EVALUATION OF OHIO-MICHIGAN REGIONAL AIRPORTS FOR AIR CARGO TRANSPORTATION: FREIGHT FORWARDERS PERSPECTIVE

FINAL REPORT

Focus Area: Infrastructure Utilization
Year 5

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1. INTRODUCTION

1.1. BACKGROUND, PROJECT OBJECTIVES & RESULTS OVERVIEW

Over the past decade, there has been consistent growth in demand for air cargo deliveries. According to the Bureau of Transportation Statistics (BTS), in 2007, the value of air cargo shipment goods in the US is over $1.8 trillion, a 31% increase in just five years (Margreta et al., 2009). Annual forecast reports by both Airbus (2010) and Boeing (2010) predict a 5.9% annual growth rate for global air cargo tonnage over the next 20 years. The unprecedented growth in the global trade has further increased the importance of just-in-time (JIT) logistics and contributed to the growth of the air cargo industry. According to a recent study for The International Air Cargo Association (TIACA), the global air cargo industry carried 100 billion ton-miles with a direct revenue exceeding $50 billion in 2005 (Kasarda et al., 2006). The biennial World Air Cargo Forecast (WACF) by the Boeing forecasts that the world air cargo traffic will grow at a rate of 5.8% per year over the next 20 years (Boeing, 2010). This forecast in conforms to the national trend in last two decades where air-cargo grew the most among all transportation modes measured by value, tons, or ton-miles. The value of air freight shipments almost doubled (97 percent) during this time, followed by increases in inter-modal air-road combinations of 67 percent and trucking of 42 percent. By tonnage, air freight shipments increased 46 percent, followed by trucking with 26 percent and rail with 20 percent. In 2006, air freight has accounted for approximately 35% of global merchandise trade by value, which is equivalent to US$4.2 trillion of the US$12 trillion value of trade (International Air Transport Association, 2008). The eminent role of air cargo industry is attributable to the requirement of global selling and sourcing and just-in-time logistics that demands for agile and reliable shipping over long distances of smaller quantities where no other means of transportation can compete with air mode (Kasarda et al., 2006).

Multi-Airport Regions

In response to this growth, the air transportation network has been steadily expanding its capacity over the past two decades. However, this capacity expansion through new airports, offering more fights options, and investing in road connectivity cause the service zones of airports to expand and overlap. This has resulted in the creation of Multi-Airport Regions (MARs) where several airports accessible in a region substitute and supplement each other in meeting the region's demand for air transportation (Loo, 2008). The potential of regional air-cargo airports to relieve congestion at major airports in the immediate area has been investigated since early 1990s. In fact, the Department of Transportation FY 1990 Appropriations Act called for a study to include the feasibility of establishing an air-cargo airport in the immediate Washington, D.C., area.

These MARs provide alternative access options for passengers as well as air cargo shippers and forwarders. For instance, air travelers consider MARs in a region and select airports and flights primarily based on airport access time, flight itinerary options, and frequency factors (Basar and Bhat, 2004). These factors are also important concerns for the air cargo transportation. The shippers are mainly concerned with the on-time delivery performance and the shipping costs, and thereby leave the flight itinerary decisions to forwarders. The freight forwarders, intermediaries between shippers and carriers, constitute more than 90% of air cargo shipments (Hellermann, 2006). In the case of MAR, the forwarders decide on which origin airport to use given the flight itinerary options and costs. Their decisions are primarily based on such factors as airport accessibility, proximity to the origin of the loads, flight itinerary options (e.g., frequency, destinations). Hall (2002) proposed the Alternative Access Airport Policy (AAAP) where considering multiple airports (and subsequently flight itinerary options) in a MAR can be beneficial to reduce truck mileage, decrease sorting and handling costs, improve delivery service level, and avoid congestion on both road and air network. The author discussed the merits of AAAP for air cargo transportation using the case study of the Southern California region.

Project Objectives:

This project aims to addresses the efficient utilization of the infrastructure for multimodal air freight shipment that directly affects the competitiveness of the freight forwarders and airports in the Ohio-Michigan (OH-MI) region. This project focuses on multimodal air-road transportation of the freight originating from OH-MI region and investigates the factors contributing to utilization of the regional airport facilities. The air freight multimodal transportation activity involves airports, carriers, freight forwarders, and shippers. The interest area of this study is North West Ohio and South East Michigan with regional airports Detroit Metropolitan (DTW) and Toledo Express (TOL). The project consider air freight shipments mostly identified by the freight forwarders included in the study and are any of the four carrier types, namely dedicated (all-cargo), mixed (belly carriers), combination, and integrators.

The proposed objectives of this study are summarized as follows:

Objective 1. Conducting a regional survey to measure and document the current decision making process of air freight forwarders and their desired service levels from the existing local transportation infrastructure (airport facilities and road network) with primary focus on alternative access airport decisions.

Objective 2. Developing an alternative access airport and flight selection decision support tool for the freight forwarders.

Objective 3. Quantify the relative air freight attraction levels of OH-MI region's airports by developing an air cargo shipment demand simulation system for the OH-MI region.

At the onset, the project team has focused on the literature review regarding the airport selection decisions. The majority of the literature identified focused on passenger transportation and the hub selection problem of air carriers. The literature review, thus, revealed that the dynamic airport selection of freight forwarders in a MAR is not studied. The team has had several meetings with the air cargo managers in TOL and DTW to learn about the air cargo freight forwarder customer base and their opinions on the project's objectives. These meetings revealed that there is strong interest from the airport authorities in support of the project objectives, especially in enabling the freight forwarders to select across multiple airports best meeting their individual freight cargo shipment needs. Next, we have had meetings (in person and over the phone) with several freight forwarders to gather information on the factors contributing to their airport selection (Objective 1). The main outcome from these meetings was that freight forwarders are in need of a decision support system (such as the one aimed in Objective 2) and require it to be customizable given the cargo characteristic and contracts with the carriers. However, these freight forwarders have expressed their concern for the consideration of TOL and DTW airports as a MAR given the low availability of flights from TOL and the separation distance between the DTW and CLE (which is the another major airport in OH with similar distance from TOL). Hence, we have decided to develop a national freight forwarder survey for alternative access airport selection. The goal with this national survey is to extract the importance factors for freight forwarders (across the nation) and then perform a what-if scenario based analysis for the OH-MI region. Specifically, our aim was, given different levels of flight availability from TOL, to simulate and analyze the alternative access airport selection in the region's airports. While we have designed the survey study (Section 2.1), we were not able to bring the survey study to a completion to date, primarily due to lack of accurate and readily available data on sample forwarders and lack of man power to distribute and follow up with the respondents. In an effort to meet the objectives 1 and 3 to a certain degree, we have developed air cargo demand density estimation process and applied it within the OH-MI region (Section 2.2).

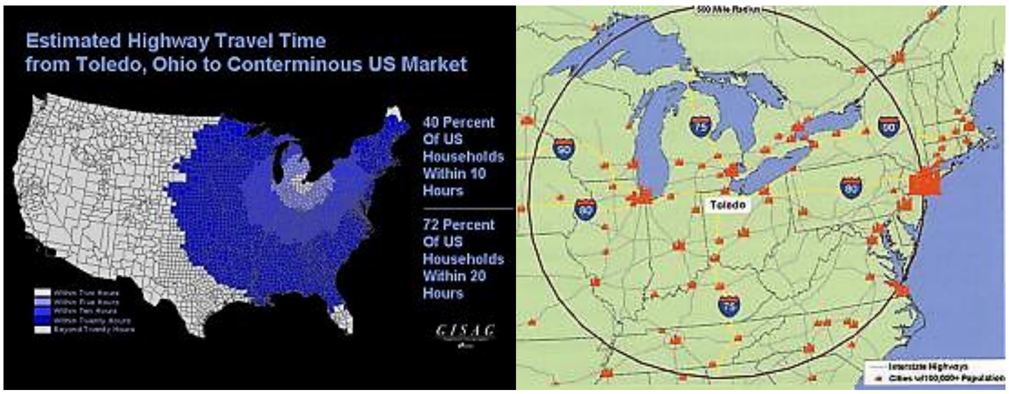
In what follows, we provide background information on the Northwest Ohio and Southeast Michigan region's airports (DTW,TOL) in Section 1.1. Next, in Section 2.1, we review the freight forwarders selection of airports (as well as carriers) based on the relevant literature. We also present the freight forwarder survey study developed for OH-MI region based on the expert opinions and interviews in the region. In Section 2.2, we describe the methodology and results for estimating the air-cargo demand density in the OH-MI region. These results serves as a benchmark data set for freight forwarders to assess geographical proximity to the ideal centroid locations for air cargo with single and multiple airport access policies.

1.2 MAJOR AIRPORTS IN SOUTHEAST MICHIGAN-NORTHWEST OHIO

1.2.1. TOLEDO EXPRESS AIRPORT (TOL)

Toledo Express Airport is an emerging participant in the global distribution network. Toledo Express has been home to regularly scheduled air cargo activity to and from Canada, Mexico, Australia, Europe and the Middle East. As a well-established domestic hub with increased international connectivity, Toledo Express Airport is well positioned to function as an inland port and an alternative to congested air cargo gateways.

The Northwest Ohio region offers a range of transportation resources: International air cargo access; highway connectivity through the juncture of two transcontinental highways; national crossroads of four railroads; proximity to the CSX National Gateway in North Baltimore, Ohio; access to the largest land-mass seaport on the Great Lake; access to regional industrial customers.



Major retailers (e.g., Walgreens, Menards and Best Buy) and integrated carriers (e.g., UPS, FedEx) have established major ground distribution centers in the Toledo/Northwest Ohio area. Toledo, within a 300-mile radius, offers vast industrial space that can be accessed to and from any other location in North America. A major population segment in both the U.S. and Canada can be accessed within a one-day truck trip from Toledo, e.g., Detroit, Chicago, Cincinnati and Pittsburgh, Ontario. Toledo is at the juncture of the nation's two transcontinental interstate highways – Interstate 80/90.

The population within 300 mile radius around Toledo.

The Toledo Express Airport (TOL) has 10,600 foot runway which accommodates a full mix of all-weather cargo operations including 747's. Toledo Express provides direct access to the Ohio Turnpike and Interstate 475/23. Toledo Express houses a 4,405 square foot refrigerated warehouse located within a Foreign Trade Zone (e.g., for perishable cargoes). The Toledo -Lucas County Port Authority manages Foreign Trade Zone #8 (FTZ) available in various locations throughout northwest Ohio. Currently, there are 337 acres of designated warehouse and land at Toledo Express Airport and 332 acres of land and warehouse space at the Port of Toledo that reside within FTZ #8. The FTZ #8 benefits include deferral of duties, customs territory, reduction of duties, elimination of duties, increased convenience and flexibility.

Toledo Express Airport is offers reduced flight pattern approach and taxi time, compact turn -around times , flexible aircraft operations and ramp access, taxi time to wheels -up is less than seven minutes, open arrival and departure slots with no curfews, full complement of aircraft and cargo ground support equipment The landing fees are $1.28 - $1.96 / 1000 lbs. whereas the parking and apron fees range between $0.65 - $0.85 / 1000 lbs. for a 24-hour period.

Aerial view of Toledo Express Airport [1]

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[1] Source: TOL: A World Class Intermodal Air Cargo Hub of Operation- Toledo Express Airport Cargo Operations Overview, Toledo-Lucas County Port Authority, 2012.

The infrastructure and cost advantages of TOL for domestic and global air cargo port are direct airfield access to 10,600 ft. runway, instrument landing system, 78-acre air cargo apron adjacent to development site designed to accommodate 747's and other large cargo freighters, 24/7 Air Traffic Control Operations, on-site U.S. Customs and FTZ, active perishables facility, competitive pricing, absence of congestion, compatible land use, and proximity to market.

1.2.2. DETROIT METROPOLITAN WAYNE COUNTY AIRPORT (DTW)

The DTW is located in Southeast Michigan in the Greater Detroit Metropolitan Area. The Detroit area includes two airports, Detroit Metropolitan Wayne County Airport (DTW) and Willow Run Airport (YIP). The two airports are located just seven miles from each other. DTW is the primary passenger and cargo airport of the Detroit aerotropolis. DTW has six runways: three of the runways are 8,500 feet long, two are 10,000 feet long, and one is 12,000 feet in length. There are 16 scheduled passenger airlines and two scheduled cargo airlines operating at DTW. In 2009, DTW had 432,589 flight operations or an average of 1,185 per day.

DTW's capacity in optimal weather conditions is between 184 and 189 arrivals and departures per hour. In 2008, DTW had approximately 17 million enplaned passengers and 707.5 million pounds of cargo (landed weight). That year, the FAA ranked DTW 14th in the U.S. for passenger enplanements and 35th in the nation for total landed weight of cargo.

In 2009, the average landing fee for signatory airlines was $2.83 per 1,000 pounds, and the passenger facility charge was $4.50. DTW is comprised of the North Terminal and the McNamara Terminal. The McNamara Terminal, which opened in 2002, has 121 gates and is used exclusively by Delta and its SkyTeam partners. The McNamara Terminal has 42 food and beverage tenants and 48 retail tenants. The North Terminal, which was renovated in 2008, has 26 gates and houses all non-SkyTeam airlines. The North Terminal has 17 food and beverage tenants and 11 retail tenants. YIP is being developed as a cargo airport to compliment the operations at DTW. YIP has five runways; the runway lengths are 7,526 feet, 7,294 feet, 6,511 feet, 6,312 feet, and 5,995 feet. There are seven scheduled cargo airlines at YIP. In 2008, YIP reported 78,818 flight operations or an average of 215 flight operations per day. YIP handled nearly 160 million pounds of cargo in 2008 or an average of 438,356 pounds per day. YIP is ranked 108th in the United States by the FAA for total landed weight of cargo. Landings fees at

YIP are assessed on a graduated scale with a discount given for larger quantities of landed weight. Landed weights up to 6,499 pounds are free and landed weights 6,500 pounds or more are charged between $2.79 and $1.50.

The table below illustrates the monthly cargo traffic in DTW since 2005 which includes air freight (all cargo and belly cargo) but excludes small package (express) and air mail.

Month	CY 2005	CY 2006	CY 2007	CY 2008	CY 2009	CY 2010	CY 2011	CY 2012*
January	34,349,299	34,823,294	37,029,209	38,016,259	27,021,182	26,677,264	33,376,773	34,086,989
February	36,187,610	35,132,419	39,941,456	46,223,196	25,183,595	29,879,447	33,581,724	36,594,321
March	40,211,537	40,147,183	43,446,223	42,228,734	26,326,130	32,113,030	40,819,032	41,274,453
April	38,963,556	35,776,572	39,663,346	42,037,048	26,262,544	31,750,756	35,026,041	
May	36,364,012	36,939,696	42,819,363	41,013,424	27,593,011	30,002,824	34,609,783	
June	41,264,221	38,813,548	43,562,574	36,988,462	26,421,558	35,578,732	37,295,008	
July	37,297,214	35,034,862	38,107,591	35,437,957	26,850,729	35,647,244	34,007,072	
August	39,112,383	40,810,540	45,818,884	34,785,707	26,272,987	35,116,994	33,882,025	
September	41,244,591	39,170,307	43,389,747	34,016,949	30,647,293	37,156,197	35,045,128	
October	43,796,175	41,223,813	45,702,838	33,239,538	32,493,390	39,591,879	37,315,806	
November	40,744,786	40,307,050	42,255,011	31,505,311	29,898,469	34,568,032	36,304,929	
December	41,213,759	40,760,567	39,917,063	29,999,672	32,525,389	39,602,657	38,908,356	
Total	470,749,143	458,939,851	501,653,305	445,492,257	337,496,277	407,685,056	430,171,677	111,955,763

Air freight by month at Detroit Metropolitan Airport (DTW)

2. Methodology & Analysis

2.1. Freight Forwarders Selection Of Alternative Access Airports OH-MI

In this section, we first review the factors affecting freight forwarders' choice of carrier and airports. Next we present the forwarder survey developed.

2.1.1. Factors and benchmark studies

One of the leading surveys in the air cargo industry is the ACE survey which assesses the performance of airports and carriers globally in terms of air cargo transportation. The following criteria are identified for the airports in relation to air cargo:

- Facilities

- Performance
- Value
- Regulatory Operations (Air cargo excellence survey, 2011)

ACE SURVEY CRITERIA FOR AIRPORTS

Performance	Value	Facilities	Regulatory Operations
Fulfills promises and contractual agreements; dependable, prompt and courteous customer service; allied services — ground handling, trucking etc.	Competitive rates; rates commensurate with service level you require; value-added programs	Apron, warehousing, perishables center; access to highways and other modes of transportation	Customs, security, FTZ

The ACW 2011 ACE Survey asked representatives from airlines to evaluate airports worldwide by rating four measures on a scale of one as the lowest to five as the highest. For each measure, the average rating across all companies in the survey was calculated and set to a value of 100.

The criteria used for the carriers are:

- Customer Service
- Performance
- Value
- IT (Air cargo excellence survey, 2011)

ACE SURVEY CRITERIA FOR CARRIERS

Customer Service	Performance	Value	Information Technology
Claims handled with expedience; problems solved in a prompt and courteous manner; professional and knowledgeable sales force	Fulfills promises and contractual agreements; dependable; accomplishes scheduled transit times	Competitive rates; rates commensurate with service level you require; value-added programs	Tracking and tracing of shipments; Internet; electronic commerce capabilities

The ACW 2011 ACE Survey asked freight forwarders to evaluate carriers by rating four measures on a scale of one as the lowest to five as the highest. For each measure, the average rating across all companies in the survey was calculated and set to a value of 100. This year, we've broken down the results by annual tonnage carried.

A recent study published in the Journal of Air Transport Management, studies the relationship between air cargo logistics providers (ACLP) and client satisfaction (SAT). The following are conclusions are identified:

- A significant relationship exists between “delivery value” and “reliability”, as well as “delivery value” and “flexibility”.
- A significant relationship exists among “knowledge innovation value”, “information value”, “service value-added” and “reliability”, “agility”, “customization”, “flexibility”. Consistent with Cheng and Yeh's (2007) study on core competencies and sustainable competitive advantage in air cargo forwarding, employees' professional knowledge can

play a role in assuring transportation efficiency and quality; furthermore, professional staff can be considered the key success factor in responding to air cargo inquiries. These findings also conform to Shang and Marlow (2005) findings that information-based capability impacts flexibility capability.

- There exist significant relationships between "performance satisfaction value", and "reliability", "customization" and "flexibility". This suggests that outside factors that produce satisfaction are: prompt handling of import/export work, willingness to help solve customer problems, standard operating procedures, flight punctuality and good transport consideration (Shiang-Min Meng, 2010).

