total commodity flow estimate of 179.66 million tons made by DRI is close to the 1993 CFS result of 179.5 million tons of shipments originating in New Jersey.

Table 1. Overall Total Tonnage Estimates (in million tons)

Database	Total Tonnage of USA	Outboard Tonnage in NJ
1993 CFS	9688.5*	179.5
DRI/McGraw-Hill	7679.9	179.66
Difference	2008.6	-0.16

*9688.5 = (12157.1 - 1609.3 - 859.3), where the total excludes the Oak Ridge National Laboratory (ORNL) for pipeline and water shipments estimates.

2. NJ Total Tonnage by Transportation Modes

The total of New Jersey shipments moved by truck, as shown in Table 2, was estimated at 155.88 million tons, in the 1993 CFS, which is close to the DRI, estimate of 147.5 million tons. However, there is a significant difference in the total New Jersey shipments moved by rail as shown in Table 3 — 2.87 million tons in the 1993 CFS versus 21.3 million tons in the DRI database.

Table 2. NJ Shipments by Truck Mode (in million tons)

Database	Total Tonnage (NJ)	Moved by Truck (NJ)
1993 CFS	179.5	135.88
DRI/McGraw-Hill	179.66	147.5
Difference	-0.16	-11.62

3. NJ Total Tonnage by Commodity

The top commodities of outboard shipments in New Jersey are similar, but the order is different. Food or kindred products rank 4th and chemical and allied products rank 5th in the 1993 CFS data. According to

the DRI database, chemical products rank 4th and food or kindred products rank 5th. A summary comparison is shown in Table 4.

Table 3. NJ Shipments by Rail Mode (in million tons)

Database	Total Tonnage (NJ)	Moved by Rail (NJ)
1993 CFS	179.5	2.87
DRI/McGraw-Hill	179.66	21.3
Difference	16	-18.43

4. Most Likely Destinations of NJ Shipments

The region definitions differ for the top destinations of New Jersey outboard shipments of the 1993 CFS data and the DRI data, which makes it difficult to compare them directly. A summary comparison is shown in Table 5.

Overview of Freight Information Management System

The research focused on developing an integrated graphical interface to help users access and search commodity flow information quickly and easily. The developed NJFIMS is a relational database management system based on MS Access platform. It is easy-to-use, intuitive in navigation, and flexible with enhanced multiple-Origin/Destination selection functionality. NJFIMS integrates the two NJDOT original databases, the 1993 database bought by the NJDOT from DRI/McGraw-Hill and the 1982 database prepared by Reebie Associates into the

Table 4. Top Commodities of NJ Outboard Shipments (in million tons)

	1993 CFS	CFS Tonnage	%		DRI	DRI Tonnage	%
1	Petroleum or Coal Products	64.08	35.7	1	Petroleum or Coal Products	50.95	28.4
2	Nonmetallic Minerals	29.44	16.4	2	Nonmetallic Minerals	32.36	18.0
3	N/A			3	Crude Petroleum, Natural Gas	25.85	14.4
4	Food or Kindred Products	23.51	13.1	5	Food or Kindred Products	13.56	7.5
5	Chemical or Allied Products	13.64	7.6	4	Chemical	19.61	10.9
6	Clay, Concrete, Glass or Stone Products	9.51	5.3	6	Clay, Concrete, Glass or Stone Products	7.06	3.9
7	Others	39.31	21.9	7	Others	58.03	32.3
	Totals	179.5	100.0	0	Totals	179.66	100.0

NJFIMS. The customized reorganization and unified formats of the data in NJFIMS make the maintenance and the analysis of the NJ freight movement information more effective and informative for seeking summarized information at different detail levels.

The system consists of diverse objects such as Access Data tables, SQL queries, Date Review forms, Visual Basic modules, and a group of linked Word documents. The integrated design of the system ties these objects together to perform certain predefined functionality as a whole.

The Access forms serve as the user interfaces for the system. Each form is designed to accomplish certain tasks, such as collecting, presenting or filtering information. The Main Menu, shown in

Figure 1, serves as a control center of the system.

The basic components on the Main Menu form are a group of checkboxes. By clicking the option checkbox or its link, a corresponding form is opened. The "About the MIS" link introduces the basic information of the system, such as the name and the copyright of the system, and briefly describes the other sections of the MIS.