Another study reflects responses based on a questionnaire sent out to 118 non-integrated airlines worldwide. The results are displayed below in the form of tables as well as statements. (Factors influencing cargo airlines' choice of airport: An International Survey, 2005)

The most important factors considered by freighter operators when selecting an airport

	Scores[a]							Mean
	1		2	3	4		5	
Night operations	0%	←5%→	5%	13%	33%	←82%→	49%	4.26
Minimise overall costs	3%	←11%→	8%	8%	35%	←81%→	46%	4.15
Airport cargo reputation	0%	←8%→	8%	13%	40%	←79%→	39%	4.10
Local origin-destination demand	3%	←11%→	8%	21%	26%	←68%→	42%	4.00
Influence of freight forwarders	3%	←9%→	6%	18%	40%	←73%→	33%	3.95
Airport road access	0%	←8%→	8%	18%	54%	←74%→	20%	3.87
Customs clearance times	0%	←8%→	8%	26%	38%	←66%→	28%	3.87
Financial incentive from the airport	3%	←11%→	8%	15%	51%	←74%→	23%	3.85
Trucking time to main markets	3%	←16%→	13%	20%	31%	←64%→	33%	3.79

[a]Scores range from 1 (not at all important) to 5 (extremely important).

Reasons for freighter operator airport relocation

What factors have led you to relocate?	% of respondents mentioned[a]
Specific demand from primary customer	67
Better facilities elsewhere	60
Lower charges elsewhere	47
Environmental restrictions	27
Increase in charges	13
More attention to cargo at other airport	7
More business potential in a new region	7
Pressure from government to move to another airport	7
Lack of capacity for expansion	7

[a]Note that airlines could make more than one suggestion.

What airlines want airports to address in order to attract their business

What can airports do to attract your business?	% of respondents mentioned[a]
Lower fees for landing, handling and fuel	53
Improve facilities and infrastructure	31
Work with businesses to increase demand	25
Improve handling efficiency	22
Give specific needs of cargo airlines more attention	16
Improve ground transport facilities	13
Give cargo equal priority to passengers	13
Improve labour quality	6
Simplify charging structure	6

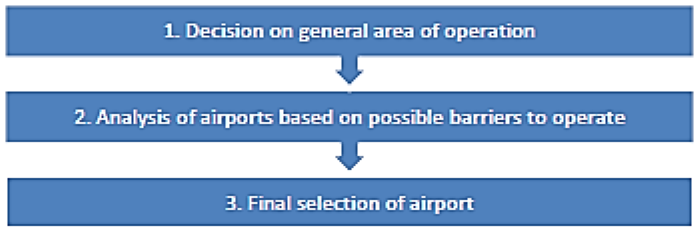
[a]Note that airlines could make more than one suggestion.

The survey confirms the argument made that freight forwarders are a major influence on a freighter operator's choice of airport. Whilst there is a lack of work relating to the effectiveness of airport marketing, the survey has revealed airport marketing to have a limited influence on freighter operators. However, it also demonstrated that marketing could be effective if properly targeted. This means not only targeting the airlines themselves but also those that have influence over their location decisions such as freight forwarders. This would suggest that, all things being equal, airports with significant cargo services today would continue to be successful in attracting new operators. (Factors influencing cargo airlines' choice of airport: An International Survey, 2005)

The factors that determines carrier's the airport choice can be broadly categorized as follows (Kupfer, 2010):

1) <u>The Airport Choice Process:</u>

When deciding which airport to operate to, every airline goes through a different choice process. This process often depends on company regulation, conventions and experience. However, some general directions of the airport choice process can be given.



2) <u>Market Factors:</u>

Airport choice factors that refer to the size of the air cargo market around the airport as well as the access to this market are grouped as market factors. Those factors include origin-destination demand, the presence of forwarders, market access, road access and intermodal access.

3) <u>Restrictions:</u>

As a second step of the airport choice process, the cargo airlines look at restrictions for their operations. Factors that restrict airlines in using certain airports are noise and night time restrictions. General noise restrictions effect in particular operators that use all-freighters as cargo aircraft are often older and louder aircrafts than passenger airlines.

4) <u>Time-factors:</u>

Congestion, airport delays, long customs clearance times and turnaround times can be critical factors in the success of an airline as well as the airport since they can lengthen the supply chain lead-time. Products transported by air are often time-sensitive and a long lead-time might not be acceptable to the shippers.

5) Cost-factors:

Airlines, as private businesses with the ultimate goal of profit maximization, consider the direct costs in every step of their decision making processes. Further, forwarders operate on tight margins and thus are very cost sensitive which, in turn, stimulates the airlines to cut their costs even more. Stefansson (2007) conducted interviews with forwarders and results show that smaller as well as larger forwarders put high priority on the price. However, the same study also shows that forwarders would like to focus less on price and more on service, but are limited by the shippers.

6) Strategic factors

In addition to the cost and time factors, there are various strategic factors (e.g., competitive advantage, complementary relationship to the hub-spoke network) that play an important role in the decision processes of airlines.

7) Airport Quality and the Perception of Airport Quality

Airport quality is often associated with the quality of airport services such as custom services and ground handling services which include loading, unloading, on-airport transport, warehousing and palletizing of goods. Cargo airlines expect the services provided by the airport to be efficient, fast and adapted to the needs of air cargo. Murphy (1989) conducted a survey of air cargo forwarders and shippers. The survey results indicate high emphasis on the importance of minimal loss and damage to the cargo when being handled at the airport. This is especially important given that the goods transported by air are often of high-value.

8) Other factors:

There are other factors than those listed above that are important for carrier's choice of airport. Climate conditions for example play a role in the decision process of cargo airlines. Especially the absence of thick fog, heavy snow or strong winds is necessary to ensure continuous operations at the airport. (Dennis, 1994). Furthermore, labor availability can be a decisive factor in the airport choice. Sufficiently trained labor is necessary to ensure good airline and airport operations.

In a related study, Hess (2007) considered Stated Preference (SP) data over Revealed Preference (RP) data for the carrier's choice of airports. The reason for focusing on SP, rather than RP, is that RP survey data often fail to account for the effect of fare differences at different airports and are generally not able to offer a treatment of the effects of airline allegiance. The results of this study identify significant effects of factors such as airfare, access time, flight time and airline and airport allegiance in selecting airports.

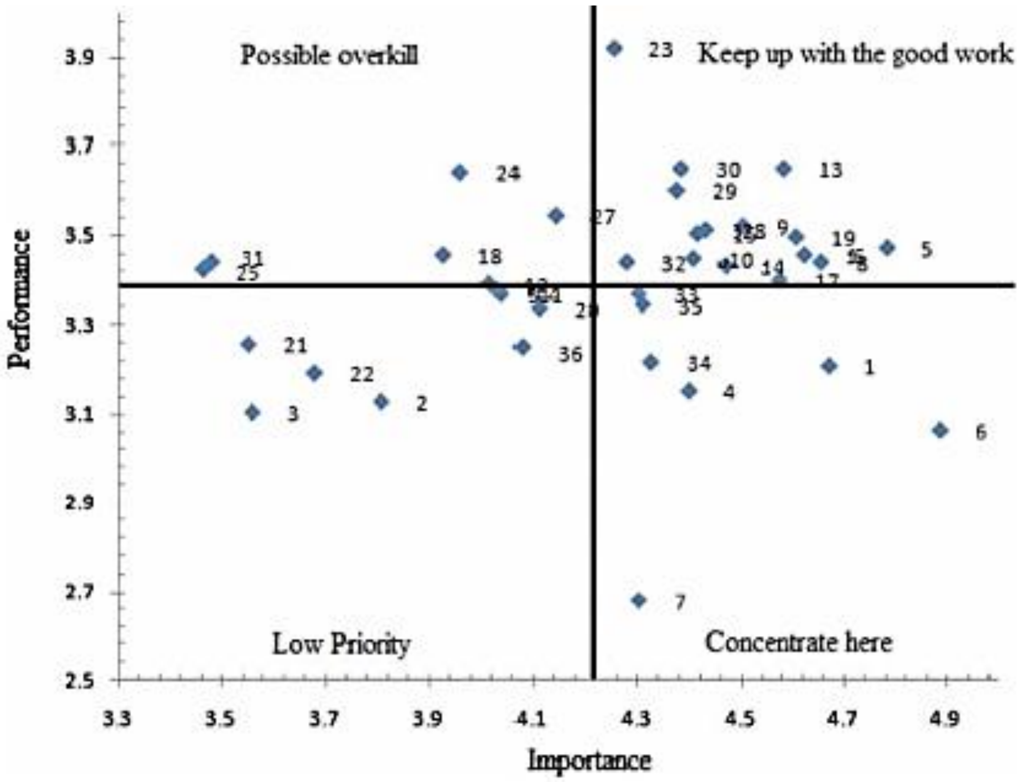
Ching-Cheng Chao et al. (2011) evaluate the market segmentation of the airline cargo transportation based on the service requirements of air freight forwarders. Data collection is executed by using a questionnaire survey. The questionnaire was designed with reference to the seven stages outlined by Churchill. (Churchill, 1991). The study considered service attributes related to the needs of air freight forwarders in Taiwan and identified 36 service attributes based on the literature review (Hsu, 2005; Lu, 2003; Meng, 2010) and interviews with 10 experts. A pilot test was conducted using the questionnaire, followed by interviews with experienced managers of air freight forwarders to further improve the questionnaire.

Table lists the importance and satisfaction ratings of the 36 service attributes. The mean scores concerning the importance of the items ranged from 3.46 to 4.78. Five service attributes stood out as being very important to the respondents. They are cargo safety, freight rate, cargo tracing and tracking, flight punctuality, and ease of getting cabin space. In contrast, respondents perceived service attributes including nationality of airlines, frequency of staff visits, door-to-door service, rebate and commission, and multi-modal cargo transport to be the least important. Ching-Cheng Chao et al. (2011).

Service attributes	Importance Mean	Importance Ranking	Performance Mean	Performance Ranking
Cargo safety	4.78	1	3.47	11
Freight rate	4.67	2	3.21	30
Cargo tracing and tracking	4.66	3	3.44	17
Flight punctuality	4.62	4	3.46	13
Ease of getting cabin space	4.61	5	3.50	10
Cargo transport speed	4.58	6	3.65	3
Handling of unusual cargo	4.58	6	3.06	35
Enough transit time	4.58	6	3.40	20
Well-managed information system	4.50	9	3.52	7
Flight frequency	4.47	10	3.43	18
Prompt booking confirmation	4.43	11	3.51	8
Direct flight	4.42	12	3.50	9
Ease of customs clearance	4.41	13	3.45	14
Flexibility in rate adjustment	4.40	14	3.15	32
Staff ability	4.38	15	3.65	2
Staff attitude	4.38	15	3.60	5
Prompt handling of complaints	4.33	17	3.22	29
Service reliability	4.31	18	3.34	25
Prompt information offered	4.30	19	3.37	24
Efficiency in compensation	4.30	19	2.68	36
Professional ground crews	4.28	21	3.44	15
Reputation of airline	4.26	22	3.92	1
Past business experience	4.14	23	3.54	6
Supply of containers and pallets	4.11	24	3.34	26
Customization	4.08	25	3.25	28
Consolidation	4.04	26	3.37	23
Strategic cooperation	4.03	27	3.38	22
Transport of special cargo	4.02	28	3.39	21
Scale of airline	3.96	29	3.64	4
Type of air freighters	3.93	30	3.46	12
Rate of special cargo	3.81	31	3.13	33
Multi-modal cargo transport	3.68	32	3.19	31
Rebate and commission	3.56	33	3.10	34
Door-to-door service	3.55	34	3.26	27
Frequency of staff visits	3.48	35	3.44	16
Nationality of airline	3.46	36	3.42	19

Note: Mean scores were calculated according to a five-point scale (1 = very unimportant/unsatisfactory to 5 = very important/satisfactory).

Following the importance-performance analysis proposed by (Martilla, 1977), authors compared the importance and performance ratings of the 36 service attributes in a two-dimensional grid plot with the vertical axis denoting importance ratings and the horizontal axis denoting performance ratings.



Using factor analysis, authors reduced the 36 service attributes of airline cargo transportation to a smaller set of underlying factors to detect the presence of meaningful patterns among the original variables and to extract the main service factors. In order to increase the interpretability of the factor structure, each factor is then ' rotated' in such a way so as to minimize the distance of each individual variable from one of the factors. (Hair, 1995)

Service attributes	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Nationality of airline	**0.781**	0.128	−0.028	0.024	−0.071	0.246
Scale of airline	**0.758**	0.192	0.230	0.072	0.278	0.117
Reputation of airline	**0.629**	0.054	0.301	0.277	0.360	−0.019
Prompt information offered	**0.582**	0.109	0.485	0.172	0.025	−0.060
Prompt handling of complaints	**0.540**	0.245	0.245	0.315	−0.014	0.048
Direct flight	0.241	**0.794**	0.110	−0.123	0.185	0.131
Flight frequency	0.261	**0.752**	0.038	0.217	0.076	0.163
Cargo transport speed	0.002	**0.709**	0.318	0.239	0.097	0.077
Well-managed information system	0.095	**0.609**	0.262	0.384	0.182	−0.054
Staff attitude	0.142	0.237	**0.860**	0.083	0.061	0.160
Prompt booking confirmation	0.297	0.025	**0.775**	0.205	0.178	0.052
Staff ability	0.113	0.360	**0.672**	0.022	0.211	0.146
Ease of customs clearance	0.039	0.319	0.130	**0.774**	0.011	0.182
Multi-modal cargo transport	0.264	−0.035	0.031	**0.683**	0.138	0.086
Cargo tracing and tracking	0.193	0.357	0.283	**0.611**	0.301	−0.197
Flexibility in rate adjustment	0.089	0.305	0.117	−0.112	**0.754**	0.035
Rate of freight	0.002	0.006	0.117	0.281	**0.744**	0.151
Cargo safety	0.393	0.206	0.185	0.288	**0.567**	−0.139
Frequency of staff visits	0.306	0.102	0.224	0.011	−0.134	**0.770**
Rate of special cargo	−0.001	0.188	0.062	0.182	0.385	**0.718**
Eigenvalues	7.240	1.676	1.475	1.252	1.222	1.074
Percentage variance	36.200	8.380	7.376	6.260	6.112	5.372
Total percentage variance	36.200	44.579	51.955	58.215	64.327	69.699
Cronbach's alpha	0.809	0.810	0.827	0.698	0.685	0.539

Note: Bold values in a column indicate the related service attributes are grouped into a factor.

Only those variables with a factor loading greater than 0.5 were extracted. The final solution contained 20 items and yielded a six-factor structure accounting for 66.70% of the explained variance. According to the score of each service type, the air freight forwarder respondents were then separated into different market segments using cluster analysis. The 125 responding forwarders were assigned to three segments, with 67 forwarders (cases) in Segment 1, 45 in Segment 2, and 13 in Segment 3. One-way ANOVA was performed to examine which of the service factors show significant difference among the three service segments. Table below displays the ANOVA results. Five service factors were found to differ significantly among the three segments. (Ching-Cheng Chao, 2011)

	Segments					
Service factors	1 (67)	2 (45)	3 (13)	*F* ratio	*F* probability	Tukey's and Bonferroni's tests
1. Assurance	**0.517**	−0.798	0.097	36.877	0.000*	(1,2), (2,3)
2. Promptness	−0.206	0.073	**0.810**	6.299	0.002*	(1,2), (1,3)
3. Empathy	−0.421	**0.518**	0.380	16.049	0.000*	(1,3), (2,3)
4. Convenience	−0.067	0.119	−0.065	0.490	0.614	
5. Value added	0.124	0.289	−1.640	28.802	0.000*	(1,3), (2,3)
6. Customization	0.111	0.160	−1.124	10.632	0.000*	(1,3), (2,3)

Main conclusions of this study are:

- First, five of the six service attributes of cargo transport provided by airlines were considered by air freight forwarders to be either important or very important. They include cargo safety, freight rate, cargo tracing and tracking, flight punctuality, and ease of getting cabin space.
- Air freight forwarders were most dissatisfied with efficiency in compensation, handling of unusual cargo, rebate and commission, rate of special cargo, and flexibility in rate adjustment.
- According to the six crucial service attributes, three market segments were identified, namely professional service-oriented, empathy-oriented, and express service oriented air freight forwarders.

Another study discusses an air cargo supply chain operations reference (ACSCOR) model to examine the integrated impact of airport operating strategies and industrial forces on airport performances, and quantifies the economic benefits of the air cargo service business. (Xue-MingYuan, 2009). This authors focus on the Hong Kong and Singapore air cargo supply chains and form and tested the following hypothesis:

H1. The cargo traffic in an airport is related to cost control and other management aspects of airport operations. *Accepted*

H2. The viability of the air cargo service at an airport is positively related to the scale and profitability of the airfreight sector. *Accepted*

H3. The scale and profitability of the airfreight sector are positively related to the scale and profitability of the aggregate logistics industry. *Accepted*

H4. The airfreight and sea freight sectors within the Hong Kong and Singapore logistics industries complement each other. *Accepted*

H5. The scale and profitability of the aggregate logistics industry are related to the economic conditions in its operating environment. *Accepted*

The ACSCOR model demonstrates that economic progress, logistics industry development, efficiency of an airport and the competitiveness of its air cargo service are closely intertwined. At the airport level, the importance of cost control in Chek Lap Kok airport can be inferred from the negative relationship between its variable costs and air cargo traffic. (Xue-MingYuan, 2009).

2.2.2. Freight Forwarder Survey for OH-MI Region

In order to understand the factors affecting the freight forwarders' choice of airports in the Michigan and Ohio regions, we have had several meetings with the DTW and TOL airport authorities and region's freight forwarders. Below, we summarize our learning outcomes as a result of the meetings with the TOL authorities (Joe Cappel) and freight forwarder (Todd Hines from BX Solutions).

Toledo Express offers one of the lowest landing fees in the US, and much lower than DTW. The region's freight forwarders choice is primarily driven by the carrier's schedule and forwarder's preference and existing business with the carrier; forwarders primarily select the carriers and then determine their airport selection for their long term contracting of air cargo capacity. Also freight forwarders, given an expediting need (e.g., unplanned), select the airports and flights based on the "requirements" such as service connection and space availability on flights. These decisions depend on the nature of cargo e.g., small parcel versus heavy cargo (heavy cargo requires DHL, UPS and FedEx) and scheduled parcel and cargo.

The decision of a freight forwarder to select another airport depends on the other carrier or airport capability. This is commonly practiced in different alternative access airport regions such as in Southern California. For instance, if a BAX flight out of LAX is not available (or preferable since the air traffic is heavy on LAX), the freight forwarder routes the air cargo to go to another airport (e.g., San Diego). However, the carrier decision remains the same, e.g., forwarder still works with BAX originating from San Diego. In comparison with integrators such as Fedex, BAX, UPS who mostly provide, the retail customers such as (Dell, Cat, DCX, etc.) door-to-door service (arrange the trucking)- 3PL, the retailers with smaller operations prefer freight forwarders. The freight forwarders, who request from the carriers (DHL, Fedex, UPS and belly space) airport-to-airport service, handle the trucking portion of the shipment themselves. This is especially the standard operation for domestic cargo shipments; in the international the freight forwarders need more services than air carriage.

There are two agreement categories between a freight forwarder and carrier, referred as "block based agreement" versus "spot agreement". The extent to which the freight forwarder practices either of these two agreements is a critical factor in alternative access airport utilization. - The block space agreement refers to in advance booking. In case the forwarder does not use this booking, then it still has to pay. On the other hand, the carrier could sell the booked but unused capacity to other customers and "might" reduce or eliminate the booking fee. Despite this practice of carriers, the risk is usually fully assumed by the freight forwarder. Forwarders often get discounts if they book more volume with the same carrier (on the same flight or business volume based discounting). In case freight forwarder cannot use the block space capacity on a flight, they can still either sell it to another forwarder or try to go to their customer base and try to sell them at a discounted rate (e.g., $2/lb say 1.50 or 1.10 reduced rate per pound). In addition, there is overbooking in the air cargo where the carrier sells more capacity than it has on cargo routes. In case, there is a realization of overbooking then the carrier does "yield management", first customers with *Block Space* agreement is given allocation, next is the *Guaranteed* service customers, then *90-95% Service Level* customers. Another important factor in freight forwarder's decision is the lockout (cutoff) time that depends on the carrier and whether the shipment is domestic or international. Usually, these times are posted online by the carriers and this cutoff time also depends on the volume, size and other characteristics of the cargo.

Domestic carriers (often small parcel) and international carriers (who can take heavy cargo) are very competitive; over several years, domestic mix passenger-cargo planes have shrunk in belly space (for fuel efficiency and other reasons) as a result they cannot accept any size load vs. international mix carriers still operate larger planes. Big manufacturing requires ability to ship heavy cargo vs. small freight forwarder type of players such as Target Logistics requires smaller shipments. Hence the size of the product is critical determinant of alternative access airport decisions. The downsizing of domestic fleet towards narrower body belly space has been an influential trend affecting freight forwarders' decisions.

Another factor that affects freight forwarders' decisions is the carrier service level. We note that the airport service level which is more appropriate for the carrier choice of airports than the freight forwarders' choice of airports. This is because the airport terminal operator is a service provider for the carrier who is in turn a service provider for the Freight Forwarder. Another consideration is the size of operations of the freight forwarder, e.g., measured in weight, $ revenue, volume, and whether the forwarder ships only domestic or both domestic and international. The use of other modes by the forwarder such as ground or rail is correlated to the nature of cargo and shipment size and is thus relevant.

FREIGHT FORWARDER SURVEY

Introduction and Scope

The purpose of this survey is to understand and measure the importance of service attributes affecting freight forwarders' airport and carrier related decisions and overall satisfaction levels. This survey is conducted solely for academic research purposes and none of the data will be used or distributed for commercial purpose. Your invaluable cooperation in this research helps us to convey the forwarders voice and expectation to the service providers.

Privacy & Confidentiality

This survey is part of a Wayne State University research project supported by funding grant DTRT06-G-0039 from the US Department of Transportation (US DoT) through the University Transportation Center at University of Toledo (UT-UTC). All the provided data are kept confidential and only summary and aggregate data will be shared with third parties to the extent needed for academic research reporting purpose. We would be happy to further elaborate and answer any of your concerns. Our contact information is provided below.

Instructions

The questions are presented in two main categories: Carrier and Airport factors. Please return the completed questionnaire to the address provided below. This survey can also be filled out electronically online at WSU Freight Forwarder Survey (please copy and paste into your browser http://www.surveymonkey.com/s/T7PRPKC).

Report

In recognition of your participation effort and time, we will be providing you with a copy of the report of this survey study. If you would like to receive a copy of the report, please provide an e-mail address.

E-mail address to receive the survey study report : _______________________

Contact:

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Fax: 313-577-8833

Important: Does your company provide air-cargo transportation? ☐ Yes ☐ No

Note: If your company **does not** provide Air Cargo transportation to customers, please terminate answering any further questions in this survey. Thank you for your participation.

BACKGROUND INFORMATION

Please provide the following information about your company.

1. ☐ Private ☐ Public

Name of Company: ___________________________________

2. ☐ Corporate ☐ Local

US Head Office Address: ____

City: _________________ State: _________ Zip Code: _____________

Company Service: ☐ Domestic ☐ International ☐ Both

Year of Establishment (YYYY): ___________

Company Revenue Turnover (in million $US):

☐ < 1 ☐ 1 -10 ☐ 10 – 50 ☐ 50 – 150 ☐ 150 – 500 ☐ >500 ☐ Confidential

Company business (tonnage) in different MODES: _____% GROUND _____% AIR _____% OTHERS

Goods Handled (check all applies):

☐ Electronics ☐ Pharmaceutical Products ☐ Textiles ☐ Machinery ☐ Fresh Products

☐ Vehicle (including parts) ☐ Express Mail & Parcels ☐ HAZMAT ☐ Others

List the TOP 5 AIRLINE CARRIERS you're working with based on volume of air-cargo business (highest first):

1) _______________________ 2) _______________________ 3) _______________________

4) _______________________ 5) _______________________

List the TOP 3 AIRPORTS your company most frequently (highest first):

1) _______________________ 2) _______________________ 3) _______________________

Name of Respondent:_________________________ Contact Phone: ____________________________

Respondent's Position/Title (choose only one):

☐ CEO/Director ☐ Vice President ☐ Operations Manager ☐ Transportation Manager

☐ Department Head ☐ Unit Head ☐ Other; please state: _________________________

Years of employment in air-cargo related industries (years):

☐ < 5 ☐ 6 -10 ☐ 11 – 15 ☐ 16 – 20 ☐ > 21

SURVEY QUESTIONS

In the following section, please select the "importance" of each service factor and your "satisfaction" with the current service levels you are receiving. The scaling for these two measures is as follows:

Importance	**Satisfaction**

1: Extremely Important	**1: Extremely Satisfied**
2: Very Important	**2: Very Satisfied**
3: Moderately Important	**3: Neither satisfied or dissatisfied**
4: Slightly Important	**4: Very Unsatisfied**
5: Not Important or Not Applicable	**5: Extremely Unsatisfied**

1. Airport Factors

Factor	Importance	Satisfaction
Location - Proximity to the depot(s) of Forwarder	1 2 3 4 5	1 2 3 4 5
Location - Proximity to the customers	1 2 3 4 5	1 2 3 4 5
Truck waiting area for smooth loading and unloading	1 2 3 4 5	1 2 3 4 5
Access to major highways	1 2 3 4 5	1 2 3 4 5
Access to intermodal facilities and transportation channels	1 2 3 4 5	1 2 3 4 5
Value added services	1 2 3 4 5	1 2 3 4 5
Warehousing (e.g., adequate storage space)	1 2 3 4 5	1 2 3 4 5
Inclement weather protection	1 2 3 4 5	1 2 3 4 5
Perishables storage center availability	1 2 3 4 5	1 2 3 4 5
Regulatory operations – Customs and Security	1 2 3 4 5	1 2 3 4 5
Regulatory operations – Free Trade Zone	1 2 3 4 5	1 2 3 4 5
Cargo protection and security	1 2 3 4 5	1 2 3 4 5
Ease of customs clearance	1 2 3 4 5	1 2 3 4 5
Operating hours flexibility (e.g., cutoff times, night operations)	1 2 3 4 5	1 2 3 4 5

2. Carrier Factors

Factor	Importance	Satisfaction
Carrier's reputation	1 2 3 4 5	1 2 3 4 5
Carrier's nationality (Domestic vs. International)	1 2 3 4 5	1 2 3 4 5
Scale and size of carrier's fleet and operations	1 2 3 4 5	1 2 3 4 5
Past business experience	1 2 3 4 5	1 2 3 4 5
Strategic cooperation	1 2 3 4 5	1 2 3 4 5
Freight rate competitiveness	1 2 3 4 5	1 2 3 4 5
Flexibility in rate adjustments (negotiation)	1 2 3 4 5	1 2 3 4 5
Cargo safety and security	1 2 3 4 5	1 2 3 4 5
Service reliability	1 2 3 4 5	1 2 3 4 5
Cargo tracing & tracking	1 2 3 4 5	1 2 3 4 5
Well managed information system (e.g. EDI Access)	1 2 3 4 5	1 2 3 4 5
Flight reliability	1 2 3 4 5	1 2 3 4 5
Flight schedules (frequency and connectivity)	1 2 3 4 5	1 2 3 4 5
Sufficient cut off time for rendering cargo in at the airport	1 2 3 4 5	1 2 3 4 5
Capacity availability	1 2 3 4 5	1 2 3 4 5
Booking process (requirements, easiness, prompt confirmation)	1 2 3 4 5	1 2 3 4 5
Responsiveness to information requests	1 2 3 4 5	1 2 3 4 5
Staff ability and skill set	1 2 3 4 5	1 2 3 4 5
Prompt handling of complaints	1 2 3 4 5	1 2 3 4 5
Efficiency in rebates & compensation (refunds)	1 2 3 4 5	1 2 3 4 5

Factor	Importance	Satisfaction
Staff attitude	1 2 3 4 5	1 2 3 4 5
Transport of special cargo	1 2 3 4 5	1 2 3 4 5
Rates for handling special cargo	1 2 3 4 5	1 2 3 4 5
Availability of type of air freighters needed for special cargo	1 2 3 4 5	1 2 3 4 5
Customization (developing custom solutions when requested)	1 2 3 4 5	1 2 3 4 5

3. Alternative Access Airport Policy and General Feedback

A. ***Alternative Access Airport Policy*** is described as forwarder's operational policy to use more than one airport in a region for shipping out air cargo to improve service level, decrease costs (trucking, handling, air fare, etc.), avoid road congestion and take advantage of favorable departure times. Please explain whether you are practicing or would consider adopting this policy. Otherwise, please explain why you believe this policy is not applicable to your company.

B. We appreciate your opinions in this research. Please use the space below to provide us any additional comments you may have:

2.2. AIR CARGO DENSITY ESTIMATION IN THE OH-MI REGION

2.2.1. INTRODUCTION

Freight transportation maintained a steady growth over the last decades (excluding the recent economic downturn in 2008). This trend is partially due to increasing demand for air-cargo transportation, which is the fasted growing mode of transportation the US based on value of shipped goods. According to Freight Analysis Framework (FAF), in 2010, Michigan produce 21.28 KTons of air-cargo valued over 1,669 M$. In the same time, Ohio records 49.14 KTons of air-cargo with value of 1,059 M$. FAF statistics puts Michigan at 27th (21th) and Ohio at 11th (29th) position among the states based on tonnage (value) of cargo transported. Table 2.1 presents the domestic air-cargo transported from each state in 2010.

Understanding and evaluating the demand for air-cargo transportation is the key for any successful analysis and planning in the field of air transportation. The FAF dataset, however, focus on national policy and planning issues and is not directly useful for state level analysis. The availability of detailed information of state level is critical for freight forwarders, who are responsible for over 80% of air-cargo transportation. Forwarders, as intermediate between shippers and air-carriers, often responsible for arranging cargo shipment on air-network as well as its short-haul transportation of road-network. Consequently, the location of customers (demand origins) plays an essential role in forwarders planning and fleet routing. Location of forwarders facility, as the origin of vehicles also sorting and processing of good before sending them to air-carriers, can play an eminent role in their operational costs and responsiveness of their services. Indeed, the preference for any location is highly depends not only on the regional airports but also on the location of potential customers. Unfortunately, no data set is available on demand origins of air-cargo in MI-OH region. The objective of this section is to provide a statistical analysis of air-cargo origins in the MI-OH region.

2.2.2. Significance of Air-Cargo Density Estimation in OH-MI

Forwarders manage a fleet of vehicles, starting from the depot, to collect customer orders in the region and bring them back to the depot for sorting and processing. The consolidated cargo is then dispatched (usually with dedicated vehicles) to the accessible airports (Hall 2002). For time-sensitive goods, where the service level expectation of on-time delivery is high, the forwarder's ability to perform the pickup and airport deliveries in shorter time window is the key. Earlier delivery of cargo to the airport often indicate the better chance of catching earlier flight and in turn reducing the overall transportation time. Indeed, in a multiple airport region, the ability of considering multiple airports, everything else being the same) is primarily governed by the travel distance between a forwarder's depot and alternative airports.

One of the key elements in faster pickup and processing is the relative location of the forwarder's depot to customer sites. This problem is essentially a Facility Location Problem. In this scenario, forwarder needs to reduce the Euclidian distance of the depot to all customer sites while accounting for the frequency and magnitude of their orders. In other words, the objective is to find a geographical location of depot as (x, y) to minimize the following function

$$f(x, y) = \sum_i w_i\{(a_i - x)^2 + (b_i - y)^2\}^{1/2},$$

where (a_i, b_i) is the location of customer i site that generates transportation demand of weight of w_i; this weight could be defined as the cargo volume. This problem is very difficult to solve for practical large-scale instances. Therefore, often the square of Euclidian distances is minimized as follows.

$$f_s(x, y) = \sum_i w_i\{(a_i - x)^2 + (b_i - y)^2\}$$

The optimal solution to this problem, (x^*, y^*), is often called the Center-Of-Gravity (COG), and it may be obtained through the following two formulae (Kuo and White 2004).

$$x^* = \left(\sum_i w_i a_i\right) \Big/ \left(\sum_i w_i\right)$$

$$y^* = \left(\sum_i w_i b_i\right) \Big/ \left(\sum_i w_i\right)$$

Since, the actual location and air cargo demand of customers are not known in advance (the strategic planning phase), forwarders need to rely on estimation of demand and location of potential customers. Accordingly, in order to make depot location decisions and consequently evaluate alternative airports, forwarders first need to know the air-cargo demand distribution within the multi airport region.

However, the geographical demand distribution of air-cargo is currently not available for Michigan & Ohio region. The objective of this section is to provide a systematic approach to establish an estimated geographical air-cargo demand distribution for MI-OH region. Note that this approach could also be applied to other MARs. Given that forwarders may have different levels of air cargo transportation for various goods, we separate goods and provide the distribution for each goods code separately.

Indeed, by having the geographical demand distribution, a forwarder can easily apply the COG formulation to identify the depot location, which in turn indicates which airports in a multiple airport region should be considered due to their proximity to the candidate depot location as well as the customer demand. Note that we are considering Clevaland airport (in addition to the DTW and TOL) since some of the air cargo demand density in Ohio is captured through this airport.

2.2.3. Freight Analysis Framework Data Set[2]

Freight Analysis Framework (FAF) estimates commodity flows and related freight transportation activity among states, sub-state regions, and major international gateways. It also forecasts future flows among regions and relates those flows to the transportation network. FAF includes an origin-destination database of commodity flows among regions, and a network database in which flows are converted to truck payloads and routes.

Table 2.1. Domestic air-cargo statistics based on origin state

Domestic Origin State	Total KTons	Total M$
California	572.95	20667.62
Tennessee	23.79	9094.36
Texas	140.80	9086.98
Washington	33.16	7263.00
Kansas	44.07	7168.40
New Jersey	84.99	5815.80
New York	48.01	5126.59
Georgia	35.80	4531.98
Arizona	84.24	4377.80
Massachusetts	27.57	3806.63
Florida	59.01	3503.07
Colorado	12.59	3466.61
Illinois	42.53	3433.64
Kentucky	96.91	3177.81
New Hampshire	10.26	3022.47
Connecticut	31.83	2476.55
Pennsylvania	39.55	2324.64
Missouri	24.35	2307.92
Minnesota	22.52	2238.00
Michigan	21.28	1669.74
Wisconsin	24.03	1575.62
North Carolina	39.61	1550.01
Oregon	4.95	1256.76
South Carolina	56.41	1216.97
Alaska	459.30	1142.39
Delaware	2.84	1130.25

[2] Freight Analysis Framework (FAF) Version 2.2 , User Guide. Accessible from http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/faf2userguide/

Utah	16.13	1060.84
Ohio	49.14	1059.37
Idaho	4.26	1050.91
Virginia	29.40	995.99
Indiana	13.76	907.88
Arkansas	4.61	895.89
Louisiana	16.48	752.39
Hawaii	181.14	648.43
Alabama	15.10	559.74
Maryland	8.49	550.08
Oklahoma	13.63	449.90
Nevada	22.30	436.94
Iowa	8.57	435.89
New Mexico	0.96	317.68
Rhode Island	4.46	180.92
West Virginia	0.85	130.15
Mississippi	1.58	123.10
Nebraska	6.14	103.41
Maine	2.18	87.39
Montana	1.04	75.50
Vermont	0.49	36.59
South Dakota	0.25	31.09
Wyoming	0.04	18.76
North Dakota	0.18	10.93
Washington DC	0.00	1.62

The FAF commodity origin-destination database includes tons and value of commodity movements among regions by mode of transportation and type of commodity. This document covers FAF Version 2.2 (referred to as FAF2.2), which replaces Version 2.1. Specific differences between Version 2.2 and 2.1 are:

- FAF2.2 contains projected commodity flow data ranging from 2010 to 2035 in five-year intervals as well as corrected 2002 base case data from Version 2.1.
- FAF2.2 excludes all foreign-to-foreign shipments via the United States. These in-transit flows were partially covered in the "sea" file of Version 2.1.

Neither version includes international air cargo data, which will be added later.

The FAF2.2 2002 base year database is built entirely from public data sources. Key sources include the 2002 Commodity Flow Survey (CFS), developed by the Census Bureau, U.S. Department of Commerce, and the Bureau of Transportation Statistics (BTS), U.S. Department of Transportation; Foreign Waterborne Cargo data, developed by the U.S. Army Corps of Engineers; and a host of other sources that are documented in various papers available at www.ops.fhwa.dot.gov/freight/freight_analysis/faf. FAF statistics do not match those in mode-specific publications primarily due to different definitions that were used to avoid double counting. FAF2.2 statistics should not be compared with original FAF data because different methods and coverage are employed.

Methods in developing the 2002 base year data are transparent; and it has been expanded to cover all modes and significant sources of shipments. Future projected data covering years from 2010 to 2035 with a five-year interval are based on Global Insight's proprietary economic and freight modeling packages. However, the approach/general procedure and assumptions utilized by the modeling packages have been documented and are available for download at www.ops.fhwa.dot.gov/freight/freight_analysis/faf.

The 2002 FAF2.2 Commodity Origin-Destination Database is a product of the Federal Highway Administration (FHWA), developed in cooperation with the Bureau of Transportation Statistics (BTS) through contracts with Oak Ridge National Laboratory, MacroSys Research and Technology, Global Insight, and Battelle. Because the scope and methods have changed significantly, statistics from FAF2 and the original FAF should not be compared.

Table 2.2 Domestic air-cargo statistics (2010) for Michigan and Ohio

State	Measure	Within Sate	From State	To State
Michigan	*Total KTons*	0.0001	21.2809	15.5808
	Total M$	0.4425	1669.2941	1535.524
Ohio	*Total KTons*	0.0045	49.1306	37.9276
	Total M$	3.8805	1055.4858	4583.6432

Table 2 shows the aggregated FAF data on 2010 for MI and OH. This data is also available for individual Standard Classification of Transported Goods (SCTG) codes.