The other links open data review forms for retrieving commodity flow information based on user interests. Selection combination boxes on these forms provide a convenient and intuitive guidance for users to search relevant data. Particularly, the system has multiple-selection functionality in selecting Origin/Destination lists. Users obtain high flexibility in grouping regions of

Table 5. Most Likely Destinations of NJ Outboard Shipments (in million tons)

1993 CFS (Top Six)	CFS Tonnage	%	DRI (Top Six)	DRI Tonnage	%
1. New Jersey	106.62	59.4	1. New Jersey	73.47	40.9
2. New York	22.44	12.5	2. New England	21.19	11.8
3. Pennsylvania	17.41	9.7	3. New York	18.59	10.3
4. Massachusetts	5.56	3.1	4. South Coast	14.56	8.1
5. Connecticut	4.49	2.5	5. Pennsylvania	10.17	5.7
6. Maryland	2.33	1.3	6. Midwest	7.22	4.0
7. Others	20.64	11.5	7. Others	34.46	19.2
Totals	179.5	100.0	Totals	179.5	100.0

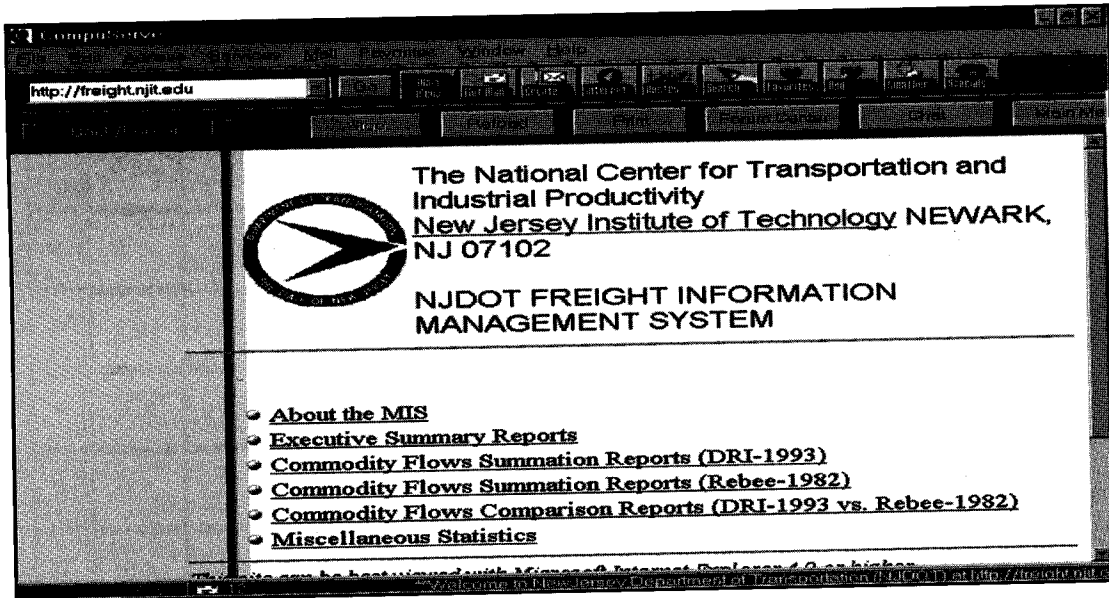
commodity flows according to their interests, thus getting insight of commodity flow patterns in New Jersey areas at different aggregated levels.

Executive Summary Reports

This form contains geographic and economic data descriptions, and describes commodity flow information for each of the 21 counties of New Jersey. Each Executive Summary Report contains the following:

- Introduction
- Transportation Overview
- Population and Industry Overview
- Section 1: Commodity Flows between County and 21 New Jersey Counties
- Section 2: Commodity Flows between County and Selected Counties Bordering New Jersey
- Section 3: Commodity Flows between County and Selected Surrounding Zones
- Section 4: Largest Commodity Flows between County and Selected Surrounding Zones
- Section 5: Commodity Flows between County and US and Canadian Regions
- Section 6: Largest Commodity Flows between County and US and Canadian Regions
- Section 7: County Foreign Trading Partners
- Section 8: Miscellaneous Comparative Statistics
- Section 9: Commodity Flows between The State of New Jersey and the Foreign Trading Partners
- Section 10: Changes of County Commodity Flows between 1982-1993

Figure 1: MIS Interface for Main Menu



The Introduction provides a brief description of the geographic location of the selected county, while the Transportation Overview describes the major roadway, rail, and pipeline networks. Figures showing the location of the facilities on a New Jersey map are included.