2.2.4. Other Freight Data Sets

The Commodity Flow Survey (CFS)

The CFS is a shipper-based survey and captures data on shipments originating from select types of business establishments located in the 50 states and the District of Columbia. The CFS is conducted as a partnership between the Bureau of Transportation Statistics and the U.S. Census

Bureau[3]. The survey is conducted on a five-year cycle as a component of the economic census. The three previous surveys were conducted in 1993, 1997, and 2002. The 2007 survey sampled over 100,000 establishments with paid employees that were located in the United States and were classified, using the 2002 North American Industry Classification System (NAICS) in mining, manufacturing, wholesale trade, and select retail trade industries (electronic shopping, mail-order houses, and fuel dealers). The survey also covers auxiliary establishments (i.e., warehouses and managing offices) of multi-establishment companies, which had non-auxiliary establishments that were in-scope to the CFS or were classified in retail trade.

The primary goal of the 2007 Commodity Flow Survey (CFS) is to estimate shipping volumes (value, tons, and ton-miles) by commodity and mode of transportation at varying levels of geographic detail (i.e., national, state, select MSAs). A secondary objective is to estimate the volume of shipments moving from one geographic area to another (e.g., flows of commodities between states, regions, etc.) by mode and commodity. The CFS, however, does not include establishments classified in forestry, fishing, utilities, construction, transportation, and most retail and services industries. Farms and government-owned entities (except government-owned liquor stores) were also excluded. Foreign-based business importing to the United States are also excluded from the survey sample; however, in theory, domestic portions of imported shipments can be captured in the CFS once arriving at a U.S. based establishment (assuming it is an eligible shipping establishment included in the CFS).

However, our objective in this research is to evaluate the distribution of demand for air-cargo at lower regional level,; CFS falls short to accommodate the needed data for this evaluation. Firstly the CFS does not include all commodities; more importantly, the mode-specific O-D matrices are limited to states and fewer geographical regions.

GLOBAL INSIGHT TRANSEARCH

TRANSEARCH is a privately maintained comprehensive market research database for intercity freight traffic flows compiled by Global Insight, formerly Reebie Associates. The database includes information describing commodities (by Standard Transportation Commodity Classification (STCC) code), tonnage, origin and destination markets, and mode of transport.

[3] The Commodity Freight Survey accessible at http://www.bts.gov/help/commodity_flow_survey.html

Data are obtained from Federal, state, provincial agencies, trade and industry groups, and a sample of motor carriers. Forecasts of commodity flows for up to 25 years also are available.[4]

TRANSEARCH data are generally accepted as the most detailed available commodity flow data and are commonly used by states, metropolitan planning organizations (MPO), and FHWA in conducing freight planning activities. However, it should be noted that there are some limitations to how this data should be used and interpreted:

- **Mode Limitations –** The Rail Waybill data used in TRANSEARCH are based on data collected by Class I railroads. The waybill data contain some information for regional and short-line railroads, but only in regards to interline service associated with a Class I railroad. This is important to Maine, as it does not have any direct service from a Class I railroad. The rail tonnage movements provided by the TRANSEARCH database, therefore, are conservative estimates.

- **Use of Multiple Data Sources –** TRANSEARCH consists of a national database built from company-specific data and other available databases. To customize the dataset for a given region and project, local and regional data sources are often incorporated. This incorporation requires the development of assumptions that sometimes compromise the accuracy of the resulting database. Different data sources use different classifications; most economic forecasts are based on SIC codes while commodity data are organized by STCC codes. For example, the U.S. Bureau of Census' VIUS has its own product codes that must be assigned to STCCs to convert truck commodity flows to truck trips. These and other conversions can sometimes lead to some data being miscategorized or left unreported.

- **Data Collection and Reporting –** The level of detail provided by some specific companies when reporting their freight shipment activities limits the accuracy of TRANSEARCH. If a shipper moves a shipment intermodally, for example, one mode must be identified as the primary method of movement. Suppose three companies make shipments from the Midwest United States to Europe using rail to New York then water

[4] Quick Response Freight Manual II available at http://ops.fhwa.dot.gov/freight/publications/qrfm2/sect09.htm

to Europe. One company may report the shipment as simply a rail move from the Midwest to New York; another may report it as a water move from New York to Europe; the third may report the shipment as an intermodal move from the Midwest to Europe with rail as the primary mode. The various ways in which companies report their freight shipments can limit the accuracy of TRANSEARCH.

- **Limitations of International Movements –** TRANSEARCH does not report international air shipments through the regional gateways. Additionally, specific origin and destination information is not available for overseas waterborne traffic through marine ports. Overseas ports are not identified and TRANSEARCH estimates the domestic distribution of maritime imports and exports. TRANSEARCH data also do not completely report international petroleum and oil imports through marine ports. This is a concern to a state like Maine, which receives large amounts of petroleum through its major marine ports from Canada. Finally, TRANSEARCH assigns commodity data only to the truck, rail, air, and water modes, though a large percentage of foreign imports (by weight) consist of oil and petroleum products – commodities that are frequently shipped via pipeline to storage and distribution points.

The above mentioned data sources, although cannot directly be used to acquire the required regional data for air-cargo demand distribution, they can be used with some analysis to estimate the disaggregated data at a lower level (county level) needed for our research goal. Next section presents the methodology to achieve this goal.

2.2.5. Methodology for Estimating Air Cargo Origins

In the absence of reliable data for demand origin of air cargo, we have to pursue econometric models to estimate the amount of air cargo demand in lower-levels (e.g., at the county level). In this section, we discuss the methodology to disaggregate FAF data to extract county level air-cargo demand in Michigan and Ohio. This methodology is proposed by Cambridge Systematic (2008)[5].

[5] Use of FAF Data for Florida Multimodal Freight Analysis, 2008, Final report prepared for System Planning Office, Florida Department of Transportation.

The methodology utilizes the relationship between employment by industry and the commodities that those industries produce and consume. While the FAF2 data is available only at a regional level, employment by industry is more readily available at smaller levels of geography. The US Census Bureau provides County Business Patterns (CBP), a publicly available database, employment by county by North American Industrial Classification System (NAICS) industry. Commercial and state data sources may provide employment by NAICS or comparable industry classifications at smaller levels of geography. This employment data can be aggregated to develop mathematical relationships between the FAF2 commodity shipments to and from a FAF2 region and the employment by industries in that FAF2 region.

The availability of employment data by industry can be used with these equations to estimate the expected production of freight tonnage in a FAF2 region and the units of smaller geography in that FAF2 region. The shares of the smaller units of geography tonnage to the regional tonnage can then be used to disaggregate the freight flows from FAF2 regions to the smaller units of geography within those FAF2 regions. This method is suitable for disaggregating the FAF2 regional flows to flows from Michigan and Ohio counties. The focus of this study is to develop a FAF2 county database for MI-OH region. CBP data is readily available at the county level and while it is possible to disaggregate FAF2 data to higher spatial resolutions than counties, employment by industry information at smaller geographies is not easily available from public sources.

The first step in this methodology is to determine the employment levels at the three-digit NAICS county level. The CBP data is the most appropriate data source to determine employment at the three-digit NAICS level at the county level. Next, we estimate the production of goods based on the employment level. Having the estimated production of goods based on NAICS code, we establish a relationship between NAICS codes and SCTG codes that are used on FAF data sets. Finally, we obtain the disaggregated county level production of goods by SCTG codes.

Given inter- and intra-state freight transportation data from FAF data set based on SCTG codes, we estimate the overall ratio of freight movement by different modes. This way, we then calculate the percentage of air-cargo by SCTG codes. In the final step, by adjusting the good production based on freight shipment, we estimate the air-cargo generation at county levels based on SCTG codes.

The details of the algorithm are presented in the following.

Regional Air-Cargo Demand Estimation Algorithm

Step 1. Extract total KTons of commodity shipment from a origin state (e.g., Ohio) from Freight Analysis Framework Data Extraction Tool (available to public at http://faf.ornl.gov/fafweb/Extraction2.aspx). This data is available by mode and SCTG codes. Figure 1 shows a snapshot of online FAF data extraction tool.

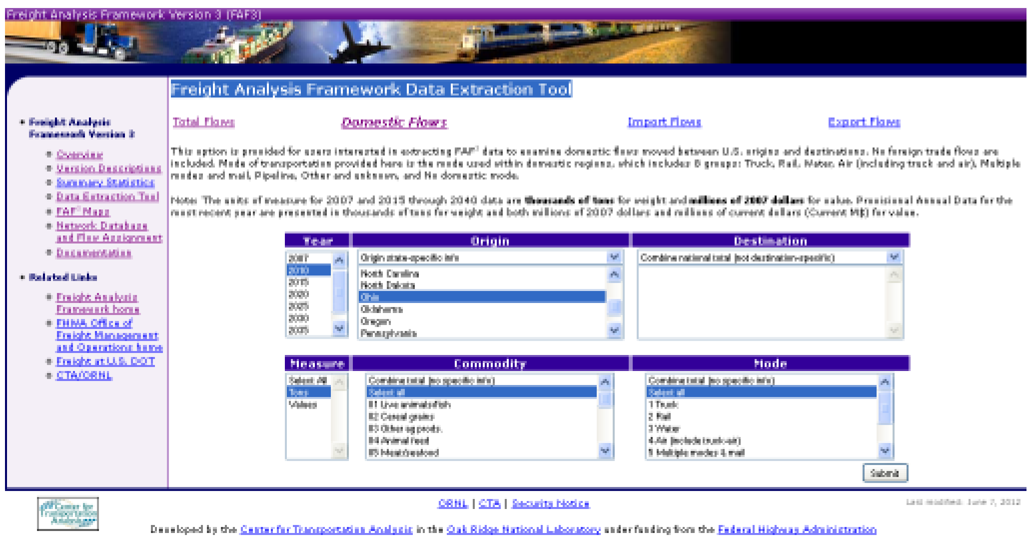


Figure 2.1. Snapshot of FAF3 Data Extraction Tool

Step 2. Calculate the percentage of modal transportation for SCTG codes. List of descriptive SCTG codes is presented in the appendix.

Step 3. Collect employment for the selected state by three-digit NAICS codes for each county from American Fact Finder based on CENSUS data set (available factfinder2.census.gov). Figure 2 shows the user interface for American Fact Finder.

Step 4. Process the employment data and convert the codes employment codes to reference numbers. We use averages to estimate the employment (if employmentdata is provided in ranges). Table 3 presents the CENSUS ranges for each code.

Step 5. Use the linear regression formula to estimate the commodity production by SCTG code at county level based on the three-digit NAICS codes. In the following formula, P_{SCTG} is the production by SCTG code, E_{NAICS} is the employment by three-digit NAICS code and β_{NAICS} is the regression coefficient. The linear regression coefficients are presented in the appendix.

$$P_{SCTG} = \sum_{NAICS} \beta_{NAICS} E_{NAICS}$$

Table 2.3. Employment Data Code Description

Code	Employment Range	Estimation
A	0 to 19	9.5
B	20 to 99	59.5
C	100 to 249	174.5
E	250 to 499	374.5
F	500 to 999	749.5
G	1,000 to 2,499	1749.5
H	2,500 to 4,999	3749.5
I	5,000 to 9,999	7499.5
J	10,000 to 24,999	17499.5
I	50,000 to 99,999	74999.5

Step 6. Adjust the state-wise production according to freight data set for the corresponding state. Based on Step 2, calculate the total tonnage of air-cargo demand by SCTG code at the county level.

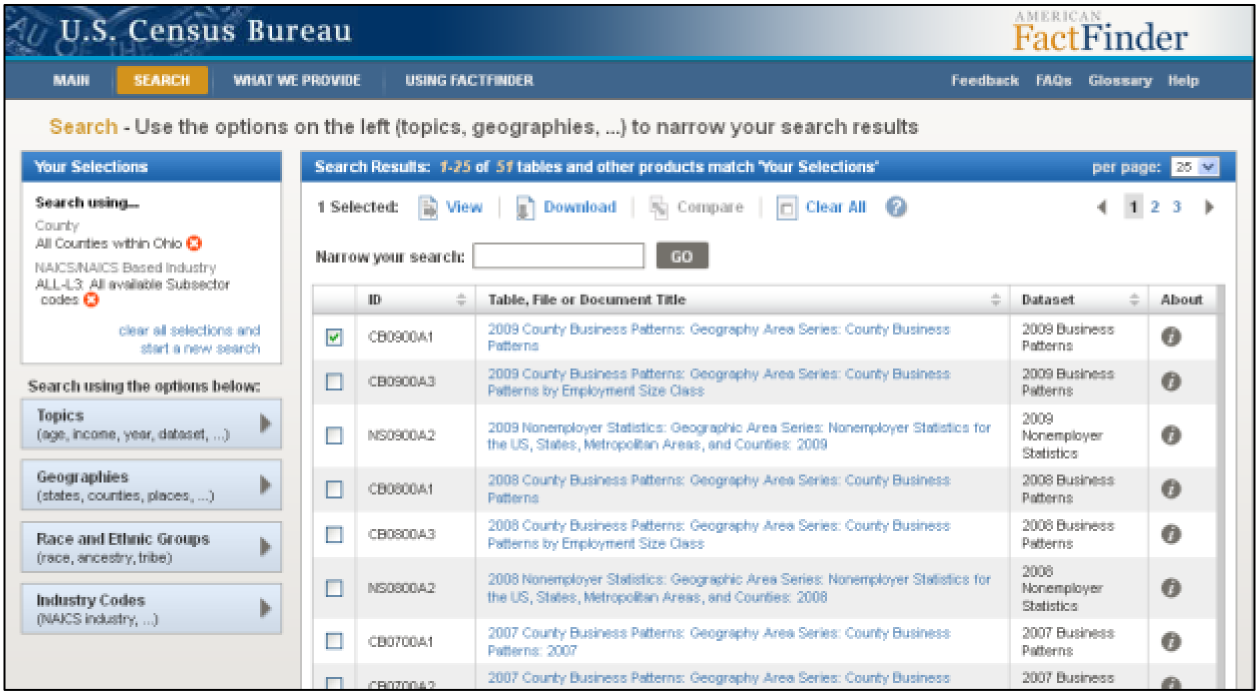


Figure 2.2. American Fact Finder Search Tool

The above algorithm provides a county level air-cargo production for each SCTG code. In the next section, we present the result of this algorithm for Michigan and Ohio region.

2.2.6. Air-cargo Demand Distribution in MI-OH Region

Following the algorithm presented in the previous section, we generate the county level air-cargo demand for the Michigan and Ohio. We use MATLAB to generate automatic projection of demand distribution on map. For this projection, we present counties by their centroids and use Gaussian smoothing for surface fitting. There is no air-cargo demand for some SCTG codes.

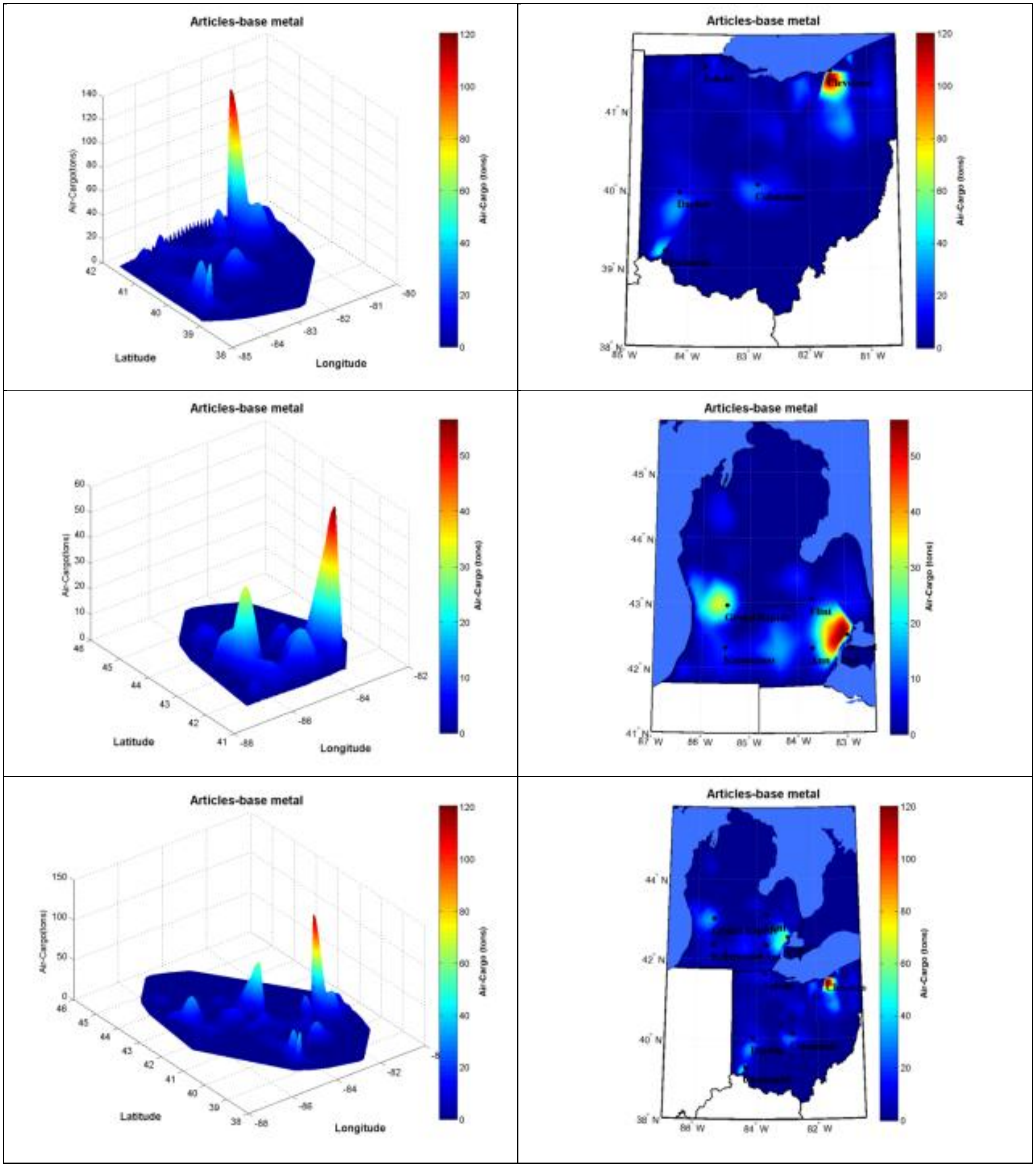
In the following pages, the demand distribution is presented in 3D map view, e.g., demand density overlaid geographical map, as well as color-coded 2D geographical map. In the 2D plots, the demand at each point is estimated and indicated by color code. The side color bar on each graph explains the color code. Note that scales are varying for different graphs.

Table 4 presents the overall air-cargo demand for each state.

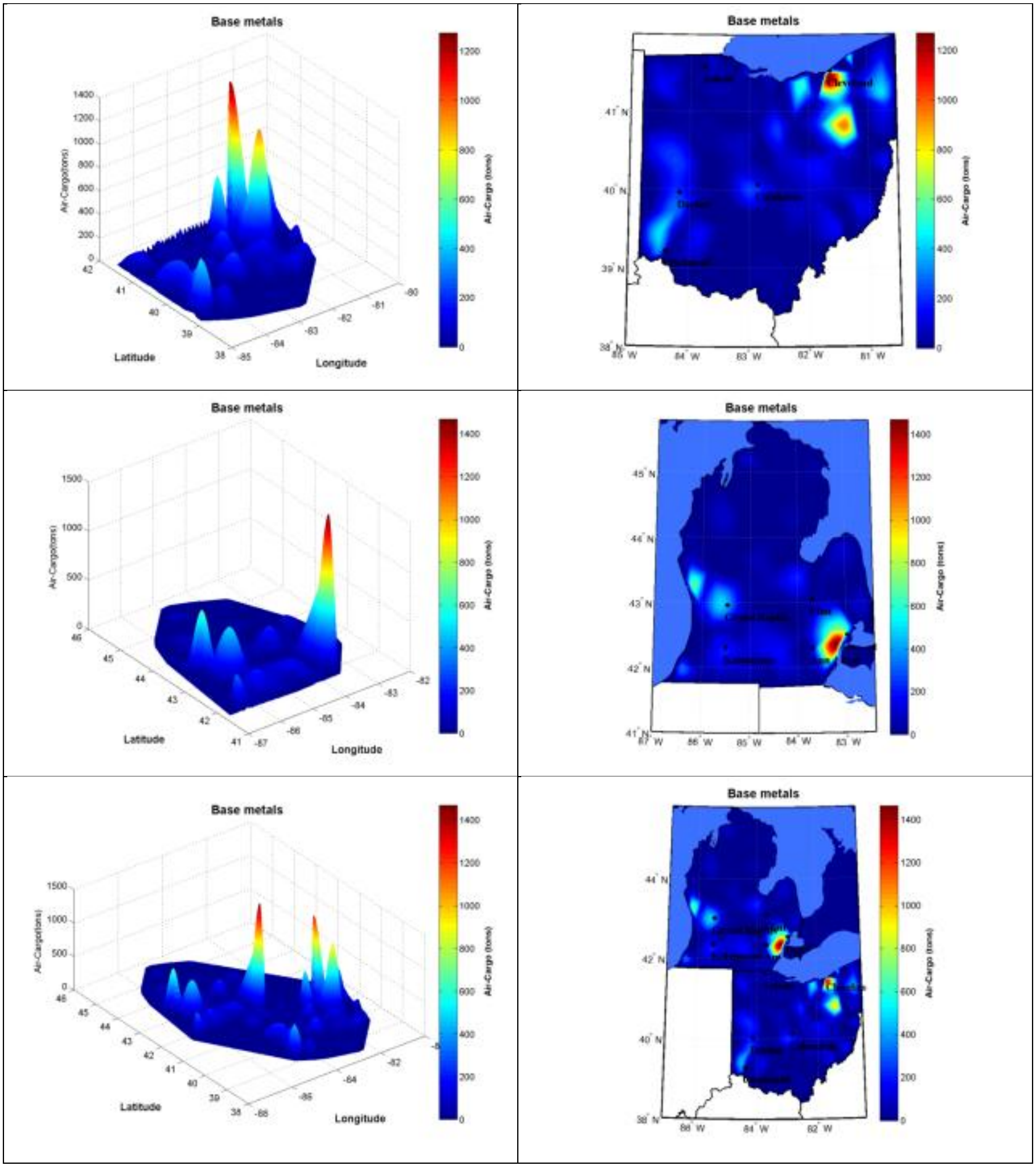
Table 4. Air-Cargo Demand for Different Goods in Michigan and Ohio (Tons)

SCTG Code Description	SCTG Code	Ohio	Michigan
Precision instruments	38	35.19	9.99
Electronics	35	0.79	1.73
Transport equip.	37	1.06	1.09
Machinery	34	1.38	0.33
Plastics/rubber	24	1E-01	1.13
Chemical prods.	23	1.05	0.17
Printed prods.	29	0.88	0.28
Motorized vehicles	36	0.59	0.36
Textiles/leather	30	0.56	0.22
Articles-base metal	33	5E-02	0.37
Misc. mfg. prods.	40	0.13	0.21
Base metals	32	0.28	1E-02
Pharmaceuticals	21	4E-03	7E-02
Paper articles	28	7E-02	0
Furniture	39	1E-03	5E-02
Wood prods.	26	0	8E-03
Nonmetal min. prods.	31	3E-03	1E-04
Basic chemicals	20	1E-03	2E-04
Mixed freight	43	3E-04	1E-03
Nonmetallic minerals	13	4E-04	0
Other foodstuffs	7	2E-05	0

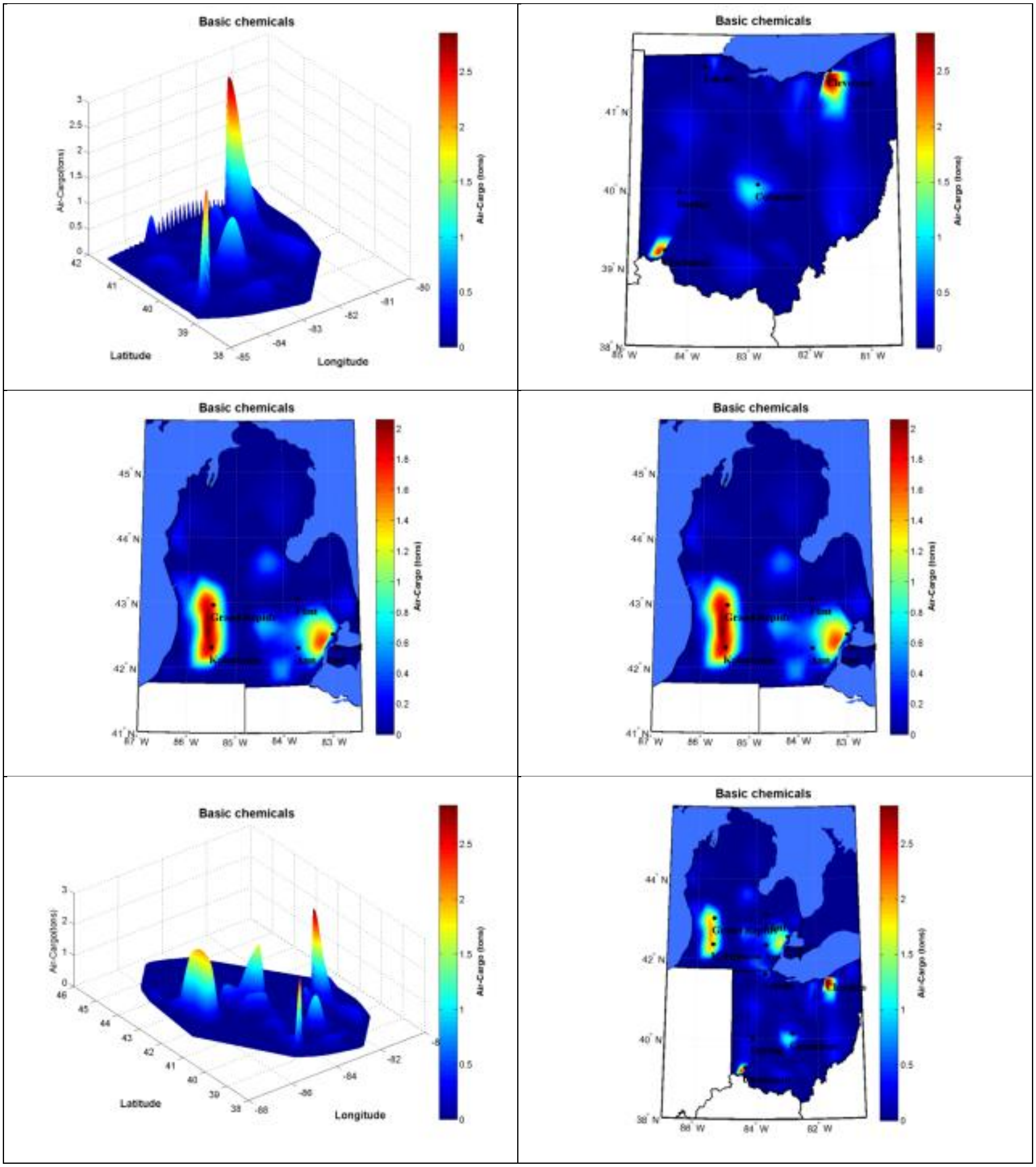
As can be seen in Table 4, the top five goods by weight in Ohio are Precision Instruments, Machinery, Transportation Equipments, Chemical Products, and Printed Products. As for Michigan, top five goods are Precision Instruments, Electronics, Plastic/Rubber, Transportation Equipments, and Article-Based Metals.



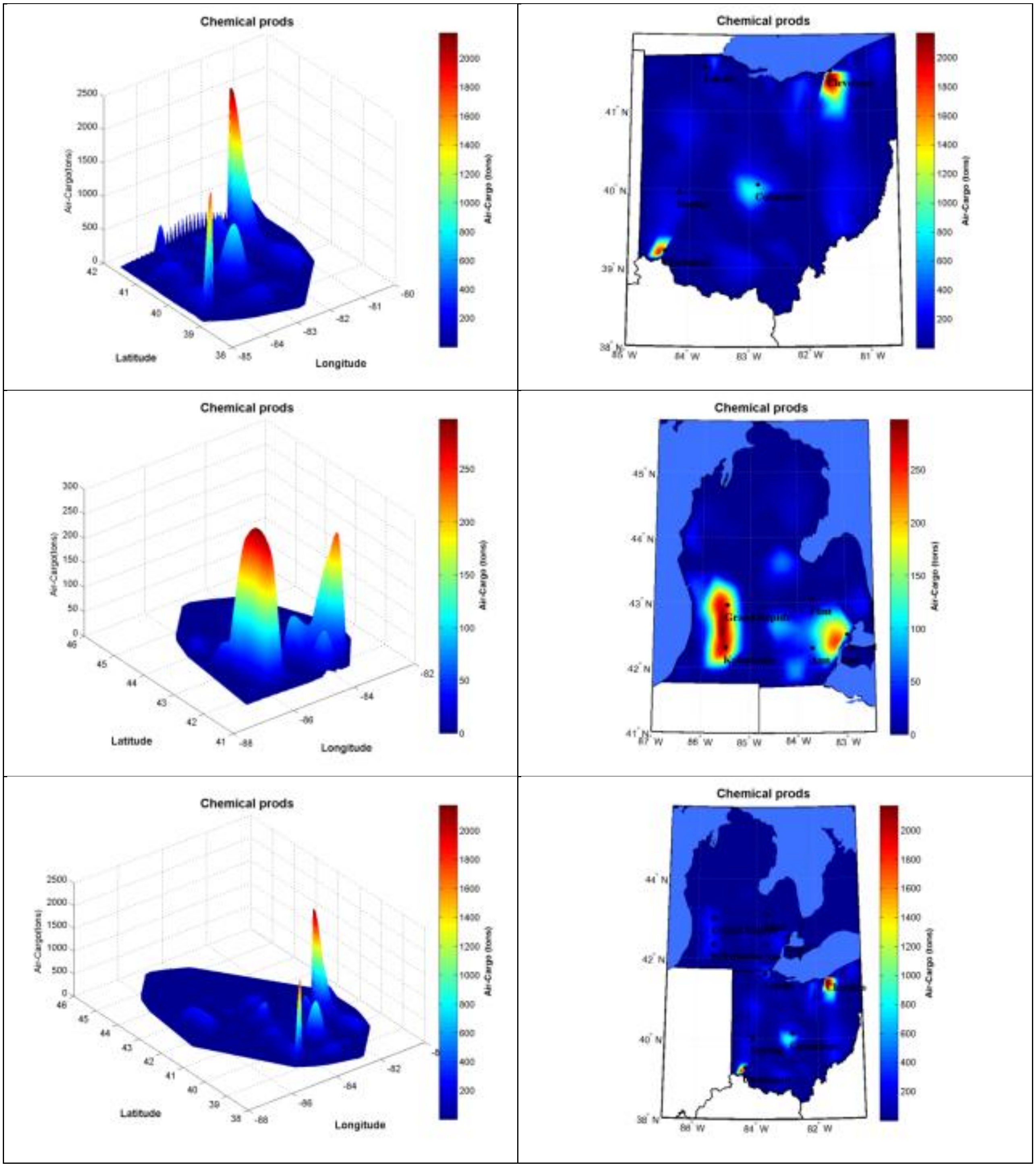
Ohio State Air-Cargo Demand Distribution (top), Michigan State Air-Cargo Demand Distribution (middle), MI-OH Region Air-Cargo Demand Distribution (bottom) of Article-base Metal (SCTG Code 33).



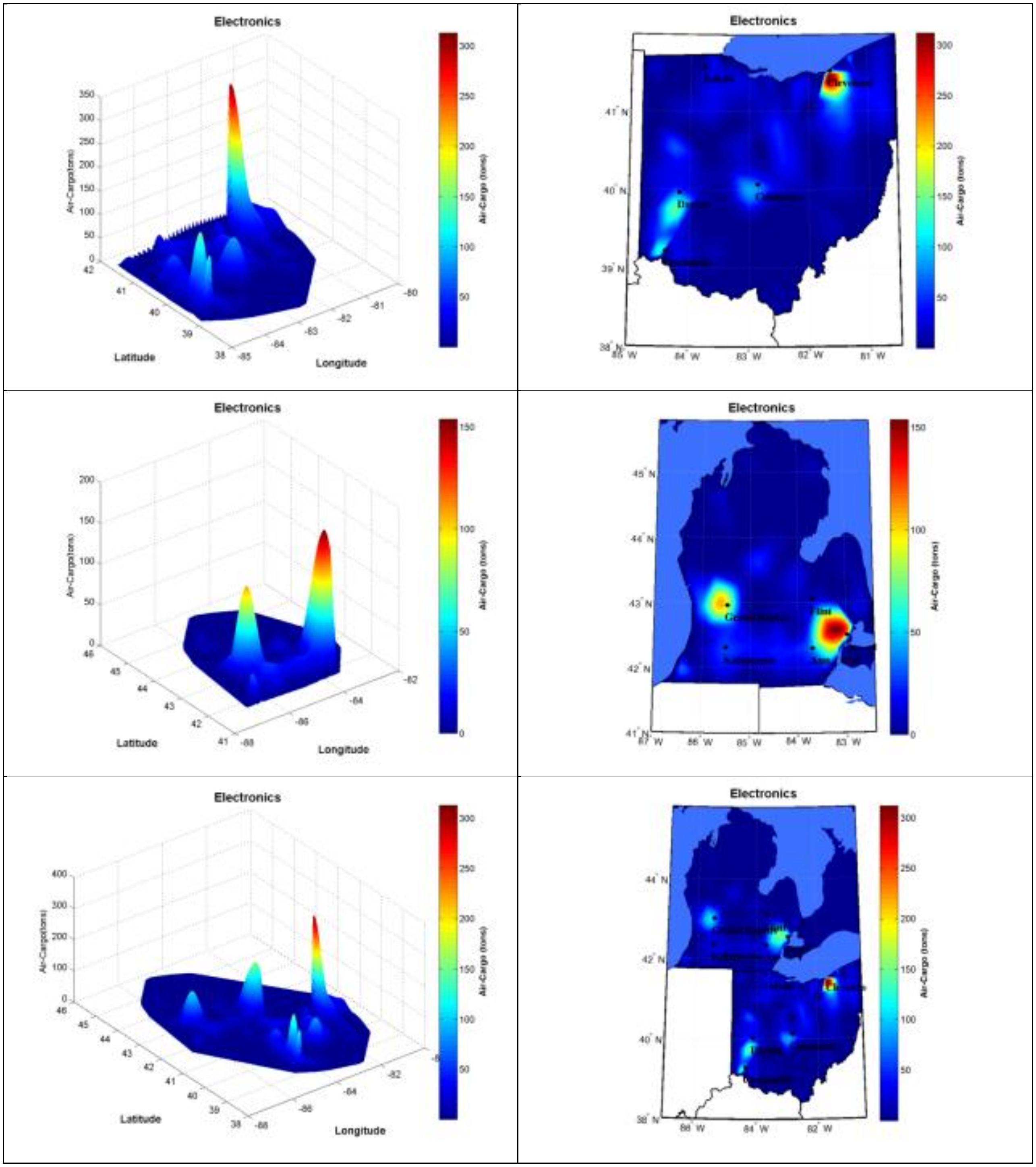
Ohio State Air-Cargo Demand Distribution (top), Michigan State Air-Cargo Demand Distribution (middle), MI-OH Region Air-Cargo Demand Distribution (bottom) of Base Metal in Primary or Semi-Finished Forms and in Finished Basic Shapes (SCTG Code 32).