The Population and Industry Overview describes the selected county's population trends and corresponding economic data. Also highlighted are the major industries and top employers in the county.

The Commodity Flows (Sections 1-10) describe intrastate commodity flows, which include inter-county flows as well as intra-county flows. Net Commodity flows are given, as well as total inflows and outflows by STCC and mode. Summary tables are presented indicating the total commodity flows among all New Jersey counties for each mode of transport. In addition, summary tables presenting commodity flows originating in the county

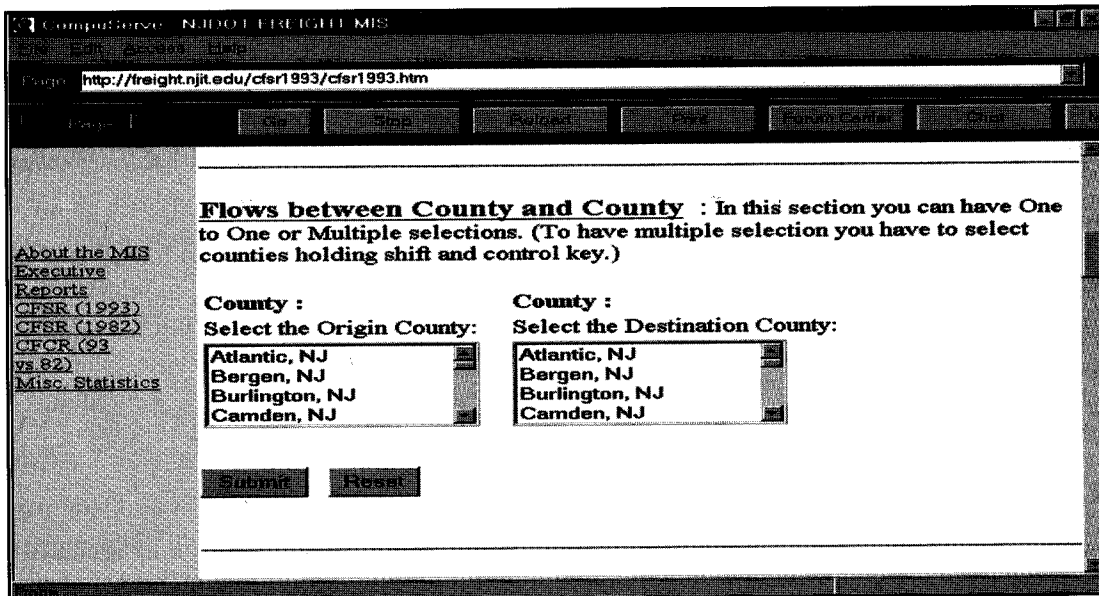
and destined for the county are shown. All statistics are presented in inbound and outbound flows (in thousand tons) sorted by the two-digit STCC and by mode of transport: Truck (common carrier, package carrier, and company fleet), Rail (boxcar and trailer on flat car/container on flat car, known as TOFC/COFC), Air, and Water/Other. Some examples of STCC are Farm Products (01), Food and Kindred Products (20), Apparel (23), Petroleum and Coal Products (29), and Hazardous Waste (48).

Commodity Flows Summation Reports (DRI 1993)

This form contains the commodity flow summations for each of the 21 counties of New Jersey contained in the DRI 1993 database. Each Summation Report contains the following:

- Flows Between County and County
- Flows Between County and Zone

Figure 2: MIS Interface for DRI 1993 Database Query



- Flows Between County and Region
- Flows Between County and USA/ Canada

This form includes combination boxes to provide a convenient and intuitive guidance for users to search relevant data. Figure 2 shows the MIS interface used to search the DRI 1993 database for County-to-County flows. The MIS is very flexible with respect to the database queries: users are permitted to select multiple counties for the origin and destination counties.