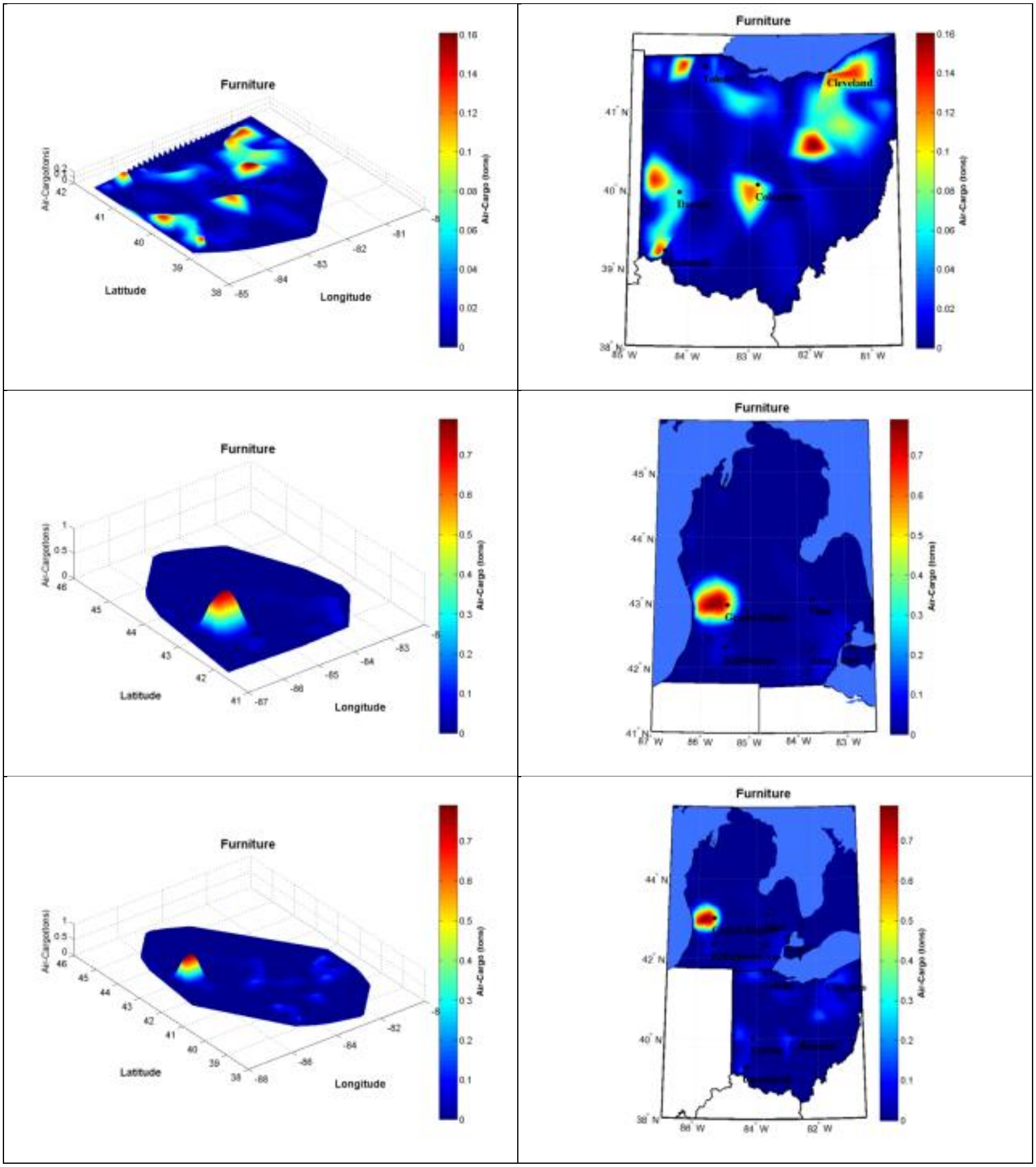
Ohio State Air-Cargo Demand Distribution (top), Michigan State Air-Cargo Demand Distribution (middle), MI-OH Region Air-Cargo Demand Distribution (bottom) of Basic Chemicals (SCTG Code 20).



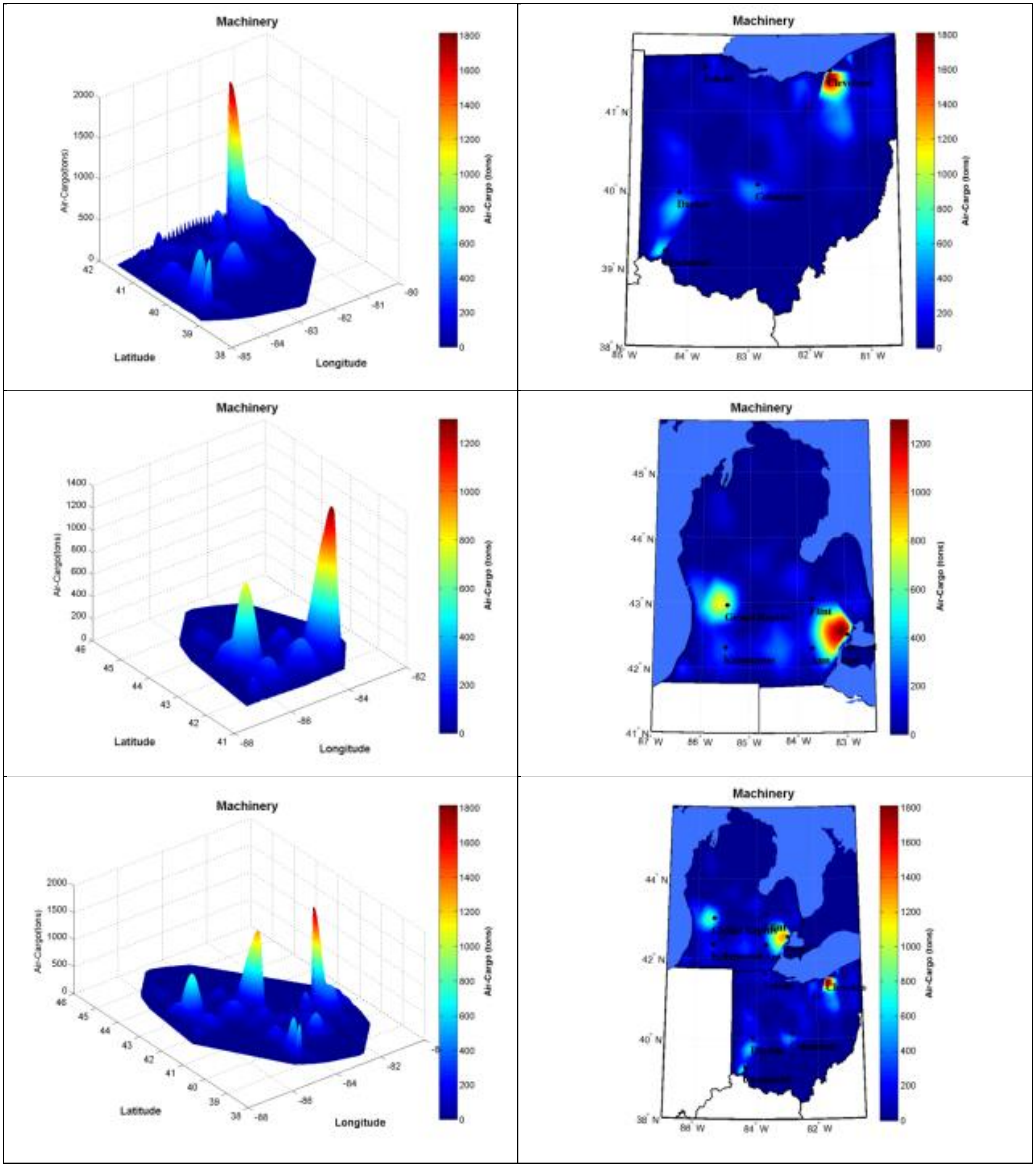
Ohio State Air-Cargo Demand Distribution (top), Michigan State Air-Cargo Demand Distribution (middle), MI-OH Region Air-Cargo Demand Distribution (bottom) of Other Chemical Products and Preparations (SCTG Code 23).



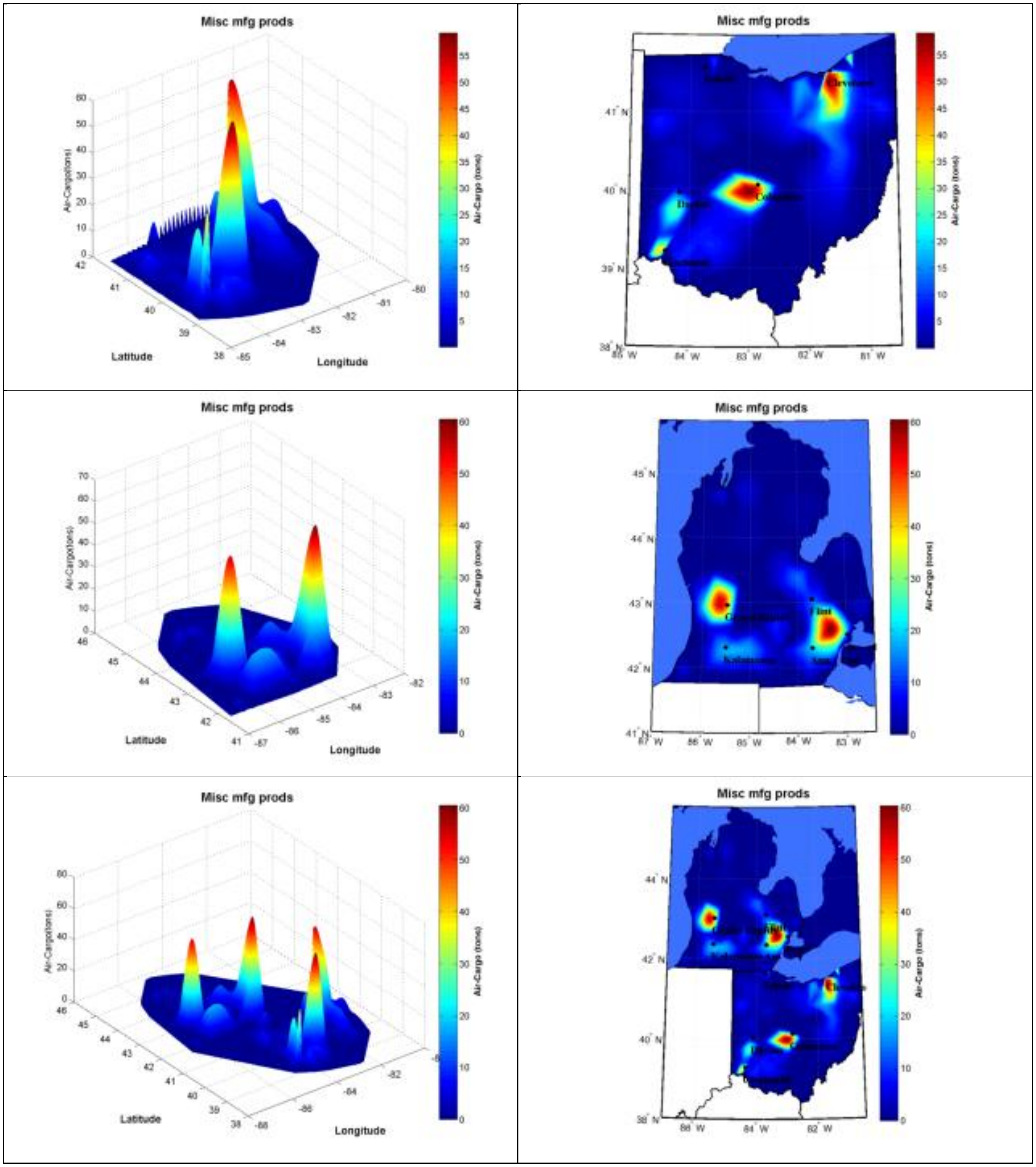
Ohio State Air-Cargo Demand Distribution (top), Michigan State Air-Cargo Demand Distribution (middle), MI-OH Region Air-Cargo Demand Distribution (bottom) of Electronic and other Electrical Equipment and Components, and Office Equipments (SCTG Code 35).



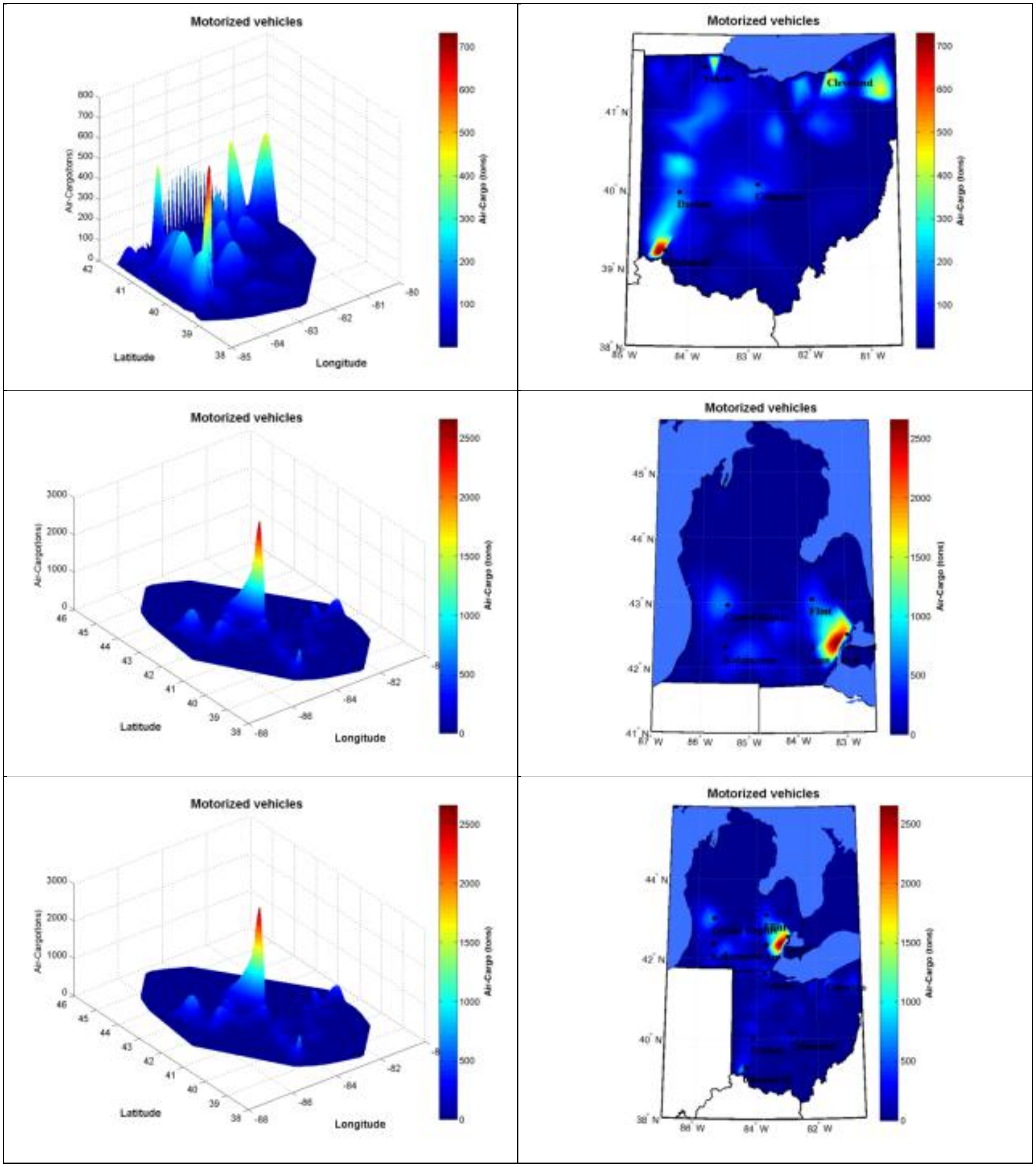
Ohio State Air-Cargo Demand Distribution (top), Michigan State Air-Cargo Demand Distribution (middle), MI-OH Region Air-Cargo Demand Distribution (bottom) of Furniture, Mattresses and Mattress Supports, Lamps, Lighting Fittings, and Illuminated Signs (SCTG Code 39).



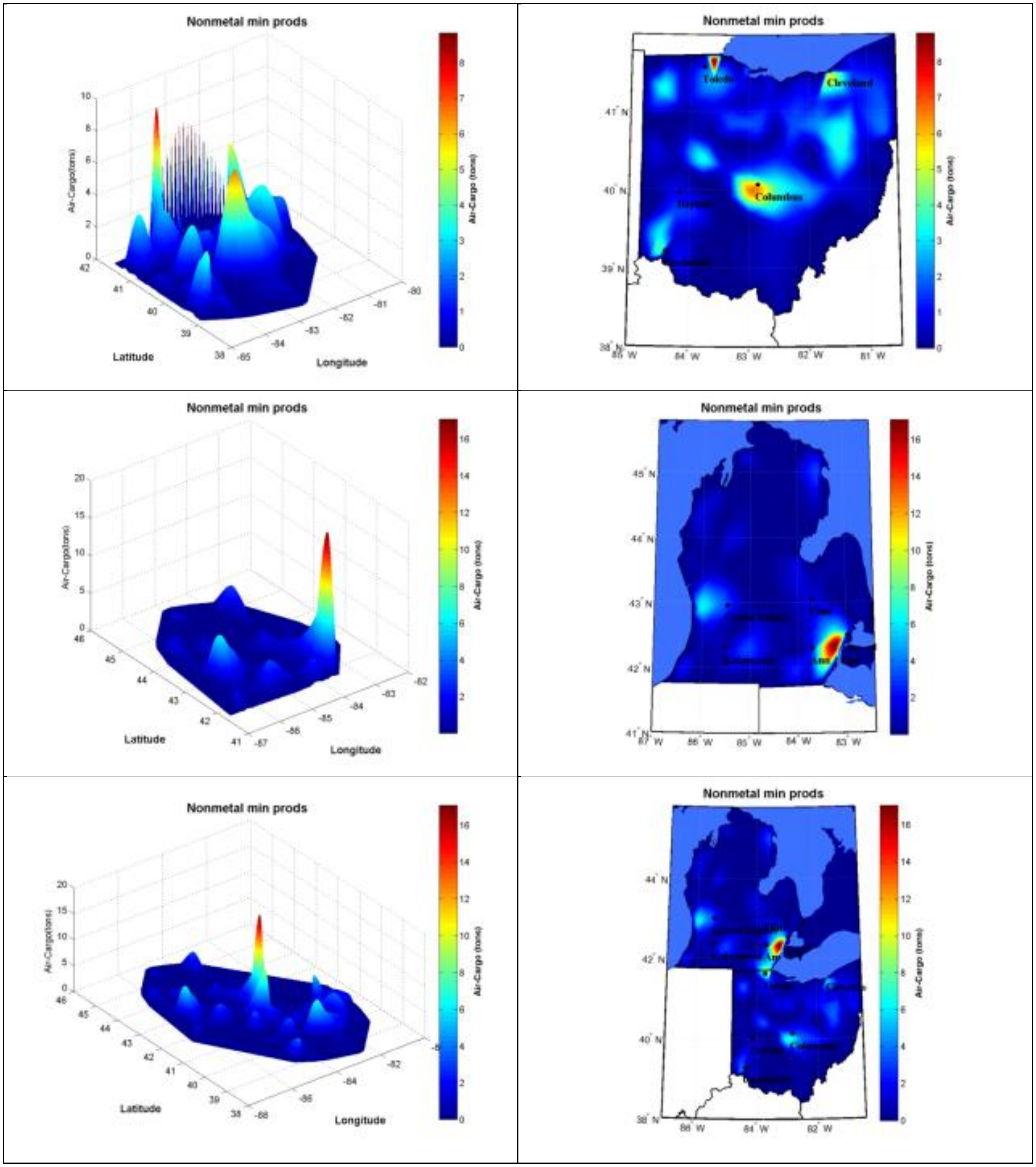
Ohio State Air-Cargo Demand Distribution (top), Michigan State Air-Cargo Demand Distribution (middle), MI-OH Region Air-Cargo Demand Distribution (bottom) of Machinery (SCTG Code 34).



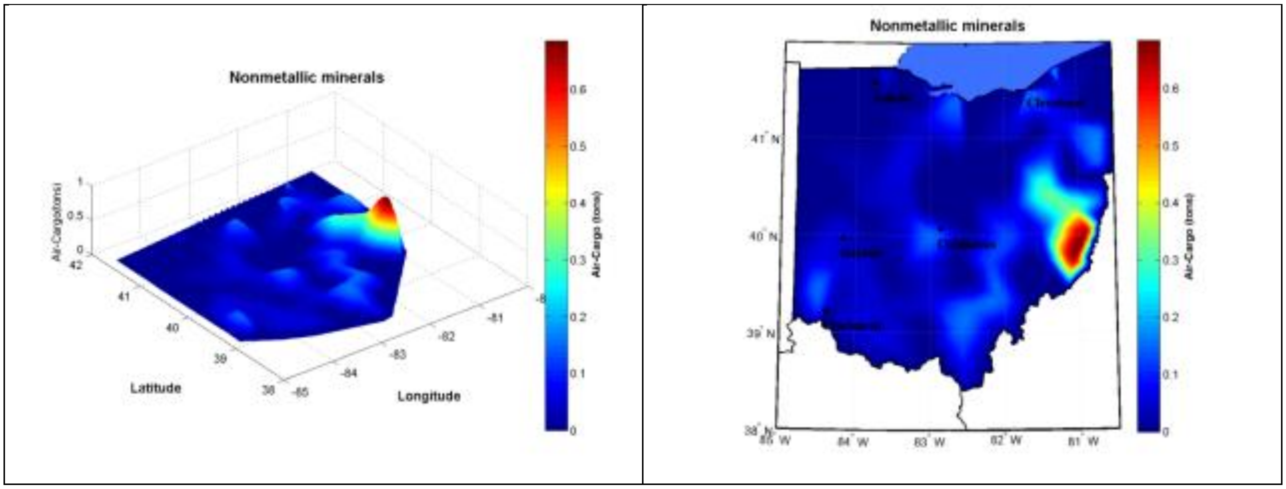
Ohio State Air-Cargo Demand Distribution (top), Michigan State Air-Cargo Demand Distribution (middle), MI-OH Region Air-Cargo Demand Distribution (bottom) of Miscellaneous Manufactured Products (SCTG Code 40).



Ohio State Air-Cargo Demand Distribution (top), Michigan State Air-Cargo Demand Distribution (middle), MI-OH Region Air-Cargo Demand Distribution (bottom) of Motorized and Other Vehicles Including Parts (SCTG Code 36).

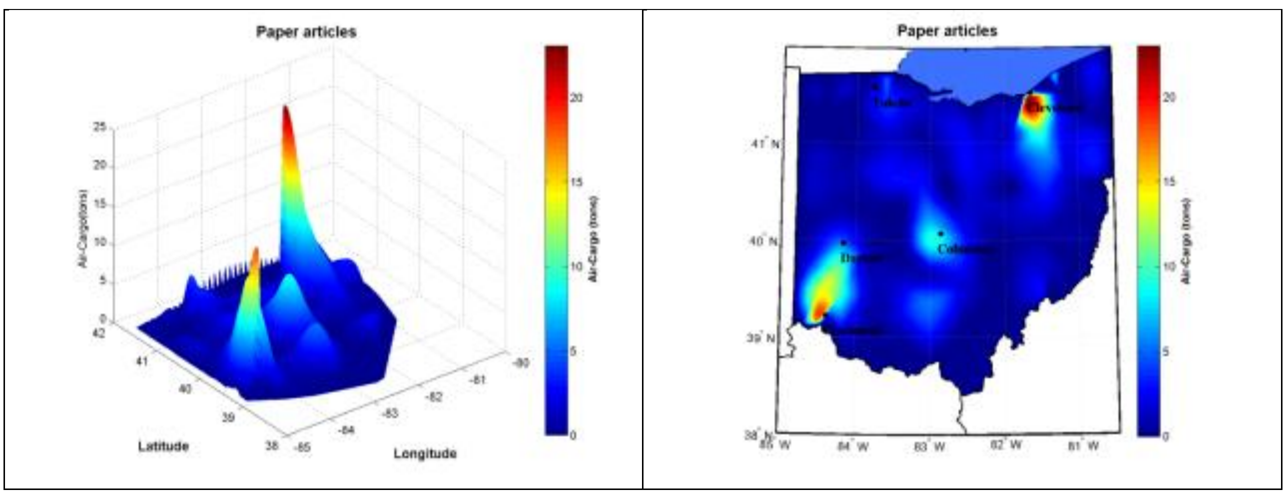


Ohio State Air-Cargo Demand Distribution (top), Michigan State Air-Cargo Demand Distribution (middle), MI-OH Region Air-Cargo Demand Distribution (bottom) of Non-metallic Mineral Products (SCTG Code 31).



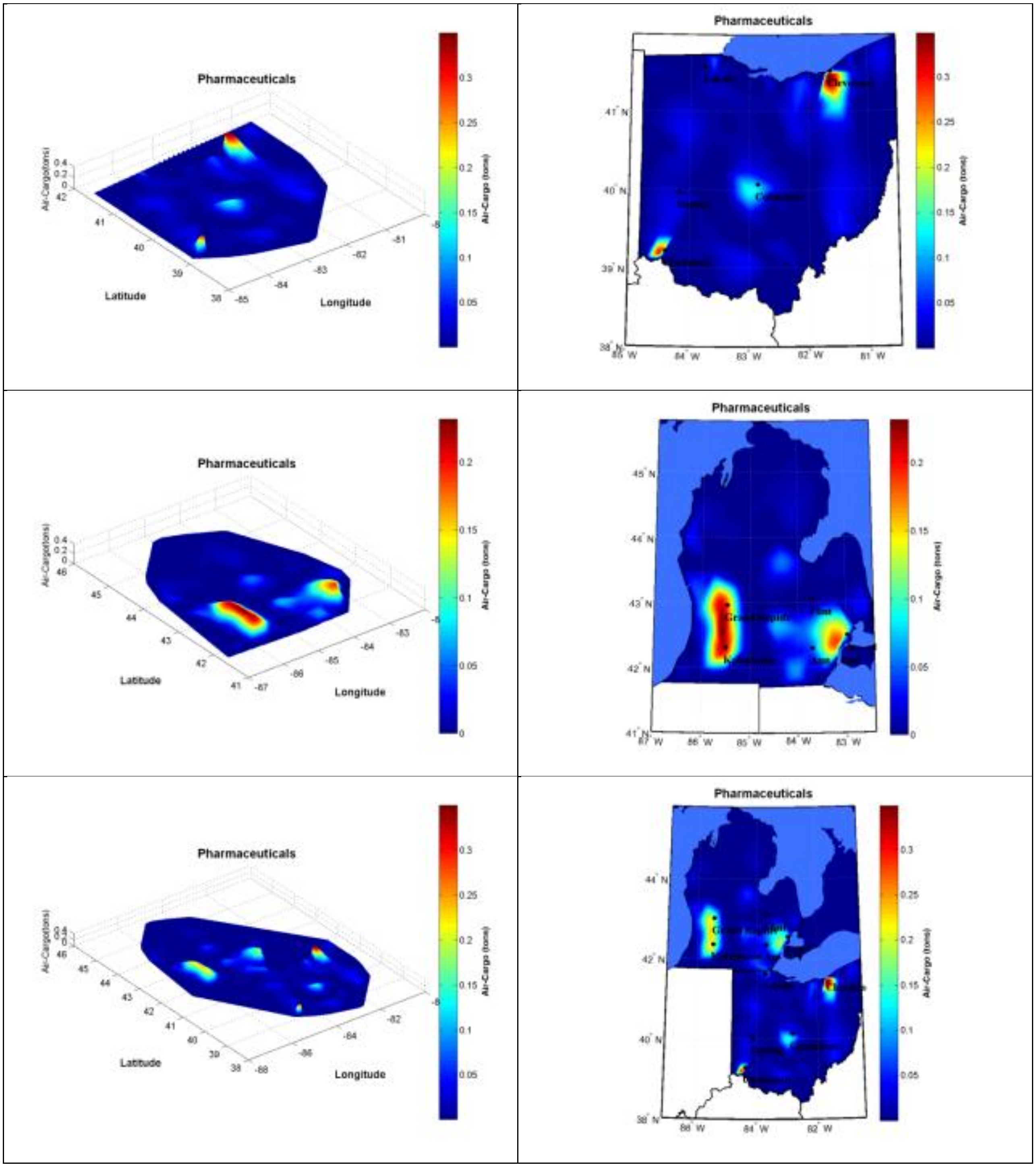
Ohio State Air-Cargo Demand Distribution of Other Non-Metallic Minerals (SCTG Code 13).

**No Ai-cargo Demand for this Code in Michigan.*

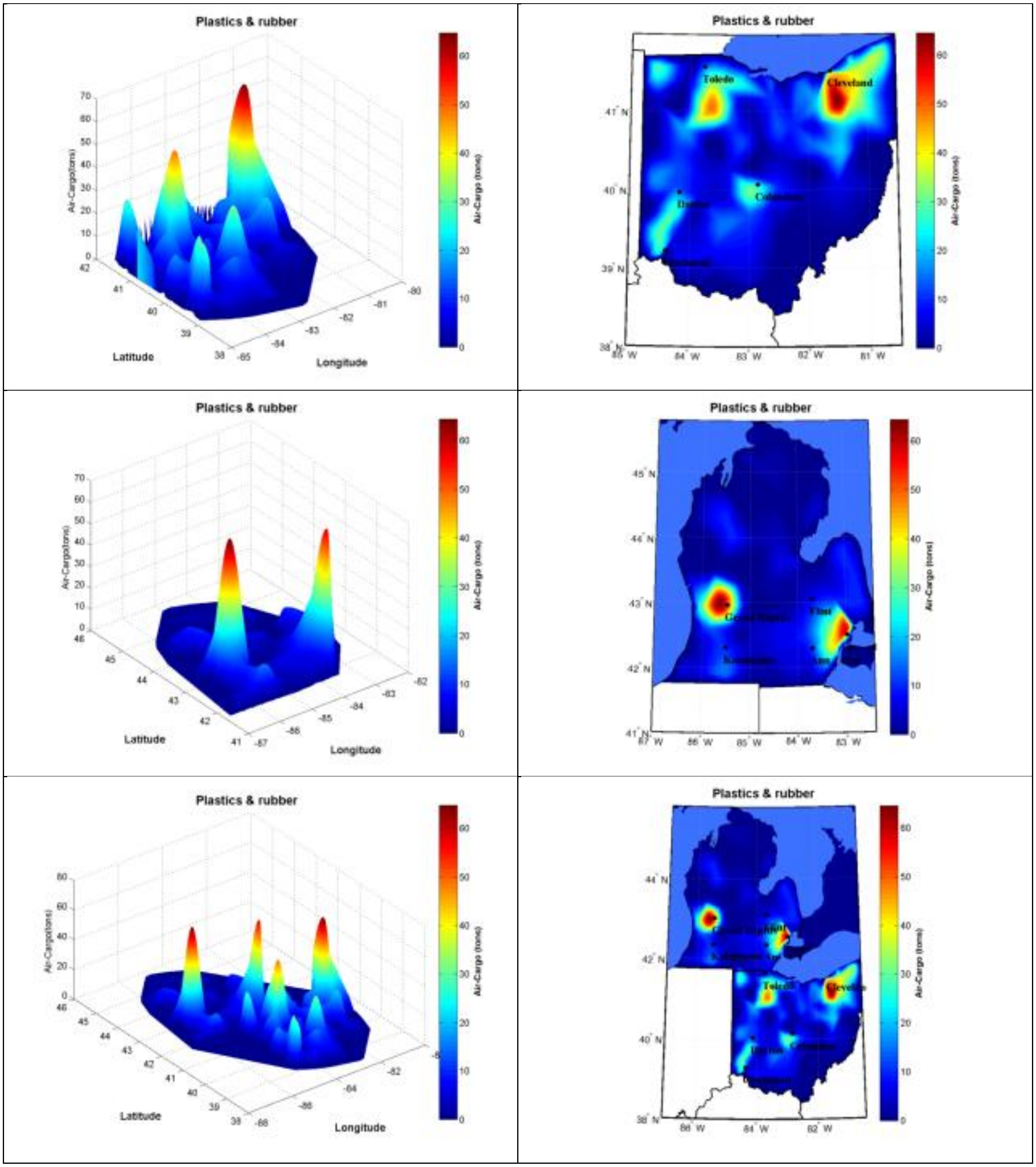


Ohio State Air-Cargo Demand Distribution of Paper or Paperboard Articles (SCTG Code 28).

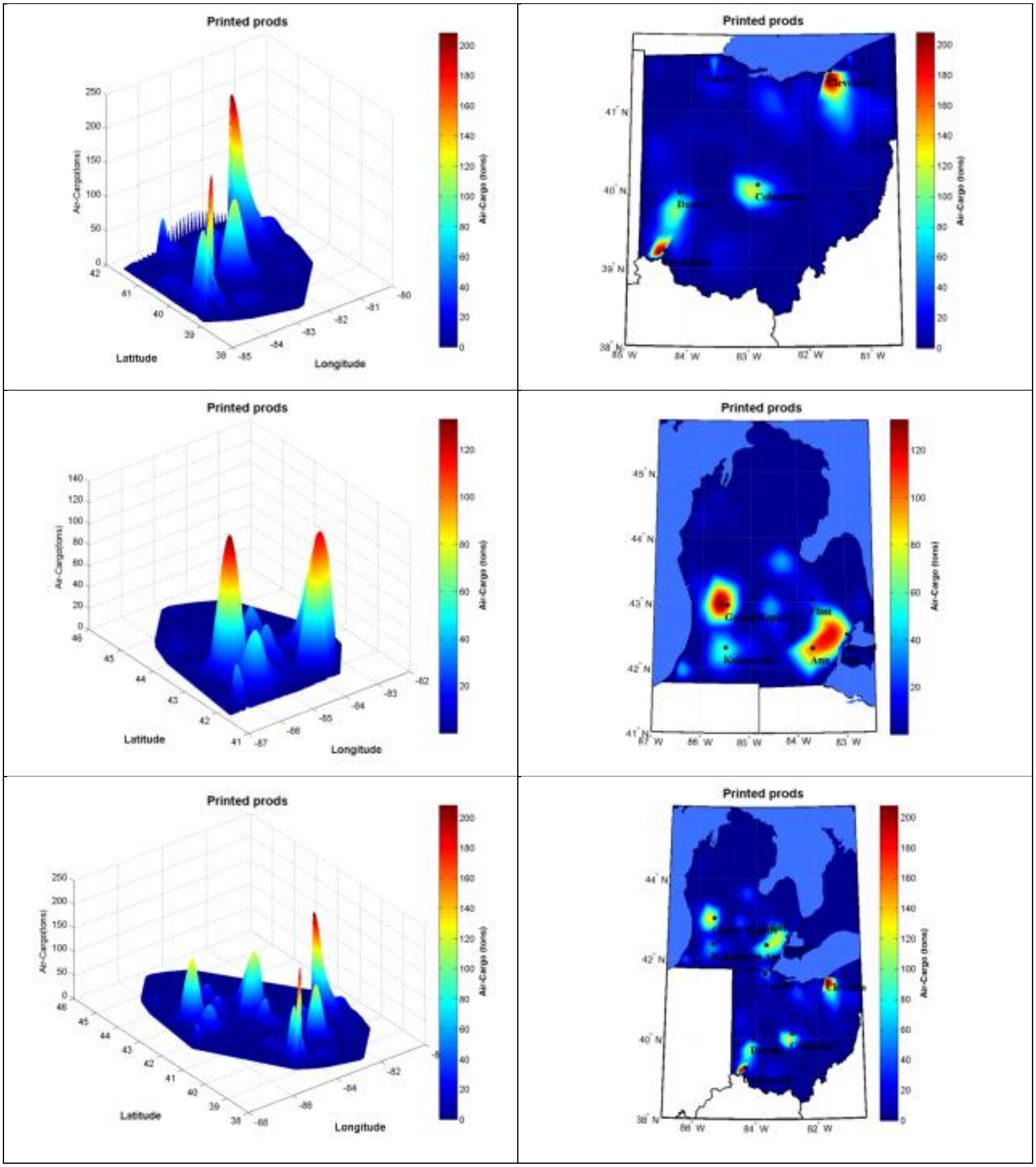
**No Ai-cargo Demand for this Code in Michigan.*



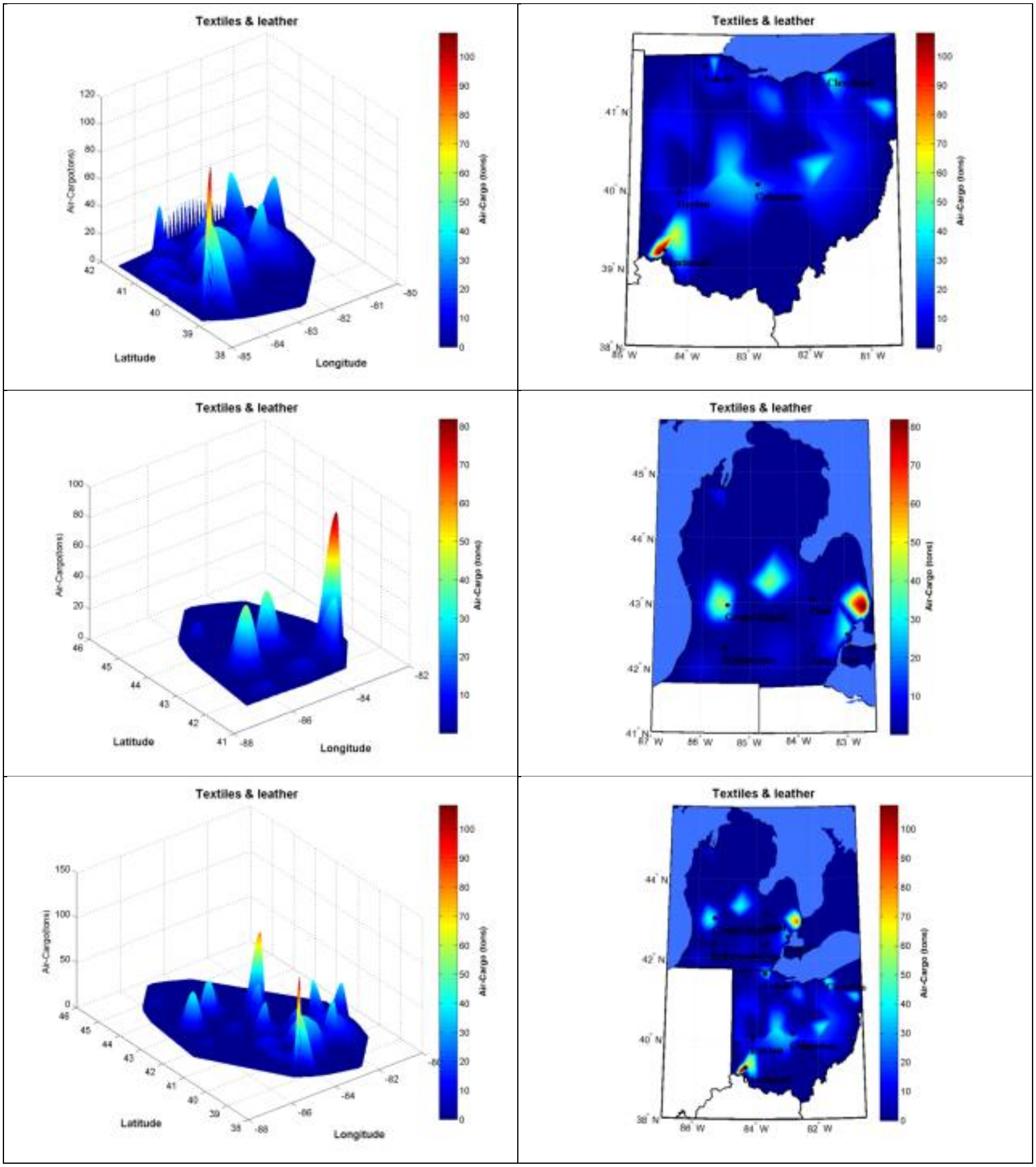
Ohio State Air-Cargo Demand Distribution (top), Michigan State Air-Cargo Demand Distribution (middle), MI-OH Region Air-Cargo Demand Distribution (bottom) of Pharmaceutical Products (SCTG Code 21).