The MIS interface for the other commodity flows summation reports mimic Figure 2. Users can obtain high flexibility in grouping regions of commodity at the origin and destination levels, so that results can be examined for different aggregated levels.

Commodity Flows Summation Reports (Rebee 1982)

This form contains the commodity flow summations for each of the 21 counties of New Jersey contained in the Rebee 1982

database. Each Summation Report contains the following:

- Flows Between County and County
- Flows Between County and Zone

Like the Commodity Flows Summation Reports (DRI 1993) interface, the MIS interface for the Rebee 1982 database is very flexible with respect to the database queries. The user can have multiple selections of origins and destinations.

Commodity Flows Summation Reports (DRI 1993 versus Rebee 1982)

This form contains the commodity flow comparisons of the DRI 1993 and Rebee 1982 databases. Each Summation Report contains the following:

- Flows Between County and County
- Flows Between County and Zone

Due to the different Origin/Destination specifications in the two original databases, only the inter-county and intra-county commodity flows of New Jersey counties and

the commodity flows between counties and selected zones (Delaware Valley, New Jersey, New Jersey South, NJTPA, and the USA) are compared.

Miscellaneous Statistics

This section presents additional comparative netflow statistics for each county using either the DRI 1993 or Rebee 1982 databases. Available summation reports include the following:

- Netflows (DRI 1993 or Rebee 1982 databases)
- Trading Partners for Each Mode (Outflow or Inflow)
- Total Commodity Flow by Transportation Mode (DRI 1993 or Rebee 1982 databases)

Also accessible from the Miscellaneous Statistics form is Trading Partners for each County (or group of counties) by mode (Air, Rail, Truck, Water, Total). The MIS interface is presented in Figure 4. In the resulting queries, Trading Partners are divided into ten categories: Canada, North Europe, South Europe, East Europe, Mexico, LA/Other Caribbean, Mideast IS, Japan, Asia/Other, and Other. Thirty four different categories of two-digit STCC are presented.

Summary

The goal of NJFIMS is to provide a powerful and effective tool for managing the commodity flow data in New Jersey. To this end, an integrated graphical interface to help users access and search commodity flow information quickly and easily was developed. This user-friendly program is available on the Internet for engineers and

planners to provide input into the transportation planning process.

The research product examined the most recent information available to develop the NJFIMS. The 1993 DRI database was compared against other available sources to ensure validity, including the 1993 CFS.

Compared with 1993 CFS results, the DRI database provides fairly close estimates for New Jersey information. Most categories of compared elements fall in 90-percent confidence intervals listed by 1993 CFS. However, some discrepancies exist, most notably in the different estimates of USA total tonnage, a significant difference in NJ originated shipments moved by rail mode, and different orders of the top five NJ outboard shipments.

The DRI data, along with the Rebee 1982 database, provided a basis by which commodity flows in and out of New Jersey were generated.

The Executive Summaries provide a general assessment of the role of New Jersey in the regional, national and world transportation market. Trends in population and economic data are provided, along with an overview of the transportation network. Commodity flows in and out of each county in New Jersey to selected areas are presented, along with information on foreign trading partners. Changes in commodity flows between 1982 and 1993 are highlighted.

In addition to the information available in the Executive Summaries, the databases are available online to query. Users can obtain high flexibility in grouping regions of commodity flows at the origin and destination levels, so that results can be

examined for different aggregated levels. Consequently, the MIS is capable of provid-

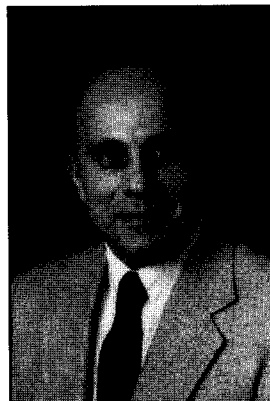
ing analytical answers to a myriad of critical planning issues.



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Dr. Athanassios K. Bladikas is chair of the Industrial and Manufacturing Engineering Department at NJIT, and director of the Interdisciplinary Program in Transportation. He is an expert in the areas of public transit, finance and pricing and logistics. Dr. Bladikas received an MBA in operations research from Columbia University and an M.S. and Ph.D. in transportation planning and engineering from Polytechnic University in New York.