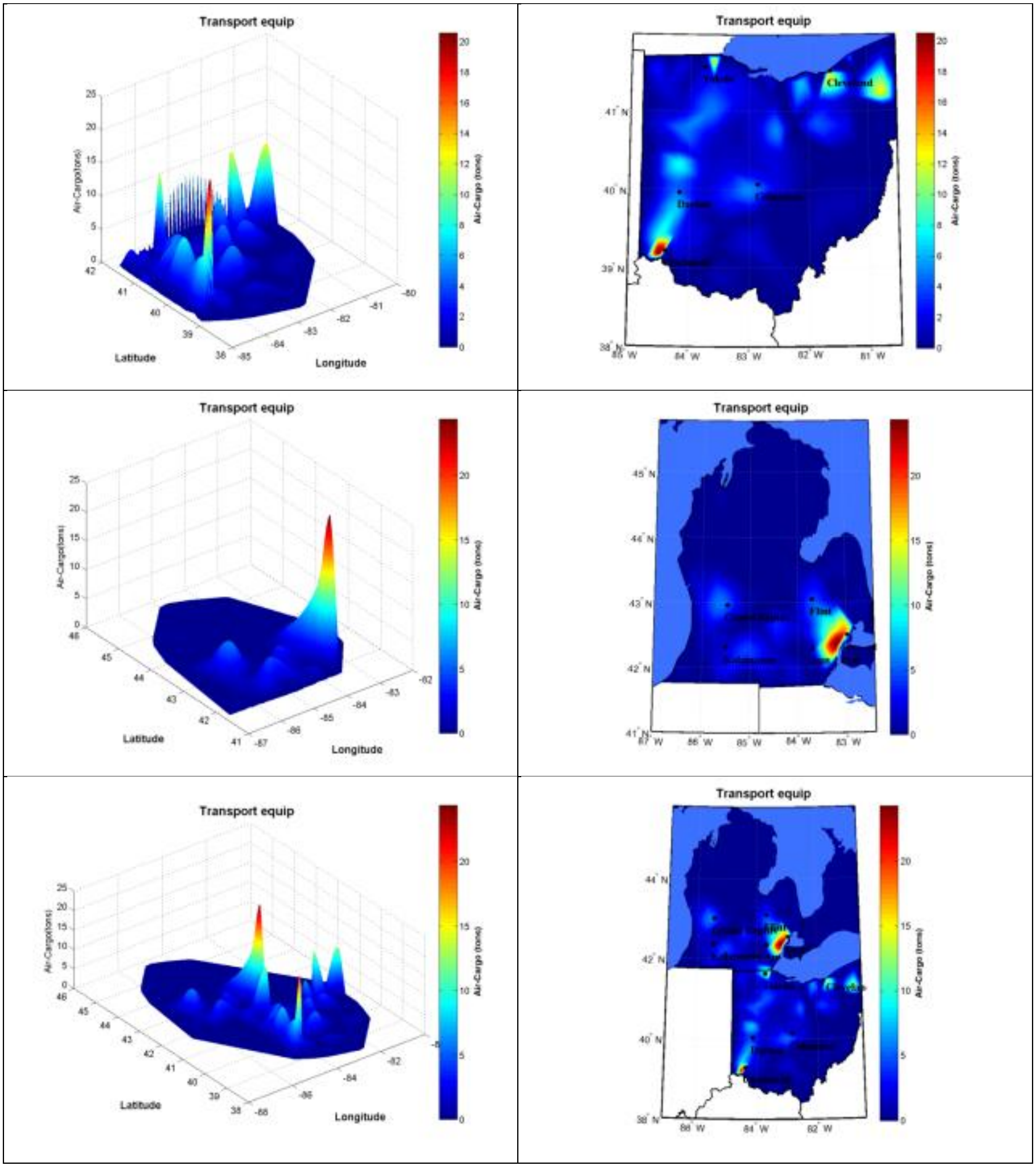
Ohio State Air-Cargo Demand Distribution (top), Michigan State Air-Cargo Demand Distribution (middle), MI-OH Region Air-Cargo Demand Distribution (bottom) of Plastics and Rubber (SCTG Code 24).



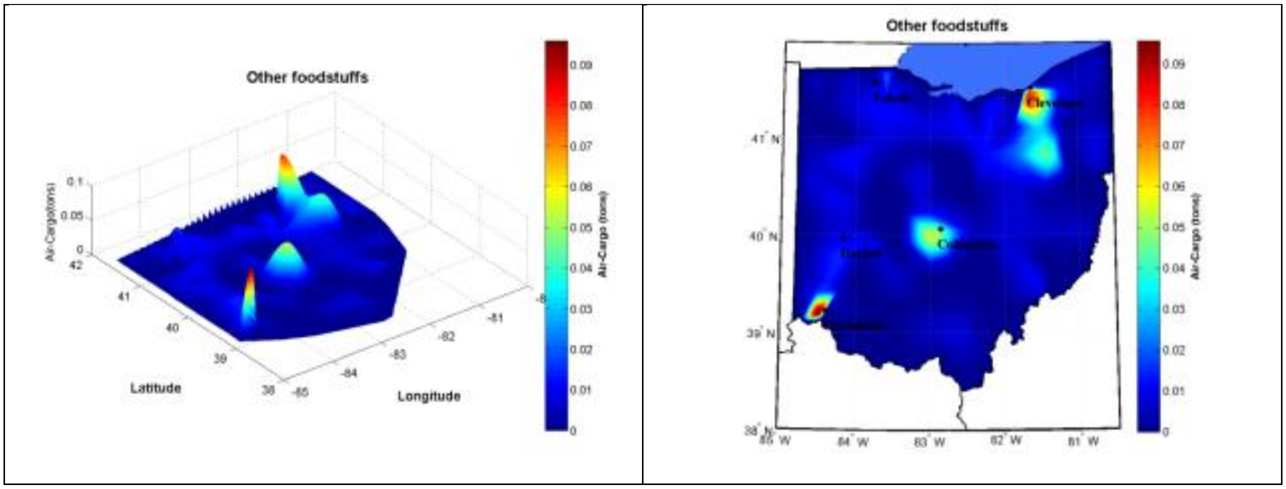
Ohio State Air-Cargo Demand Distribution (top), Michigan State Air-Cargo Demand Distribution (middle), MI-OH Region Air-Cargo Demand Distribution (bottom) of Printed Products (SCTG Code 29).



Ohio State Air-Cargo Demand Distribution (top), Michigan State Air-Cargo Demand Distribution (middle), MI-OH Region Air-Cargo Demand Distribution (bottom) of Textiles, Leather, and Articles of Textile or Leather (SCTG Code 30).

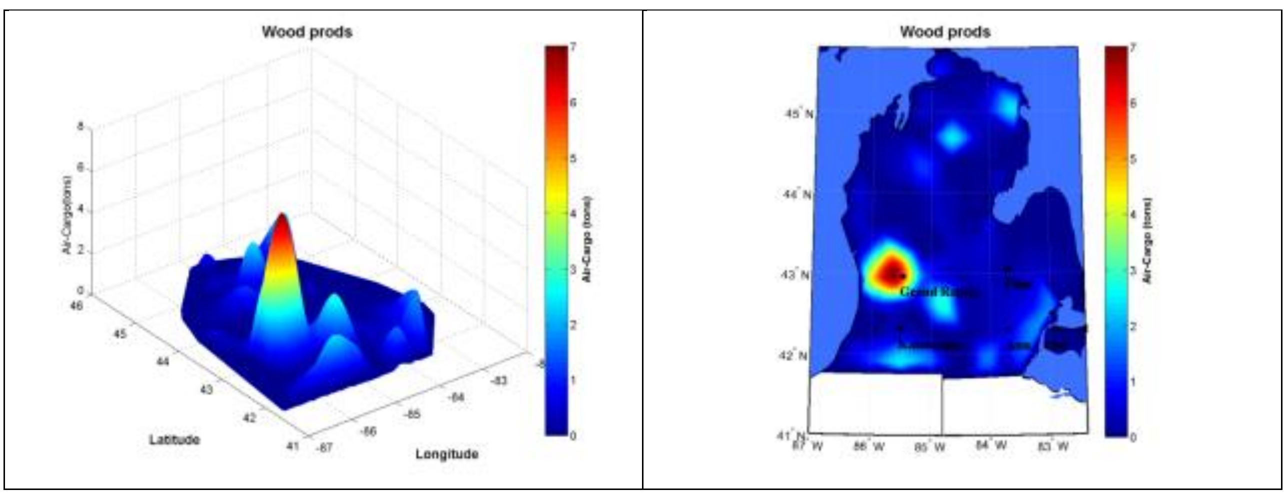


Ohio State Air-Cargo Demand Distribution (top), Michigan State Air-Cargo Demand Distribution (middle), MI-OH Region Air-Cargo Demand Distribution (bottom) of Transportation Equipments (SCTG Code 37).



Ohio State Air-Cargo Demand Distribution of Other Prepared Food Stuffs, and Fats and Oils (SCTG Code 07).

**No Ai-cargo Demand for this Code in Michigan.*



Michigan State Air-Cargo Demand Distribution of Wood Products (SCTG Code 26).

**No Ai-cargo Demand for this Code in Ohio.*

3. CONCLUSION

In this research, we studied the alternative access airport selection decisions of freight forwarders. First, we have conducted a literature review to understand the airport selection decisions of air cargo carriers and carrier selection decisions of freight forwarders. Our literature review and subsequent interviews with air cargo experts from freight forwarders and airport air cargo managers revealed that the freight forwarders' airport selection decisions and carrier choice are dependent. In other words, the freight forwarder considers alternative access policy in a MAR if the airports have comparable flight availability/schedule and provide similar service level in other factors discussed in Section 2.1. At the onset, our goal was to consider TOL and DTW as a MAR and analyze the forwarder's preferences with respect to these two airports. However, due to low flight availability from TOL, we were unable to collect reliable survey data for this comparison. Hence we have developed a nation-wide survey based on the interviews and literature review. While the results of survey analysis are not complete at the time, the results are currently being collected and analyzed. We provide the survey developed in Section 2.1.

In a MAR, when airports have comparable flight schedules (frequency, destination connectivity) and similar in other attributes listed in Section 2.1., the freight forwarders would consider the alternative access airport policy based on the proximity to the customers as well as to the airports. For this reason, we have developed a novel process for estimating the air cargo demand density in the OH-MI region using several datasets (Section 2.2). The results indicate that the air cargo demand density distribution is diverse in the OH-MI region and vary by the industry category of the air cargo goods. While the air cargo demand density peaks are around the metropolitan areas (e.g., Detroit, Toledo) and agglomerated around the airports, the use of alternative access policy may favor forwarders' depot locations at intermediate locations. We have not performed this simulation analysis (e.g., determining ideal locations of forwarder's depot) since the DTW and TOL are not comparable in terms of flight availability.

Upon the completion of the survey results, the results in Section 2.2 will be used to generate candidate depot locations that can be analyzed for improved forwarder performance under alternative access airport policy.

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APPENDIX

Table A1. Two Digit SCTG Commodity Classification

Commodity Code	Commodity Description
01	Live Animals and Fish
02	Cereal Grain (including seed)
03	Agricultural Products *Except for Animal Feed* (other)
04	Animal Feed and Products of Animal Origin.
05	Meat, Fish, and Seafood and Their Preparations
06	Milled Grain Products and Preparations, and Bakery Products
07	Other Prepared Food Stuffs, and Fats and Oils
08	Alcoholic Beverages
09	Tobacco Products
10	Monumental or Building Stone
11	Natural Sands
12	Gravel and Crushed Stone
13	Other Non-Metallic Minerals
14	Metallic Ores and Concentrates
15	Coal
16	Crude Petroleum Oil
17	Gasoline and Aviation Turbine Fuel
18	Fuel Oils
19	Other Coal and Petroleum Products
20	Basic Chemicals
21	Pharmaceutical Products
22	Fertilizers
23	Other Chemical Products and Preparations
24	Plastics and Rubber
25	Logs and Other Wood in the Rough
26	Wood Products
27	Pulp, Newsprint, Paper, and Paperboard
28	Paper or Paperboard Articles
29	Printed Products
30	Textiles, Leather, and Articles of Textiles or Leather .
31	Non-Metallic Mineral Products
32	Base Metal in Primary or Semi-Finished Forms & in Finished Basic Shapes
33	Articles of Base Metal
34	Machinery
35	Electronic, Other Electrical Equipment, Components, and Office Equipment
36	Motorized and Other Vehicles (including parts)
37	Transportation Equipment
38	Precision Instruments and Apparatus
39	Furniture, Mattresses and Mattress Supports, Lamps, Lighting Fittings, and Illuminated Signs
40	Miscellaneous Manufactured Products
41	Waste and Scrap (except of agriculture or food).
43	Mixed Freight

Source: FHWA Office of Freight Management and Operations, Report 4 – FAF Commodity Classification

Table A2. Production Equations (thousands of tons)

NAICS CODE	SCTG		
	SCTG	Live animals/fish (1)	
	Description	COEFFICIENT	T-STAT
115	Support Activities for Agriculture and Forestry	0.239	4.80
R^2		0.17	
	SCTG	Cereal grains (2)	
311	Food Manufacturing	0.407	5.11
	Farm acres (in thousands)	0.441	4.20
R^2		0.48	
	SCTG	Other Agriculture Products. (3)	
311	Food Manufacturing	0.188	10.43
	Farm acres (in thousands)	0.051	2.14
R^2		0.65	
	SCTG	Animal feed (4)	
115	Support Activities for Agriculture and Forestry	0.883	7.45
	Farm acres (in thousands)	0.102	6.64
R^2		0.60	
	SCTG	Meat/seafood (5)	
311	Food Manufacturing	0.053	25.94
R^2		0.86	
	SCTG	Milled grain products (6)	
311	Food Manufacturing	0.053	13.64
R^2		0.62	
	SCTG	Other Foodstuff (7)	
311	Food Manufacturing	0.180	10.03
325	Chemical Manufacturing	0.127	3.85
R^2		0.75	
	SCTG	Alcoholic Beverages (8)	
312	Beverage and Tobacco Product Manufacturing	0.336	10.66
R^2		0.50	
	SCTG	Tobacco prods. (9)	
312	Beverage and Tobacco Product Manufacturing	0.014	4.45
R^2		0.15	
	SCTG	10,11,12,13,14,15	
212	Mining (except Oil and Gas)	2.144	10.10
R^2		0.13	
	SCTG	Crude Petroleum (16)	
211	Oil and Gas Extraction	8.324	5.36

R^2		0.21	
	SCTG	Gasoline (17)	
324	Petroleum & Coal Products Manufacturing	7.592	23.67
R^2		0.83	
	SCTG	Fuel Oils (18)	
324	Petroleum & Coal Products Manufacturing	3.885	19.39
R^2		0.77	
	SCTG	Other Coal & Petroleum Products (19)	
211	Oil and Gas Extraction	2.064	1.17
324	Petroleum & Coal Products Manufacturing	11.737	8.07
R^2		0.62	
	SCTG	20,21,22,23	
325	Chemical Manufacturing	0.184	7.60
R^2		0.11276	
	SCTG	Plastics/Rubber (24)	
326	Plastics and Rubber Products Manufacturing	0.111	9.28
R^2		0.43	
	SCTG	Logs(25)	
113	Forestry and Logging	0.323	4.02
115	Support activities for Agriculture and Forestry	0.843	3.91
321	Wood Product Manufacturing	0.465	6.48
R^2		0.70	
	SCTG	Wood Products (26)	
321	Wood Product Manufacturing	0.625	18.37
R^2		0.75	
	SCTG	Newsprint/paper (27)	
113	Forestry and Logging	0.887	13.59
323	Printing and Related Activities	0.086	7.38
R^2		0.73	
	SCTG	Paper Articles (28)	
322	Paper Manufacturing	0.101	10.76
323	Printing and Related Activities	0.038	4.82
R^2		0.81	
	SCTG	Printed Products (29)	
322	Paper Manufacturing	0.015	2.48
323	Printing and Related Activities	0.077	15.25
R^2		0.85	
	SCTG	Textiles/Leather (30)	
313	Textile Mills	0.059	2.68

314	Textile Product Mills	0.187	5.86
R^2		0.73	
	SCTG	Nonmetallic Mineral prod. (31)	
327	Nonmetallic Mineral Product Manufacturing	2.09	13.25
R^2		0.61	
	SCTG	Base Metals (32)	
331	Primary Metal Manufacturing	0.424	8.69
333	Machinery Manufacturing	0.085	3.24
R^2		0.75	
	SCTG	Articles of Base Metals (33)	
332	Fabricated Metal Product Manufacturing	0.115	14.51
R^2		0.65	
	SCTG	Machinery (34)	
332	Fabricated Metal Product Manufacturing	0.085	2.92
333	Machinery Manufacturing	0.081	2.01
R^2		0.63	
	SCTG	Electronic & Electrical (35)	
333	Machinery Manufacturing	0.020	3
334	Computer and Electronic Product Manufacturing	0.012	4.35
335	Electrical Equipment, Appliance, and Component Manufacturing	0.029	2.44
R^2		0.7	
	SCTG	36, 37	
336	Transportation Equipment Manufacturing	0.084	18.01
R^2		0.741	
	SCTG	Precision Instruments (38)	
339	Miscellaneous Manufacturing	0.03128	7.65
R^2		0.34	
	SCTG	Furniture (39)	
337	Furniture and Related Product Manufacturing	0.055	11.94
R^2		0.56	
	SCTG	Misc. Manufactured Prod. (40)	
339	Miscellaneous Manufacturing	0.104	14.21
R^2		0.64	
	SCTG	Waste and Scrap (41)	
115	Support activities for Agriculture and Forestry	0.778	3.75
221	Oil and Gas Extraction	0.436	1.75

321, 322, 323, 324, 325, 326, 327	Nondurable	0.063	5.39
331, 332, 333, 334, 335, 336, 337, 339	Durable	0.062	2.61
R^2		0.86	